

Sentinel  
North



SHEDDING LIGHT ON THE NORTH  
ENVIRONMENT | HEALTH | INNOVATION

ACTIVITY REPORT  
2017 | 2018

Sentinel North



UNIVERSITÉ  
LAVAL

With its Sentinel North strategy, Université Laval is building on half a century of excellence in northern and optics/photonics research to develop innovative new technology, train a new generation of transdisciplinary researchers, and improve our understanding of the northern environment and its impact on humans and their health.

The program is made possible, in part, thanks to funding from the Canada First Research Excellence Fund.

Canada



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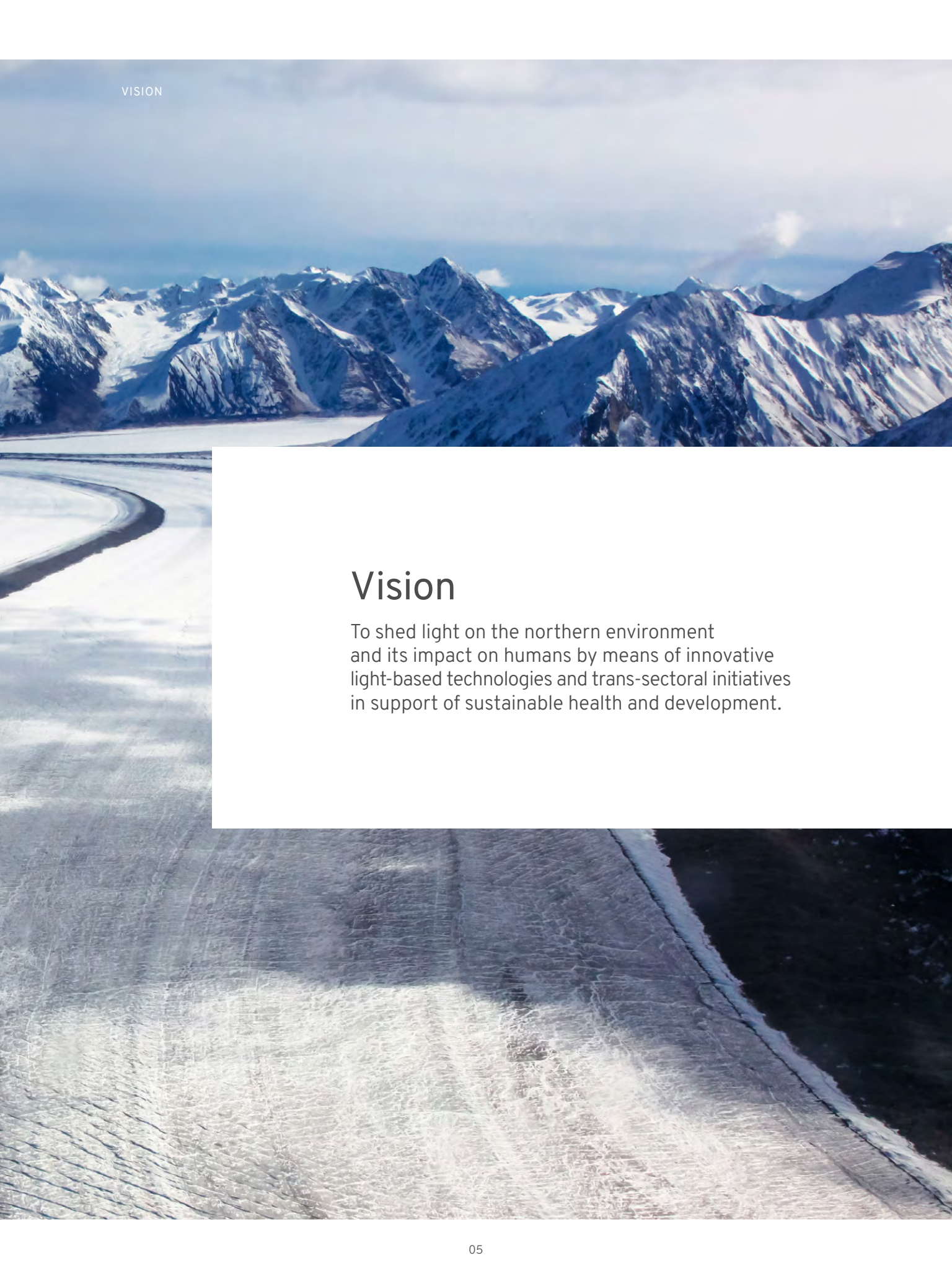


Experts in optics/photronics, microelectronics, ecology, and complex systems have joined forces to better understand the impact of winter snow cover on the ecology of northern mammals.



