EXCELLENCE IN RESEARCH AND INNOVATION

THE GLOBE AND MAIL TUESDAY, NOVEMBER 17, 2015 SECTION R&I

The Amundsen holds numerous internal and external laboratory spaces and an impressive array of instruments that allow it to complete research assignments in addition to its icebreaking duties for the Canadian Coast Guard. MARTIN FORTIER/ARCTICNET

Tools and talent

World-class facilities enable Canadian researchers to collaborate in the pursuit of solutions for today's pressing challenges, including climate change, health issues, food security concerns and the economic downturn.

There is an area north of Ellesmere Island where scientists predict that sea ice will be present even during future summers when the rest of the arctic will have no ice cover. That's where Guillaume Massé wants to go.

"My aim is to collect sediment samples that will tell us if there ever was a time in history when the area was ice-free in the summer," explains the Université Laval paleoceanographer.

The region is "very icy and very difficult to access," but fortunately for Dr. Massé, he has access to the right transportation: the Canadian Coast Guard Ship (CCGS) Amundsen, a T1200 class medium Arctic icebreaker and research vessel.

Converted to a research vessel in 2003 with funding from the Canada Foundation for Innovation (CFI), the Amundsen holds numerous internal and external laboratory spaces and an impressive array of instruments that allow her to complete research assignments from May to November, before resuming icebreaking services for the Canadian Coast Guard.

The Amundsen is equipped with giant corers for lifting sediment samples from the ocean floor, as well as seabed sounding systems that help to locate areas of high-quality sediment deposits, says Dr. Massé. The samples, collected in areas like northern Baffin Bay, are examined for organic chemicals that indicate the presence – or absence – of sea ice.

"Ice-free regions are very productive," he explains. "There are a lot of algae in the water, which feed zooplankton. Zooplankton feeds birds, marine mammals and fishes, which, in turn, are important for surrounding communities."

MARTIN FORTIER/ARCTICNET

> "We want the [research] infrastructure to act as a magnet for talent and a catalyst for collaboration."
>
> **Dr. Gilles Patry**
> is president and CEO of the Canada Foundation for Innovation

Accessing lower levels of sediment means digging deeper into the past, says Dr. Massé. "We can go back in time to re-construct ocean conditions. This is important to study, not only for communities and ocean productivity, but to understand climate change."

Dr. Massé, who joined Université Laval three years ago, was still working in France when he first set foot on the Amundsen in 2005. He was impressed right away and says the CFI's support for such research facilities is admired by researchers around the world.

Dr. Massé adds that a recent CFI grant is helping to bring the vessel's scientific instruments – many of them installed 10 or 12 years ago – to current standards.

It's the CFI's mandate to support world-class research, says Dr. Gilles Patry, president and CEO of the CFI. "We do this by funding research facilities to enable those types of discoveries," he adds. "And we don't only fund the infrastructure, we also support the operation of state-of-the art national facilities like the Amundsen."

Yet funding infrastructure is not enough, says Dr. Patry. "You also need to attract and retain top talent. In our guidelines for selecting the recipients of funding, we ask how a piece of infrastructure is going to attract the participation of the best researchers," he explains. "We want the infrastructure to act as a magnet for talent and a catalyst for collaboration."

For Dr. Massé, the facility was not his only reason for coming to Canada. "Since I'm working in the north, the Amundsen is central to my research but it's only part of the attraction. Equally important are my colleagues at Université Laval and ArcticNet."

He believes that the CFI's strategic investments have been crucial for building an impressive network of researchers that enables teamwork.

Dr. Patry also sees collaboration as critically important in research and innovation. "You don't come up with the next big idea in isolation," he says. "That's why we want the best researchers in Canada to work with the best in the world."

This combined focus on infrastructure and talent has enabled Canada to "punch above its weight class when it comes to research," says Dr. Patry, who lists regenerative medicine, subatomic physics and quantum computing as fields of particular strength.

Ocean and Arctic research are also areas where Canada has gained recognition as a world leader, according to Dr. Patry. Among the partners responsible for this reputation are Ocean Networks Canada, which is affiliated with the University of Victoria and operates the Neptune and Venus cabled ocean observatories, and the Ocean Tracking Network, an ocean research and technology development platform headquartered at Dalhousie University.

Both initiatives attract a large number of Canadian and international partners, as does ArcticNet, where 34 Canadian universities, including Université Laval, collaborate with government agencies and 150 partner organizations in 14 countries.

And while Dr. Massé's work focuses on the Canadian Arctic, his findings have global implications, he says. As will the samples he collects from the Amundsen on the day of the interview. "At least 10 to 15 groups of researchers around the world will be working with the sediments we brought back today," he explains. "Facilities like the Amundsen don't only benefit Canadian researchers – they help to advance research around the world."

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INSIDE

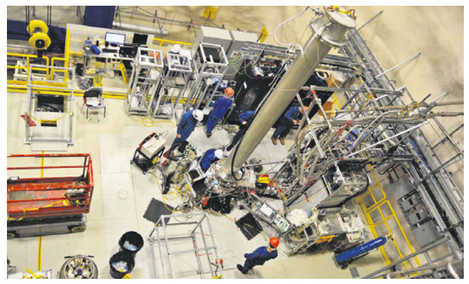
EXCELLENCE IN RESEARCH AND INNOVATION

OPINION

Unlocking science's treasure chest

Engineering and technology solutions that answer fundamental questions in science find broad applications

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



Student Dagoberto Contreras works on the prototype version of the DEAP experiment (left) and the view from above showing the DEAP-3600 experiment under construction (right). This experiment uses 3,600 kilogram of liquid argon to detect dark matter particles. These particles are so non-interactive that this experiment may only see a few per year. SNOLAB

The answers to fundamental questions about our world come from some of mankind's most sophisticated technologies. This makes basic science a veritable treasure chest of opportunity for innovation.

Dr. Arthur McDonald's 2015 Nobel Prize in Physics, awarded for his fundamental discovery that changes how we understand matter and the universe, is a great accomplishment in Canadian science. Dr. McDonald's work and the Sudbury Neutrino Observatory (SNO) in Sudbury, Ont., the research facility where he made his prize-winning discoveries, also provide a clear example of the interplay between basic and applied research, or more to the point, evidence that there is a vital continuum connecting the two.

Like all new knowledge, Dr. McDonald's discovery that subatomic particles called neutrinos have mass and can change identities could give rise to extraordinary new innovations in the same way that understanding the nature of electromagnetism led to the development of modern telecommunications. But beyond the inherent power of knowledge, science that seeks solely to illuminate a yet unknown part of the universe we inhabit – the kind of science Dr. McDonald pursued when he set out to learn what was happening to neutrinos coming from the sun – often gives forth real-world, and sometimes marketable, ideas all along the way.