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## Vision

To shed light on the northern environment and its impact on humans by means of innovative light-based technologies and trans-sectoral initiatives in support of sustainable health and development.

## A Word from Management

In August 2015, Université Laval was awarded its largest grant to date by the Canada First Research Excellence Fund to implement its Sentinel North strategy. Through a highly competitive process, the Fund helps selected postsecondary institutions deploy broad-reaching and transformative institutional strategies designed to foster and develop their strengths on the global stage.

With Sentinel North, the University is implementing an ambitious research strategy that will mark its history: to improve our understanding of the northern environment and its impact on humans by encouraging unprecedented convergence of strategic research fields in which the institution is assuming internationally recognized leadership, including Arctic and northern science, optics/photonics, microbiomes, cardiometabolic health, and neuroscience.

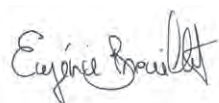
It is with the ambition of mobilizing the university's rich and diverse research community and lowering barriers between disciplines, departments and faculties that the first major Sentinel North call for proposals was launched in April 2016. With a budget of \$15 million over 3 years, the exercise has undoubtedly achieved its goal of pooling complementary expertise within the framework of innovative research projects that encourage cooperation and the exchange of ideas.

Since March 2017, a community of more than 400 professors, graduates, postdoctoral fellows, and professionals representing 34 departments, 30 research centres, and 7 faculties has been working with national and international partners on transdisciplinary projects designed to monitor and help prepare for the changes affecting the northern environment from a perspective of sustainable health and development.

The science is complex, but the enthusiasm and mobilization are there, and continue to grow. By encouraging innovative, technological, discovery-based research, Sentinel North provides a significant added value to international efforts in northern research.

Through engaged governance, the other components of our strategy are now operational:

- The Sentinel North training program is attracting and developing top students from Canada and abroad in a transdisciplinary context.
- A call for Sentinel North research chairs led to the recruitment of six new accomplished professors at the University.
- A partnership research chair program has enabled external partners to join Sentinel North.



Eugénie Brouillet  
Vice Rector, Research  
and Innovation  
Chair, Sentinel North  
Steering Committee



Martin Fortier  
Executive Director,  
Sentinel North  
Assistant to the Vice Rector,  
Research and Innovation





- The program's first annual scientific meeting brought together nearly 300 members of the emerging Sentinel North community.
- A new technological instrument development platform is now available to program researchers and students.
- The existing international joint research units (UMIs) in partnership with the French National Centre for Scientific Research (CNRS) and Sao Paulo State University (UNESP) in Brazil have been consolidated and two new UMIs have been established with Université de Lausanne in Switzerland and the Italian National Research Council (CNR).
- Joint calls for transdisciplinary research projects were launched with CNRS and Université Côte d'Azur, and others are in preparation.
- Program research teams now have access to a fund facilitating access to remote northern research facilities.
- The Sentinel North Technology Maturation Fund helps research teams with the maturation of innovations showing strong development potential.

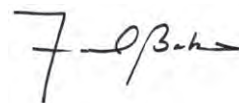
Experiential education, international mobility, international partnerships, transdisciplinary research, and the commercialization of innovations fostered by Sentinel North are directly in line with the main priorities of the University's 2017-2022 Strategic Plan. The mobilization of new expertise within projects developed in close collaboration with our institution's northern research experts also reinforces the deployment of the Institut nordique du Québec.

In the months ahead, we will actively build on this momentum to further develop and consolidate our collaborations and partnerships in Canada and abroad.

We encourage you to read this first activity report, familiarize yourselves with the various components of our program, and join us in the groundbreaking initiative known as Sentinel North.