> The fact is that to answer fundamental questions in science, highly sophisticated equipment is often required and the incredible engineering and technology development involved naturally has applications far beyond the specific research project for which it was developed.

SNOLAB, as it is now known, brims with examples of this. When the cavity for the research facility – located two kilometres below ground – was excavated in the 1990s, Sudbury mining companies used the information that was gathered about the geology and rock mechanics of the area to understand rock stresses in mineral deposits. The sensor technologies developed by SNOLAB researchers so they could better understand dark matter – one of the great mysteries of modern astrophysics – are now sold by a Montreal company to monitor radiation exposure at nuclear reactors. And the American company that developed the spherical acrylic vessel to hold the heavy water used in the facility's neutrino detector now markets the same technology to create grand aquariums for business tower lobbies.

The fact is that to answer fundamental questions in science, highly sophisticated equipment is often required and the incredible engineering and technology development involved naturally has applications far beyond the specific research project for which it was developed.

Ocean Networks Canada, a web of highly sophisticated monitoring and detection instruments that lie on the seafloor along the coast of Western Canada, reflects the research community's intrinsic understanding that science projects are more productive, and therefore more valuable, when they serve the broadest range of stakeholders. Their cabled observatories collect data on the physical, chemical, biological and geological aspects of the ocean to answer fundamental questions about the processes that make our planet work. At the same time, the team applies the massive data sets these instruments produce, and their knowledge of sensor technology, to applications ranging from early earthquake and tsunami warning systems to tools that provide detailed sea condition information to improve ship safety and sophisticated hydrophones that monitor sound levels in the ocean to protect whales and detect and reduce noise pollution from ships.

More than just the knowledge and technology that gets created by fundamental research, there are also the people who are trained in fundamental science facilities. The broad range of highly specialized skills they acquire in areas such as data handling and analysis, instrumentation engineering and the management of large-scale, highly complex science facilities is one of the most valuable outputs of basic science endeavours.

So when we celebrate a Nobel prize, we should not simply acknowledge the fundamental breakthroughs that help us better understand the universe, but also the long road it took to get there and all of the things we gained along the way.

GLOBAL OUTLOOK

Market opportunities for Canadian innovation abundant

Offering innovative products or services can help Canadian companies find success in a variety of global markets, says Todd Winterhalt, vice-president, International Business Development, Export Development Canada (EDC).

"When you have a traditional product or service, generally speaking your market is more limited," he explains. "If you're offering something more innovative and creative, then you have more markets available."

Well over 60 per cent of first-time Canadian exporters choose to go to the U.S., says Mr. Winterhalt. Less than 20 per cent aim for a different but more developed market and an even smaller percentage of companies consider an emerging market that might offer lots of opportunity but also carries a higher risk, according to data from EDC, Canada's export credit agency dedicated to helping companies respond to international business opportunities.

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> **Todd Winterhalt**
> is vice-president, International Business Development, Export Development Canada

Innovative products and services tend to be attractive to foreign buyers. ISTOCKPHOTO.COM

"The differentiator for companies that are going global is that they tend to have invested more in their product or process," says Mr. Winterhalt. "For companies that are more innovative, it's less daunting to go right away to an international market – they can see their product succeed just about anywhere."

To be successful outside the domestic market, companies have to be more competitive, innovative and efficient, he explains. "You're competing against a broader grouping of companies. Those who are more successful tend to bring something else to the game, for example a new application or technology that is attractive to a foreign buyer."

Mr. Winterhalt has seen companies go directly to emerging markets with products or services that he calls "niche or disruptive.

"We see a lot of this happen in what would be considered non-traditional sectors of the Canadian economy," he says. "For example, there is a great deal of appetite for Canadian technologies in biotech, life sciences and the cleantech space."

While innovation can increase market potential, Mr. Winterhalt adds that company culture also influences decisions on whether or where to pursue export opportunities. "If you are willing to take the risk to invest more heavily in innovation, generally speaking, you may be more open to other risks as well, such as trying another market."

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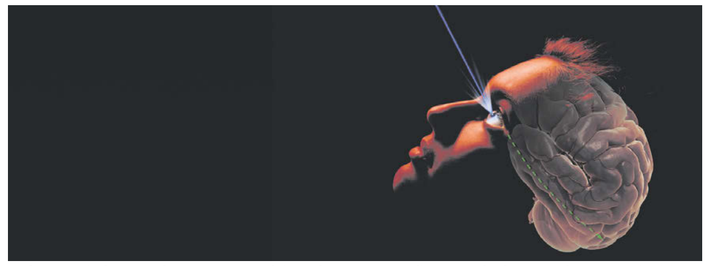
STUDY

Vision research

Collaboration between computer scientists and psychologists has implication for a range of technology solutions



York University's Centre for Vision Research is exploring areas as diverse as the function of stereoscopic vision in microsurgery and the use of remote-controlled vehicles. SUPPLIED

At first blush, the problem appears to be mundane, not particularly worthy of the attention of a team of world-class experts in human and computer vision research: how do you prevent the kind of queasiness and discomfort that watching 3D movies like James Cameron's *Avatar* can induce in theatre goers?

But in a conversation with Dr. Laurence Harris, the director of York University's Centre for Vision Research, it becomes obvious that what is learned in researching queasiness triggered by watching 3D films has significance that stretches far beyond the enjoyment of a movie audience.

The 3D movie research is a collaboration between Dr. Rob Allison, a computer scientist in York's Lassonde School of Engineering, and Dr. Laurie Wilcox, a psychologist in the university's Faculty of Health. "They are measuring which things [trigger a response], the film rate, the 3D aspect of it, for example, and how that can be optimized so that it's most comfortable for viewing," says Dr. Harris.

For the film industry, the issue is not a trivial one – for example, Cameron's *Avatar* alone has grossed more than $1-billion (U.S.) – and research findings have implications for a range of projects. "So this collaboration between the computer science people, looking into the technologies of the lenses and the visual properties, and the psychologists who know about perception and emotions is important," says Dr. Harris. The centre is exploring areas as diverse as the function of stereoscopic vision in microsurgery, in co-operation with Toronto's Hospital for Sick Children, to the use of remote-controlled vehicles that can survey dangerous environments containing toxic substances or explosives.

It's all part of what has made York University a world leader in developing and applying technology in the area of biological and computer vision, says Dr. Harris.

The centre's 31 members are drawn from several faculties and departments and have worked on many specific applied research projects that link biological and machine vision, says Dr. Robert Haché, York's vice-president of research and innovation.

"Under aging and cognitive impairment, for instance, York is helping to develop technology for monitoring and assisting individuals in their home or in home-care facilities," he says. "One avenue is the development of small personal robots that provide reminders of critical tasks and that interact with wearable devices to monitor a person's location, vital signs or if they have fallen."

York is on the leading edge of developing and applying technology in this area as a world-class hub for interdisciplinary research, says Dr. Haché, and as a strategic priority, it plans to further invest by recruiting prominent researchers and building state-of-the-art infrastructure.

EXCELLENCE IN RESEARCH AND INNOVATION

KREMBIL RESEARCH INSTITUTE

New name reflects family's dedication to research

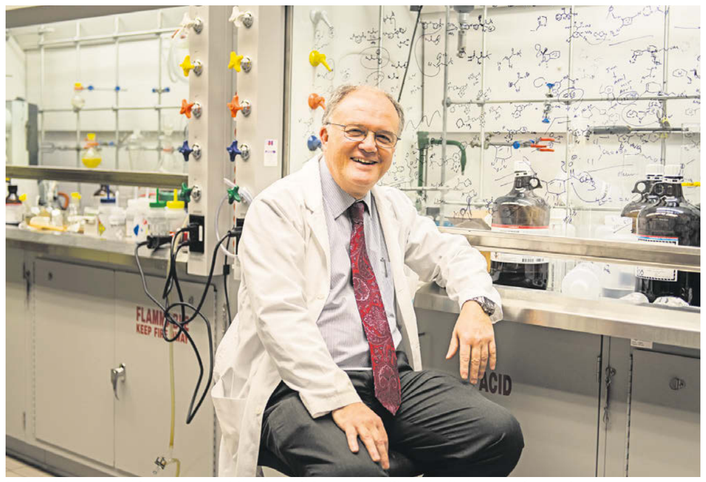
There is a new name for inquiry in Toronto's discovery district – the Krembil Research Institute. While the name of the institute may be new, the innovation and expertise of the 161 scientists who work there are well known.

A magnet for the world's leading experts in diseases of the brain, spine, bones, joints and eyes, Krembil (formerly known as the Toronto Western Research Institute) is the research arm of Toronto Western Hospital, one of five research institutes at the University Health Network (UHN) which, just last month, was ranked Canada's top research hospital by RESEARCH Infosource.

In an announcement made last week by Her Royal Highness, The Princess Edward, Countess of Wessex, the patron of the Toronto Western and Toronto General hospitals, the Krembil took on its new name in recognition of a family who understands the value of supporting world-class medical research.

"Our family has been involved with Toronto Western Hospital for nearly two decades," says Robert Krembil. "We have gained a deep appreciation for both the research excellence and the scientists who are working to find cures for some of the most debilitating health issues of our day. They are relentless and visionary in their quest for cures, and they deserve our support."

Dr. Don Weaver, director of the Krembil Research Institute, sees the Krembil family's ongoing investment as vital to the success of the institute's impact on the world stage. Dr. Weaver brings a rare and valuable combination of expertise to his position – he is the only person in Canada and among a handful across the world to be a practising neurologist who also holds a PhD in medicinal chemistry and drug design. In fact, in receiving his Centennial Award from the American Health Foundation in 2007, Dr. Weaver was cited as one of the two people in the world most likely to find a cure for Alzheimer's disease.



Dr. Don Weaver and his colleagues at the Krembil Research Institute don't shy away from using terms like "breakthrough" or "cure" when they describe the high-impact research nurtured in the collaborative environment of excellence at the institute. CHRISTOPHER KATSAROV

So how do you attract a researcher of this calibre? As Dr. Weaver tells it, the reason, in large part, was the Krembil's investment in research at UHN that drew him here three years ago from the east coast. "Investment in medical research is a challenge in Canada," he says. "The Krembils are known for their meticulous, sound decision-making when it comes to anything in which they are prepared to invest. That said, their investments are long term, and that makes all the difference when it comes to medical discovery."

Dr. Weaver's accomplishments are among many national and world firsts achieved by Krembil scientists who are dedicated to their search for cures of diseases of the brain, spine, bones, joints and eyes. While names like Lang, Lozano, Fehlings, Tymianski, Mahomed and Wallace may not be household names shared at the breakfast table, they are well known in global medical research circles.

The words "breakthrough or cure" – both said rarely in academia – are not words Dr. Don Weaver and his colleagues shy away from when they describe the high-impact research nurtured in the collaborative environment of excellence at Krembil. This, they say, is what ultimately will produce novel diagnostic and therapeutic products for chronic diseases of the nervous system, the eyes and the musculoskeletal system. Achieving this goal, which they firmly believe is attainable, will propel the Krembil Research Institute to become one of the top five medical research institutes in the world.

"Finding cures to these diseases will be the Krembil benchmark," asserts Dr. Weaver. "Our patients deserve this."

APPLIED RESEARCH

Students and industry benefit from tackling real-world problems

In the words of Saskatchewan Polytechnic's president and CEO Dr. Larry Rosia, "Partnerships are embedded in our DNA. They're fundamental to our role as Saskatchewan's sole polytechnic."

As post-secondary institutions, polytechnics are intensively focused on graduating students with job-ready skills to meet employer and labour-market needs in important economic sectors. Industry connections and collaborations are paramount, as are applied research partnerships.

Partnerships with employers and industry associations strengthen all aspects of educational programming, says Dr. Rosia. In addition to providing co-op placements and apprenticeships, employers work with the polytechnic to design courses and advise on program enhancements. "These partnerships allow us to deliver applied, hands-on learning and work experience with great value for students and employers – 93 per cent of our graduates get employment and 96 per cent of employers say they would hire another Saskatchewan Polytechnic graduate."

Other collaborations with government and industry sectors address workforce training needs in Saskatchewan and elsewhere in the country. In one project, the Saskatchewan Mining Association (SMA) and Saskatchewan Polytechnic jointly developed a contractors' safety training program at the Centre for Minerals Innovation.

Applied research at Saskatchewan Polytechnic's Hannin Creek Educational Facility enables students to familiarize themselves with the demands of the natural resource sector. SUPPLIED

"This program established common provincial training standards for contractors working for SMA member companies, helping to provide safe work environments at all mining sites," says Dr. Rosia.

Another key priority is applied research projects – through which the institution, along with government and other partners, helps smaller companies find real-world solutions to practical problems and bolsters the Saskatchewan economy.

Western Economic Diversification Canada has supported Saskatchewan Polytechnic to build its applied research infrastructure over three years. Recently they provided nearly $350,000 in funding to purchase new equipment for applied research projects at the Hannin Creek Educational Facility – a field camp for students in natural resources programs.

"The funding will allow us to acquire cutting-edge technologies, including unmanned aerial vehicles for surveying and mapping, and hydro-acoustic technology to gather sonar data for mapping and monitoring lakes, rivers and reservoirs," says Dr. Rosia.

"The opportunities for applied research and hands-on learning at Hannin Creek are limitless," he adds. "Both students and industry research partners will be able to conduct research in the station's new labs and training on the new equipment will give our students the knowledge, skills and abilities to meet the increasingly sophisticated demands of the natural resources sector."