Yves De Koninck  
Scientific Co-Director,  
Sentinel North  
Director, CERVO Brain  
Research Centre



Marcel Babin  
Scientific Co-Director,  
Sentinel North  
Laureate of the CERC in  
Remote Sensing of Canada's  
New Arctic Frontier



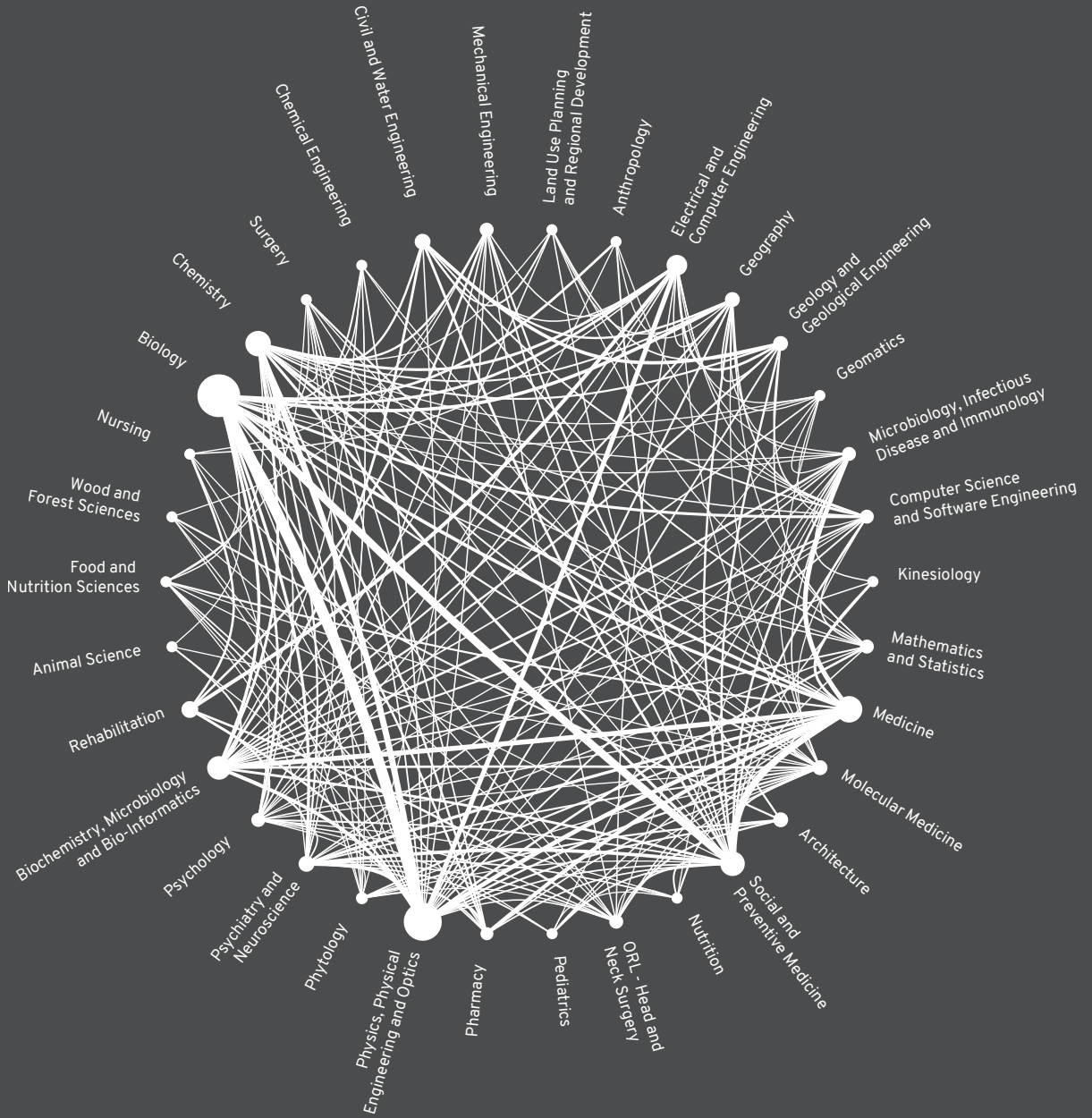
## A Transdisciplinary Approach to Research

The first Sentinel North call for projects achieved its goal of mobilizing Université Laval researchers and collaborators. The projects selected involve dozens of new and innovative transdisciplinary collaborations between high-level researchers from more than 34 departments and 30 recognized research centres at Université Laval.

BEFORE



AFTER



Networks of interdepartmental collaboration between Sentinel North's 140+ researchers "before" and "after" program deployment. The "before" network shows collaborations between coauthors of interdepartmental publications between 2004 and 2014. The "after" network shows anticipated new interdepartmental collaborations resulting from joint publications under the 21 transdisciplinary sub-projects funded by Sentinel North. The thickness of the interconnecting lines is proportional to the number of collaborators. The size of the nodes is proportional to the number of researchers in each department.



The imaging technologies developed by Professor Daniel Côté and his team draw on neuroscience and optics/photonics to help researchers better understand brain function.



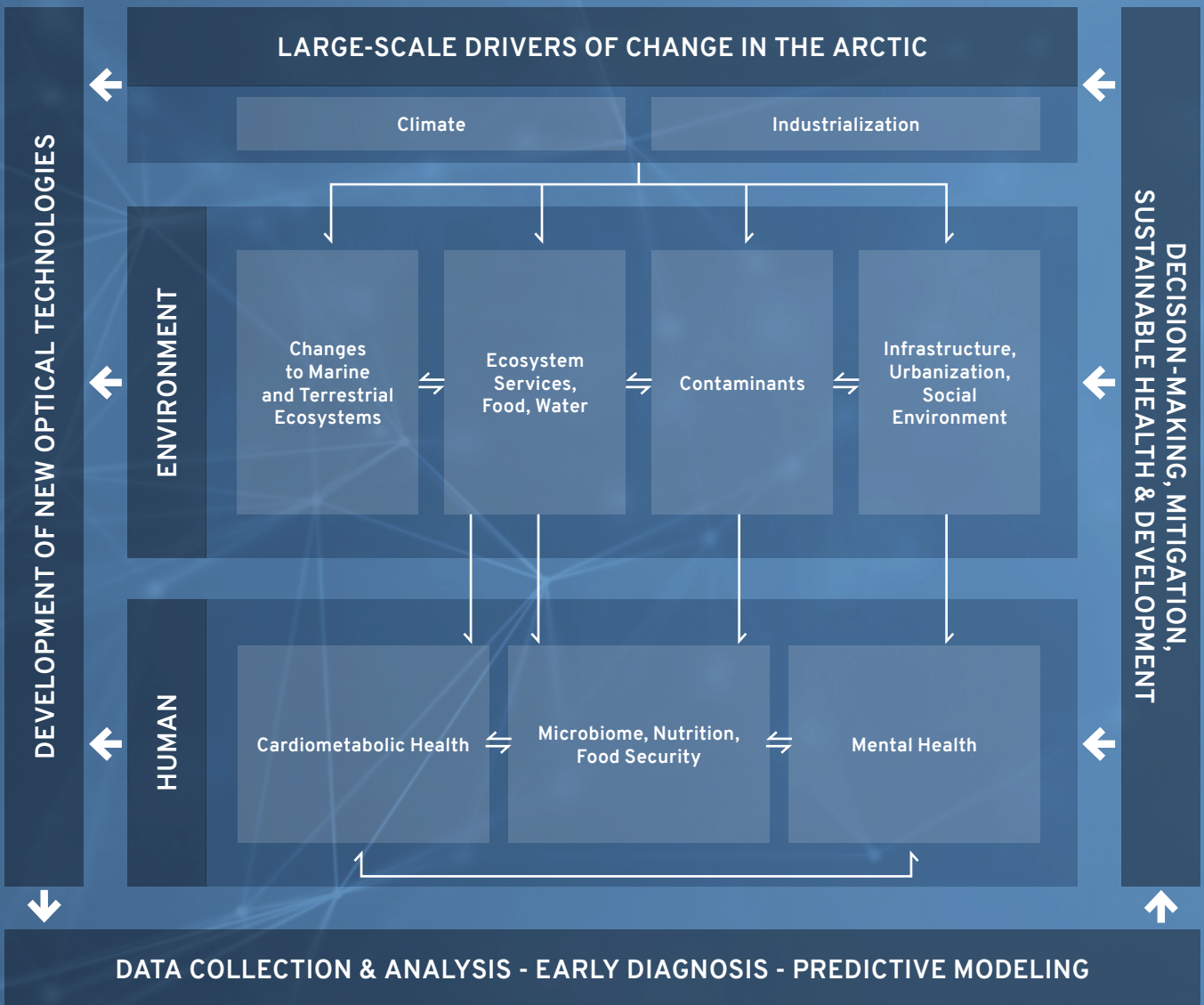
## Transdisciplinary Research Program

WHERE ENVIRONMENT, HEALTH,  
AND OPTICS/PHOTONICS INTERSECT