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FACILITY

Creating conditions for new ideas to flourish

What conditions need to be in place to allow innovation to flourish? It's a question that Simon Fraser University (SFU) has considered carefully – and answered by redefining its innovation strategy and opening VentureLabs, a state-of-the-art facility to bring together industry and the community to tackle problems alongside SFU experts.

"What we've learned is that innovation is stimulated and happens in its best form when you have a specific problem to solve," says Dr. Joy Johnson, SFU's vice-president of research. "We've also learned that innovation happens when we can remove the barriers of closed doors and find ways to engage with others."

She describes SFU's 4D LABS as an example of a "fabulous lab facility focused on material science" that has become a hub for industry partners to solve specific problems related to advanced materials and nanoscale devices. And emphasizing that innovation isn't restricted to the sciences, she cites RADIUS, the university's community-based social innovation lab, as a place where entrepreneurial thinking is applied to pressing social issues.

The newly opened VentureLabs in SFU's downtown Vancouver campus is the most recent example of how a physical space can create the conditions for new ideas to flourish.

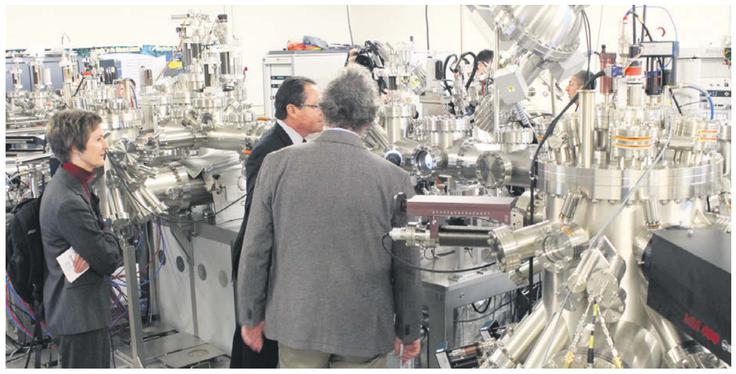
"It's a place where entrepreneurs who have great business ideas in the area of digital technology can access mentors and angel investors, connect with other innovators and benefit from the wealth of expertise offered by SFU faculty," says Dr. Johnson.

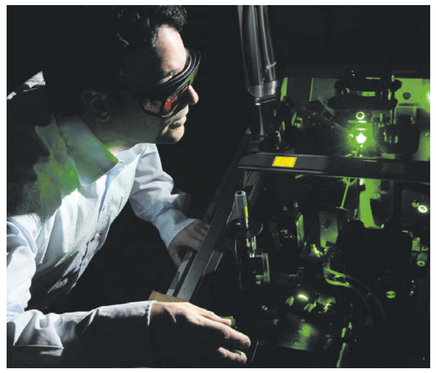
Guests learn about products being developed at SFU, which recently launched SFU Innovates, a new innovation strategy and facility. SUPPLIED

This business incubation and acceleration facility is a partnership with Ryerson University and the University of Ontario Institute of Technology. With 24,000 square feet of space and $10.7-million in federal funding, the new facility expands the capacity of the original VentureLabs, which was launched in December 2013 to help companies advance their ideas, increase revenues and expand into new markets.

Dr. Johnson says the university is dedicated to growing other spaces for innovation as part of its vision of engagement. "For us, innovation is always about exploring how we can do more with ideas, how we can use them to engage with industry and community members to solve specific problems – and that will ultimately generate economic and social benefits for us all."

EXCELLENCE IN RESEARCH AND INNOVATION





Startups that are coming out of the Institute for Quantum Computing's research are helping to cement the area's growing reputation as the quantum research equivalent of California's Silicon Valley. SUPPLIED

SPINOFFS

Harnessing quantum law for new technologies

Researchers say it's no surprise that a handful of technology startups are already sprouting up from the laboratories of the University of Waterloo's Institute for Quantum Computing (IQC), attracting the attention of major players in the U.S. defence and energy sectors.

The spinoffs have one thing in common. They are all working to find new applications for quantum technologies in areas such as medicine, communications, biochemistry, physics and nanoscience.

Universal Quantum Devices, a startup led by IQC associate professor Thomas Jennewein, is engaged in commercializing research instruments developed in his laboratory.

Dr. Jennewein, who completed his PhD thesis at the University of Vienna in 2002, is also involved in the development of ultra-long-distance communications devices using terrestrial and satellite-based systems.

A key goal is to put into orbit a communications system that cannot be hacked. The end result would be the creation of a microsatellite constellation equipped with quantum cryptography.

> "The satellite solution that we are working on could be used by telecom companies, governments, or financial corporations like banks that are interested in very secure communications."
>
> **Dr. Thomas Jennewein**
> is associate professor at the University of Waterloo's Institute for Quantum Computing

Dr. Jennewein says conventional cryptography employs algorithms that are used to create encryption keys for communications systems. The advantage with quantum cryptography, however, is that it relies on the use of photons to create those keys. Any attempt to eavesdrop or hack into that would in theory be instantly detected, because if an attempt is made to intercept or measure photons, their polarization changes.

Back in January 2015, Dr. Jennewein's IQC team completed the first successful laboratory demonstration of a prototype of a Quantum Key Distribution Receiver that is suitable for airborne experiments and ultimately Earth-orbiting satellite missions.

The prototype is backed by a $1.1-million contract from the Canadian Space Agency and is designed to solve the long-standing problem of securely transporting cryptographic keys between distant locations.

"The satellite solution that we are working on could be used by telecom companies, governments or financial corporations like banks that are interested in very secure communications," Dr. Jennewein says.

The University of Waterloo ecosystem is thought to be an ideal environment for this type of research.

It boasts one of the largest concentrations of quantum information scientists in the world. It has also attracted major investments by some major private and public partners, including Blackberry co-founder Mike Lazaridis.

With backing from academic and government partners, Mr. Lazaridis has donated more than $300-million over the past 15 years to establish two well-known research centres in Waterloo. One of those is the independent Perimeter Institute for Theoretical Physics and the other is the Institute for Quantum Computing.

Quantum Valley Investments, a fund set up by Mr. Lazaridis, aims to finance the process of taking research projects all the way from theory to commercialization.

"If you look around, the world recognizes what we are doing," says David Cory, a pioneer and innovator in quantum computing who joined IQC as Canada Excellence Research Chair in 2010.

A key focus of Dr. Cory's research is the development of the first generation of quantum computers that can solve problems beyond the scope of classical computers.

His group is also spawning startups from inside the lab. They include HighQ, a lab spinoff that is working on very sensitive detectors for use in materials and biochemistry.

The second is Neutron Optics, which grew out of a collaboration with the Maryland-based National Institute of Standards and Technology, and is making components for next-generation neutron devices for materials studies.