The Sentinel North research program encourages the development of collaborative teams and research projects with an emphasis on discovery, transdisciplinarity, innovation, teamwork, national and international partnerships, and technology transfer. The initiative builds on the convergence of research areas in which Université Laval is already recognized as a national and international leader, notably through the attribution of four Canada Excellence Research Chairs in the fields of northern and Arctic science, optics/photonics, cardiometabolic health and the microbiome, and neuroscience.

## Conceptual Framework

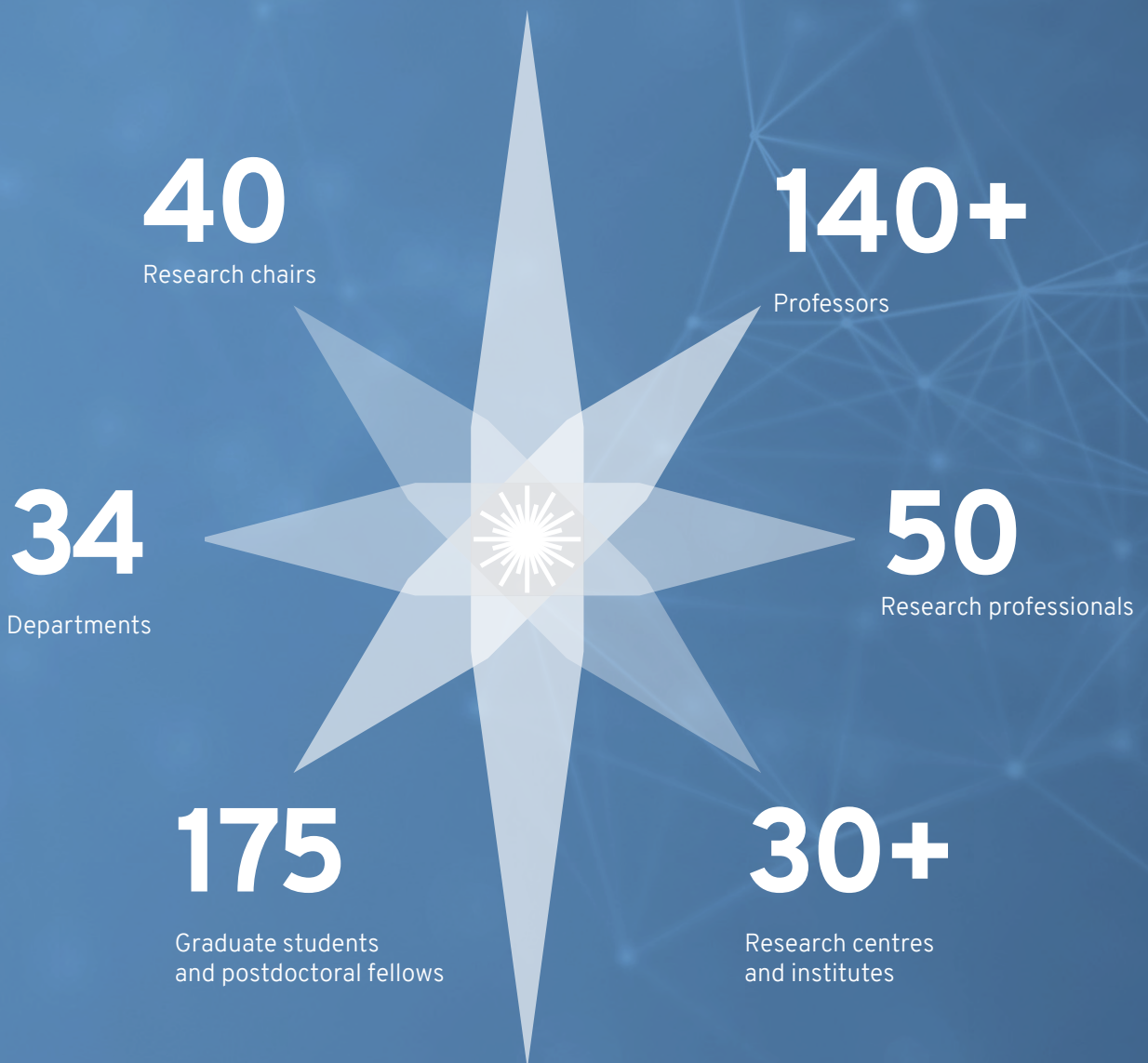
In the face of accelerating climate change and socioeconomic development in the Arctic and sub-Arctic regions, the Sentinel North research program helps generate the knowledge required to monitor and prepare for environmental changes at multiple levels—from microbes to ecosystems—using better technologies, predictive models, and intervention strategies oriented toward sustainable health and development.