Members of Dr. Cory's team were recently in talks with Lockheed Martin, the Maryland-based global aerospace and defence contractor. They also work with Schlumberger Ltd., a leading U.S. supplier of technology and services to the oil and gas sector.

Startups like these are helping to cement the area's growing reputation as the quantum research equivalent of California's Silicon Valley. "I think that in the future you will see more quantum technology companies coming out of the University of Waterloo," Dr. Jennewein says.

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OPINION

Pickering Nuclear Generating Station can continue to deliver economic and environmental value

By Don MacKinnon,
President, Power Workers' Union

Greenhouse gas (GHG) emissions from Ontario's electricity sector are expected to more than double from 2014 levels, and could negate the reductions already achieved by closing the province's coal stations. Ontario's growing dependence upon carbon-emitting natural-gas-fired generation in the next decade is particularly concerning as more and more of this fuel comes from environmentally questionable shale gas. Carbon pricing, likely in the form of a cap and trade program with Quebec and California, will bring new cost pressures for residential, commercial and industrial electricity consumers if Ontario's carbon emissions rise.

In the coming months, as the province's 2013 Long-Term Energy Plan is being updated, Ontario's decision-makers will need to address these and some other critical challenges. Besides meeting the province's GHG targets and ensuring system reliability, Ontarians will expect to see rising electricity prices kept in check and a healthy and expanding economy that sustains existing jobs and creates new ones.

Ontario's Independent Electricity System Operator (IESO) has identified a 2,000 to 3,000 megawatt shortfall in reliability reserve capacity resulting from the scheduled closure of the 3,100-megawatt Pickering Nuclear Generating Station in 2020 that will persist beyond 2032. As part of an interconnected power system, Ontario must fill this shortfall to comply with the reliability requirements of the North American Electric Reliability Corporation and the Northeast Power Coordinating Council Inc.

A recent analysis by Strategic Policy Economics (Strapolec) demonstrates that extending the operation of the Pickering Nuclear Station for four years is a near-term, low-cost option that can help address all of these challenges. Moreover, this option keeps more dollars in Ontario while significantly improving the province's energy security.

The Strapolec analysis demonstrates that continuing operations at the Pickering Nuclear Station will displace natural gas generation, helping to avoid over 18 million tonnes of GHG emissions over a four-year period. That's the equivalent of taking about three million vehicles off the road. Without the continued operation of Pickering, Strapolec predicts Ontario's increased reliance on natural-gas-fired generation will increase the overall consumption of natural gas in Ontario by 25 per cent.

In addition to producing electricity, Ontario uses natural gas for heating and industrial applications. Over 99 per cent of this natural gas is imported, which exposes Ontarians to significant natural gas price volatility. President Obama's Clean Power Plan, which is causing a major shift in U.S. dependency on coal generation to natural gas, can be expected to exacerbate this volatility.

Since operating the Pickering facility is 25 per cent less expensive than natural gas generation, Ontario's electricity system costs will be reduced by over $600-million over four years. The analysis also estimates an additional $950-million in avoided natural gas generation risks.

Overall, Strapolec modelling shows $7-billion in net new economic benefit to Ontario and 40,000 additional person years of employment. By continuing the operation of the Pickering Nuclear Station, Ontario saves $4-billion from avoided energy imports. Durham Region, where Ontario Power Generation (OPG) is the largest employer, retains $1.2-billion of economic activity. The Government of Ontario could realize over $1.1-billion in additional revenues from an increase in GDP and cost savings at OPG.

Strapolec suggests that Ontario's industrial and residential ratepayers should also see a benefit with comparative rates lower by four per cent and one per cent respectively.

Continuing to operate reactors at the Pickering generating plant for a four-year period can deliver substantial environmental and economic benefits. Achieving these outcomes requires the Government of Ontario to direct the Minister of Energy, the IESO and OPG to consult with the Canadian Nuclear Safety Commission for the purpose of securing approval for the longest possible period of continued safe operation of the Pickering Nuclear Generating Station beyond 2020.

METHODOLOGY

Program science approach useful in combatting a range of health and social issues

Too many of the world's poorest and most marginalized populations are not benefiting from the modern technologies and medical innovations designed to improve human health, says a renowned epidemiologist and public health specialist focusing on global health. Dr. James Blanchard, who holds the Canada Research Chair in Epidemiology and Global Public Health at the University of Manitoba, is bridging the health equity gaps by taking a "program science" approach to the problem.

It sounds esoteric, but it is elegant in its simplicity and effective when applied – and best illustrated by example. A decade ago, India was experiencing a substantial HIV epidemic. It was clear that the solution would require effective programs to reduce HIV risk among sex workers. But how? Dr. Blanchard and his colleagues started by involving sex workers in a social mapping process to identify where best to focus resources and efforts, and then moved on to the action phase, which included evolving better ways to implement peer education and community outreach and mobilization efforts. Condom use jumped from less than 50 per cent to almost 90 per cent and the epidemic was reversed. The community mobilization processes were also associated with declines in violence against sex workers.

The program was so successful that it is being expanded in India and adopted by countries in Africa, albeit in customized ways in order to accommodate financial, social, political and cultural barriers. "Kenya had seen it work and said it wanted the program as well," says Dr. Blanchard.

The beauty of the methodology is that it can be used to combat a broad range of health and social issues; a program is under way to address maternal, newborn and child health. "The solutions may be different but the approach is the same," says Dr. Blanchard, adding that the program science methodology is also cost effective "because you implement these processes by leveraging already existing resources, introducing efficiencies and then working with government to fill them."

"When it comes to improving global health it's not so much a matter of knowing what to do, but how to implement the technologies and innovations we already have."

Dr. James Blanchard
is Canada Research Chair in Epidemiology and Global Public Health at the University of Manitoba

An approach based on program science has been used to effectively tackle a broad range of global health and social issues, including the HIV epidemic in India. SUPPLIED

According to Dr. Stephen Moses, a professor in the University of Manitoba's departments of Medical Microbiology, Community Health Sciences and Medicine, Dr. Blanchard has addressed the problem of taking small pilot projects and scaling them up, sometimes exponentially. "Dr. Blanchard's contribution shows that it is possible to design health programs and services that can be implemented on a very large scale, and that it can be done in a systematic and scientific way."

Dr. Blanchard and his team have received numerous funding awards, including a $21.1-million (U.S.) grant from the Bill and Melinda Gates Foundation (2014) to establish a technical support unit in Uttar Pradesh, India, providing "technical assistance to the government of Uttar Pradesh to improve health, nutrition and development coverage and outcomes" for the state's 210 million inhabitants.

"When it comes to improving global health, it's not so much a matter of knowing what to do, but how to implement the technologies and innovations we already have," says Dr. Blanchard. "The program science approach gives us the tools we need to do just that."

ANNIVERSARY

Ten years later, the Canadian Light Source is the 'ultimate enabler'

The year 2015 marks the 10th anniversary of the Canadian Light Source (CLS) synchrotron. Individual discoveries over the past decade have changed the face of research in areas of health, materials, mining and agriculture – but CEO Rob Lamb takes even greater pride in the CLS's role as "the ultimate enabler" of science and innovation.

"We're enabling innovation across disciplines, in pure scientific research as well as in industrial processes. In house, we're working constantly to 'build a better car,'" he says.

In the last decade, the Saskatchewan-based CLS has gone from seven original beamlines to 22, operating around the clock. More than 2,500 users from 28 countries and every province and territory in Canada have had access to the beamlines.

"Scientists come here to get more information about the research they're doing. In scientific terms, they may come here knowing something to one decimal place. They leave the CLS with knowledge to five decimal places," says Dr. Lamb.

Researchers from the University of British Columbia, for example, recently developed a technique to turn nearly any blood into a universal type resembling O-type blood, which would make transfusions simpler, and shortages for rare blood types a thing of the past.

The CLS has also developed its Industrial Science Program, helping more than 100 industry clients solve real-life problems for almost 300 projects.

"Industry doesn't want an extra decimal place. They want a solution. We have mining specialists on staff who work with mining companies; we have agricultural specialists working with agriculture companies. We've integrated ourselves closely with Canada's major needs and Saskatchewan's unique strengths."

"If you look at the locations of the top synchrotrons in the world, it reads like a fashion label: Berlin, Paris, London, New York, Tokyo... and Saskatoon. There is no other synchrotron in such close proximity to agricultural and mining industries. We're positioning ourselves to strengthen the innovation in those areas."

The CLS may be only 10 years old, but the University of Saskatchewan has a 51-year history with particle accelerators, and that long experience is fuelling in-house research.

Recently, CLS staff formed a startup company after discovering a way to make medical isotopes using accelerators, rather than nuclear reactors.

At the centre of scientific research and innovation in Canada and around the world, CLS staff are in a position to draw connections between research projects that come through their doors.

Dr. Lamb says, "We see a cross-section of great science through all of Canada. In order to get research time, you need to be doing spectacularly interesting research. We often see the opportunities in what people are working on, and help them go away with a deeper understanding, so they can create something really cool and impactful."

It is in collaborative opportunities and analyzing cross-sections of research where the CLS has the potential to shine brightest in its next 10 years of operation, says Dr. Lamb.

Enabling innovation across disciplines has been an important part of the Canadian Light Source's mandate, says CEO Rob Lamb (left), pictured with Mario Pinto, president of the Natural Sciences and Engineering Research Council of Canada. CANADIAN LIGHT SOURCE; DAVE STOBBE PHOTOGRAPHY

ECONOMICAL IMPACT

Creating an ecosystem where startups and dynamic companies thrive

Jim Diodati's city is home to the world's most celebrated waterfalls. But Mr. Diodati, who is mayor of Niagara Falls, Ont., has so much more to be proud of these days.

Niagara Falls recently announced a billion-dollar mixed-use development – with the Chinese government as a major shareholder – that will include an innovation park and spaces for residential, commercial, retail and recreational use. The city is also building an incubation and commercialization hub where innovative ventures can get the support and resources they need to bring their products or services to market.

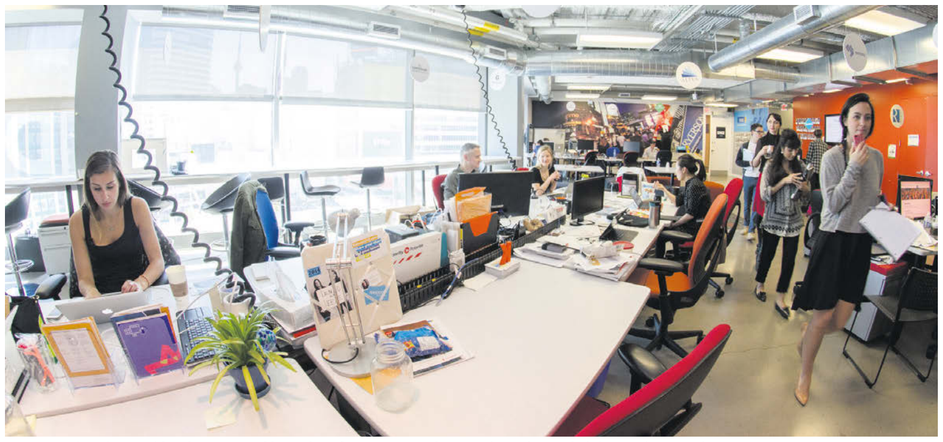
After an economic downturn driven largely by the decline of manufacturing in the region, Niagara Falls is building its future on innovation, and it's getting help from a partner that knows how to link innovation with economic development: Ryerson University in Toronto.

"We're looking at strategies to support technology innovation and to strengthen our backbone, small and mid-sized businesses," says Mr. Diodati. "Ryerson is helping us as we work to develop an ecosystem of dynamic companies with the potential to succeed on a global scale."

Ryerson's collaboration with the city of Niagara Falls is just one of several partnerships the university has forged with organizations and governments seeking to close the gap between innovation and application. Ryerson has worked recently with partners in Mumbai in India, Johannesburg in South Africa and Birmingham in the United Kingdom.

"Now we're looking at our own backyard," says Dr. Wendy Cukier, vice president of research and innovation at Ryerson.

In addition to Niagara Falls, the university has also started working with the Eastern Ontario Regional Network, a not-for-profit organization that's leading a large-scale broadband project for the region. In both of these partnerships, Ryerson's main goal is to complement existing local efforts to strengthen the regions' innovation ecosystem.



Ryerson University provides the space and know-how for partners and companies to boost their innovation capacity. SUPPLIED

"Many companies don't understand the business case for using particular technologies, do not have people with appropriate skills and do not have the time to figure it out."

Dr. Wendy Cukier
is vice president of research and innovation at Ryerson

To do this, Ryerson is creating an innovation ecosystem map that will give a big-picture view of each region's capacity to create, develop and support startups, and that will show how existing industries are using technology.

"We are also looking at how to strengthen their connections to the Greater Toronto Area, and to national and global markets," says Dr. Cukier.

Through extensive research on entrepreneurship, technology adoption and innovation processes, Ryerson is developing models and best practices for turning technology research into useful – and well-used – innovations.

"When we look at the innovation gap in Canada, we see that Canadian companies are lagging globally and that big investments in research – particularly at universities – are not producing the desired impact from the point of view of commercialization, startups and job creation," says Dr. Cukier. "Part of this is because we have focused on how to create new technology but paid insufficient attention to the drivers and impediments to adoption."

She points to research by the Ontario Chamber of Commerce, which found that 40 per cent of small and medium-sized enterprises in Ontario do not have an Internet presence – a surprising finding given that these businesses are driving economic growth not just in the province but in all of Canada.

Another study by Ryerson, for Rogers Communications, reports that while Canadian consumers are world leaders in their use of mobile technology, Canadian businesses are laggards.

"We must focus on users, linking the technology to organizational goals," says Dr. Cukier. "Many companies don't understand the business case for using particular technologies, do not have people with appropriate skills and do not have the time to figure it out."

To bridge the innovation gap, researchers, organizations and governments need to adopt market-driven approaches to solving real world problems, she says. At Ryerson, research excellence is combined with relevance through close partnerships with private- and public-sector organizations, Dr. Cukier adds.

"One of the strengths Ryerson brings is a multidisciplinary approach that considers the users, the applications and the application processes," she says. "Because if new technologies, processes and products are not actually used, there is no innovation."

EXCELLENCE IN RESEARCH AND INNOVATION

SUSTAINABILITY

Canada's 'breadbasket' home to food security innovation powerhouse

To feed a growing world of more than nine billion people by 2050, the United Nations expects global food production will need to increase by 70 per cent – a daunting challenge for the world's farmers.

But a uniquely equipped innovation hub at the University of Saskatchewan (U of S) is poised to respond to this global food security challenge.

"We have led far-sighted agricultural research and innovation at the U of S to help grow a province and feed a growing nation," says president Peter Stoicheff. "Now, through innovative partnerships and a bold new vision, we are building on our strengths, world-class facilities and expertise to provide new research solutions that will help feed a growing world."

In the past year alone, the university has received a $37.2-million Canada First Research Excellence Fund (CFREF) award to develop a transformative new approach to crop breeding, as well as three Genome Canada awards totalling almost $24-million to improve wheat, lentil and cattle production.

"We aim to become the global centre for revolutionary 'by design' plant breeding," says Dr. Maurice Moloney, who heads the Global Institute for Food Security (GIFS) at the U of S, which will lead the CFREF-funded initiative.

"We will use drones (aerial sensors) in the field and the latest imaging and computer technology to digitize desired crop traits (phenotypes) and link them to specific genes in a searchable database," he says.

University of Saskatchewan plant scientist Dr. Curtis Pozniak studies the genetic blueprint of wheat. SUPPLIED

"A plant breeder anywhere in the world with Internet access will then be able to get all the information needed to 'design' a plant with improved yield, nutrition, drought-resistance or other desired traits for their region – all at a previously unimaginable speed and scale."

The multidisciplinary project brings together plant, soil and nutrition scientists along with computer science, imaging and public policy experts, as well as partners at other institutions. This expertise, along with imaging facilities such as the Canadian Light Source synchrotron, provides an unprecedented environment for the next leap in food security innovation.

"No place in the world has all of the contributing technologies for this that we have on this campus," says Dr. Moloney.

In another cutting-edge project, U of S plant scientist Dr. Curtis Pozniak is developing new genomic tools for wheat breeding that are expected to lead to more productive, profitable and environmentally sustainable wheat varieties.

"It is about studying the genetic blueprint of wheat, learning how genes in the genome influence economically important traits that we select for as plant breeders," Dr. Pozniak says.

The project, funded by Genome Canada and the Western Grains Research Foundation, is part of an international collaboration of more than 1,000 scientists worldwide, co-led by Dr. Pozniak, to sequence the entire wheat genome – which is five times larger than the human genome.

"We're leveraging research that's ongoing in other countries, as well as contributing to the research activities of those same collaborating organizations," he says.

Dr. Jerome Konecsni, president of Innovation Saskatchewan, says the university is fortunate to have a number of significant national scientific centres that are unique in Canada, including the Canadian Light Source, VIDO-InterVac and the Sylvia Fedoruk Canadian Centre for Nuclear Innovation.

"By integrating our innovation activities, we're creating synergies among these different disciplines, finding unique opportunities to build the capacities that are of strategic importance to Saskatchewan and globally," he says.

COLLABORATION

Taking aerospace research to new heights

How does fatigue affect pilots' thinking and perception at the airplane controls? How can older pilots develop skills to compensate for age-related cognitive changes? What improvements to advanced flight simulators will produce the best-trained pilots?

These are some of the questions occupying researchers and their partners at the Advanced Cognitive Engineering Laboratory (ACE Lab) at Ottawa's Carleton University. ACE Lab is the type of research and innovation model that helped attract Dr. Nimal Rajapakse to join Carleton in September 2015 as vice-president (Research and International).

"ACE Lab is unique in Canada and internationally recognized, and its success is fuelled by multidisciplinary research and collaborations with industry and government," says Dr. Rajapakse. "It's the type of approach we want to strengthen as we further develop Carleton's research enterprise."

ACE Lab houses sophisticated flight simulators and brings together experts from diverse disciplines. Its director is cognitive scientist and psychologist Dr. Christopher Herdman. "Aerospace is more than engineering," Dr. Rajapakse says. "In this lab, engineers work alongside researchers from cognitive science, psychology and computer science to enhance safety and performance in aerospace and aviation."

Facilities at the Advanced Cognitive Engineering Laboratory (ACE Lab) at Ottawa's Carleton University enable experts like aeroacoustics researcher Dr. Joana Rocha to study issues like turbulence-induced noise in aircraft. CARLETON UNIVERSITY

The partnerships are also extensive. Collaborators and funders include CAE, a global leader in simulation, the Canadian Space Agency and the Civil Air Search and Rescue Association.

Dr. Rajapakse has managed programs in applied research, partnership engagement and international initiatives for various universities, most recently as dean of the Faculty of Applied Sciences at Simon Fraser University.

He says he is excited about enhancing Carleton's capacities in areas of research strength, including aerospace, using collaborative models.

"Our vision is to expand and strengthen collaborations with industry, government and other external partners – regionally, nationally and globally. We are already doing well in this area and seek to take it to the next level of engagement," says Dr. Rajapakse.

Another flagship aerospace research project is headed by Dr. Joana Rocha, who is investigating ways to reduce turbulence-induced noise in aircraft. This aeroacoustic research explores aircraft design changes that could reduce noise levels to give passengers and crew a quieter, more comfortable flight. Dr. Rocha uses another of Carleton's world-class facilities for her experiments – the Pratt and Whitney High Speed Wind Tunnel Lab.

"Aerospace is one of our strategic research areas, not only because of our long history and strengths, but also because it contributes to Canada's technology and innovation agenda," says Dr. Rajapakse. "We strongly believe that contributing to the economic development of the country is part of the key responsibilities of the modern university."

EXCELLENCE IN RESEARCH AND INNOVATION

INTERVIEW

Leveraging the tools of innovation

Q&A with Michael Duschenes, Managing Director and Chief Operating Officer of the Perimeter Institute for Theoretical Physics in Waterloo, Ontario

Where does innovation start?
The innovation chain goes from theory to experiment to application to commercialization. As one of the world's leading research hubs in theoretical physics, the Perimeter Institute is a first link in that chain. Perimeter researchers seek new discoveries in areas spanning quantum materials, quantum information, particle physics and the structure of the universe – and, importantly, they work collaboratively across disciplines.

What's next?
Fundamental research drives other organizations along the innovation chain to develop new experiments, which subsequently lead to new applications and the creation of vital new technologies. This is the kind of big-picture innovation that fuels wealth-creation and long-term prosperity for the societies that foster it.

What's the contribution of innovation hubs like the Quantum Valley?
Between Perimeter and the Institute for Quantum Computing, the region known as Quantum Valley has one of the largest concentrations of theorists and experimentalists in the world working on quantum science, which is expected to transform technology in the coming years. Ontario's region of Waterloo is also home to Quantum Valley Investments, which seeks opportunities to commercialize technologies emerging from quantum research, and a high-tech entrepreneurial scene that has launched more than 1,100 startup companies over the past five years. The unifying goal of the Quantum Valley ecosystem is to accelerate discovery in an area of science that will fuel innovation and prosperity.

What's the role of fundamental physics research in innovation?
Practically every technology we use today – from computers to smartphones to life-saving medical devices – emerged from breakthroughs in fundamental, curiosity-driven physics. It's said that today's physics is tomorrow's technology.

What will that technology of tomorrow look like?
The revolution that drove innovation and economic development in the second half of the 20th century – the information revolution – was made possible by fundamental physics discoveries in the first half. The 21st century will see a "quantum revolution," with innovation and prosperity driven by the coming wave of quantum technologies, from computers to medical sensors, which will be vastly superior to today's digital technologies. We can't predict exactly what all those innovations will be, just as pioneering physicists like Einstein and Maxwell could not have predicted their discoveries would make possible the technologies that have shaped our world, from computers to satellites to life-saving medical devices. History has shown that the transformative benefits to humanity of physics breakthroughs always surpass anything we can predict.

Practically every technology we use today – from computers to smartphones to life-saving medical devices – emerged from breakthroughs in fundamental, curiosity-driven physics.

Why is multidisciplinary collaboration important?
The most profound breakthroughs and innovations are made at the intersections between fields, which is why Perimeter – and the ecosystem as a whole – fosters a collaborative and multidisciplinary approach. Innovation happens because the right people and organizations are interacting at every step of the innovation chain. It's happening in Canada's Quantum Valley in Waterloo through collaborations between theorists, experimentalists and industry across the country and internationally.

KNOWLEDGE INTEGRATION

Building creative thinking and problem-solving competencies across disciplines

A device that can help find your misplaced keys may sound too good to be true, but at Sheridan College it's the kind of thing that a focus on scholarship, research and creative activity is producing.

A new initiative at the Greater Toronto Area post-secondary institution is bringing students and faculty together with industrial partners to collaborate on innovative ideas such as the iBeacon, new mobile technology that has applications from tracking and locating objects to monitoring their status and condition.

Called Scholarship, Research and Creative Activities (SRCA), the new philosophy goes beyond discovery-based research, which is the traditional domain of universities, and applied research, which is common at colleges. It also encompasses knowledge integration, teaching and learning, as well as creative works such as photography, music, artwork, films and plays. SRCA supports the full spectrum of knowledge creation and more accurately reflects the strengths and talents of Sheridan's professoriate. It also helps to engage students in projects that are personally meaningful and inspiring.

"It's about embedding creativity into our DNA," says Dr. Darren Lawless, dean of undergraduate research at Sheridan. "It's not a theoretical exercise only; it's the ability to apply knowledge to solve real-life problems."

Dr. Yael Katz, dean of the Institute for Creativity and Creative Campus, says that Sheridan has adopted a "unique and purposeful approach to creativity" and deliberately integrated it into everything from curriculum to the way it conceptualizes space and applies research in the classroom.

"Students engage in some form of creative thinking and problem solving, regardless of what discipline they're in," Dr. Katz says, noting that the college's inaugural Scholars and Creators Conference held this fall showcased and advanced the scholarly, creative and research activities across disciplines at Sheridan.

Partners have "greatly embraced" SRCA, Dr. Lawless says, such as SOTI Inc., a provider of enterprise mobility management solutions in Mississauga that worked with Sheridan on the iBeacon project. It uses a tag placed on an item and Bluetooth technology to track down its location, status or condition and report the information to a mobile device.

Students devised innovative uses for the technology, such as an app that helps truck drivers keep track of their keys and another that lets healthcare workers locate devices in patients' homes.

"These weren't programmers sitting in a dark room writing code," Dr. Lawless says, noting SOTI ended up hiring some of the students after the project finished. "That's what we define as a true creative partnership."

"Students engage in some form of creative thinking and problem solving, regardless of what discipline they're in."

Dr. Yael Katz
is Sheridan College's dean of the Institute for Creativity and Creative Campus

BY THE NUMBERS

Predicted research and development (R&D) spending for 2015:

Business enterprise sector:
$15.5-billion
down 2.6% from 2014, and expected to account for 48.9% of overall R&D spending

Higher education sector:
$13-billion
up 1% from 2014, and expected to account for 41.1% of overall R&D spending

Federal government sector:
$2.7-billion
up 3% from 2014

Source: Statistics Canada

Krista Kenyon is working with the University of Manitoba's Centre for Earth Observation Science research group on a project designed to better understand the impact of climate change on the Arctic. SUPPLIED

ENVIRONMENT

What Arctic whales tell us about their habitat

As far as Krista Kenyon is concerned, her life is her work and her work is a grand adventure. Currently a graduate student in the Clayton H. Riddell Faculty of Environment, Earth, and Resources at the University of Manitoba, she's as likely to be found bobbing around in boats in Arctic waters as sitting behind a desk. "It's worked out really well because I love wildlife and I love to work outdoors," she says.

She's currently working with the university's Dr. David Barber within the department's Centre for Earth Observation Science research group on a project designed to better understand the impact of climate change on the Arctic's fragile ecosystem, which both humans and animals still depend upon for survival. Her thesis is focused on which type of sea ice two Arctic whales, narwhal and bowhead, choose within their habitat.

"The Inuit people rely on traditional means of food gathering," she says. " We're trying to understand how the narwhal and bowhead use their habitat so that researchers can understand how they might be affected by climate change and the increasing pressure from commercial activities such as resource extraction and shipping." Her work includes examining GPS locations of whales that are equipped with satellite transmitters, and determining why they choose one type of sea ice over another.

Her base of fieldwork operations has been the tiny hamlet of Pangnirtung (pop. 1425) on Baffin Island, where researchers and local Inuit work together to equip satellite transmitters on bowhead whales. "It's been a wonderful experience; everyone is really friendly and more than happy to share their traditional knowledge with you," she says.

Pretty good work if you can get it, and Krista Kenyon's got it.