## Sentinel North at Université Laval

The core research program includes 21 transdisciplinary projects that form 3 main themes, all of which incorporate technological innovations. Along with these projects are the programs of 6 new Sentinel North research chairs and a number of PhD and postdoctoral projects funded by our scholarship and grant programs.

Over 140 professors, 175 graduate students and postdoctoral fellows, and 50 professionals from 34 departments and 7 faculties are working with their Canadian and international peers within the program.





Thematic Project 1 draws on powerful numerical models and cutting-edge optical sensors with the aim of better understanding complex systems in the North.



THEMATIC PROJECT 1

# Complex systems: Structure, function and interrelationships in the North

The North, with its multiple interconnected networks, is a vast and complex system confronted by rapid climatic, ecological, economic, and social changes. The theme's main goal is to develop a better understanding of the internal logic of Northern complex systems, which depends in part on mutual interactions.

Researchers will explore northern systems at every level – from the microscopic (microbiotas) to the mesoscopic (biodiversity, infrastructure) and macroscopic (permafrost, ecosystems, society) – using powerful numerical models and a new generation of optical sensors with multiple networking capabilities.

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SUB-PROJECTS OF THEMATIC PROJECT 1

1.1

## Network analysis of umbrella and indicator species: Assessing the integrity of northern ecosystems

Principal investigator: Daniel Fortin, Biology

Climate change is transforming ecosystems and enabling industrial development in regions that are further and further north. In such conditions, how can biodiversity conservation be assured without monitoring every species one by one? Using data on indicator species—plants, insects, birds, and wolves—collected at various latitudes along two north-south axes in Québec and Alberta, researchers will build new models of ecosystem integrity based on their analysis of complex networks. The models will subsequently be applied to monitor forest-dwelling caribou, an umbrella species whose conservation is vital to the viability of many others.

1.2

## The resilience of complex networks: Identifying critical indicators for efficient targeted interventions

Principal investigators:  
Louis J. Dubé, Physics, Physical and Optical Engineering; Simon Hardy, Computer Science and Software Engineering

The ability of a complex system to surmount challenges (i.e., its resilience) largely depends on the structure of its underlying networks. This project examines what makes networks resilient, both from a theoretical and practical perspective. The neural networks of the zebrafish, which can be manipulated using optogenetics, serve as a model for identifying “neural sentinels” indicative of the resilience of a complex system. The ultimate goal of the project is to design analytical tools capable of processing the metadata generated by complex systems in order to predict the impact of disturbances and interventions.

1.3

### **Characterization and modelling of the key interrelationships of northern water systems under climatic, geosystemic, and societal pressures**

Principal investigator:  
**René Therrien, Geology and Geological Engineering**

Climate change is having a major impact on water in northern regions. Permafrost is melting, unusual precipitation variations are occurring, and ice and snow are no longer forming or melting as they once did. Surface and ground water are taking new routes, which can cause landslides, interfere with transportation infrastructure, or disrupt drinking water supplies. This project seeks to establish a clear picture of northern water and energy flows based in part on field measurements in the Nunavik communities of Umiujaq and Salluit. The models developed will help ensure sustainable water management in the region and make it possible to adapt infrastructure to new constraints.

1.4

### **Photonic ultimate sensing (pulse) and monitoring of permafrost environments**

Principal investigators:  
**Sophie LaRoche, Electrical and Computer Engineering; Richard Fortier, Geology and Geological Engineering**

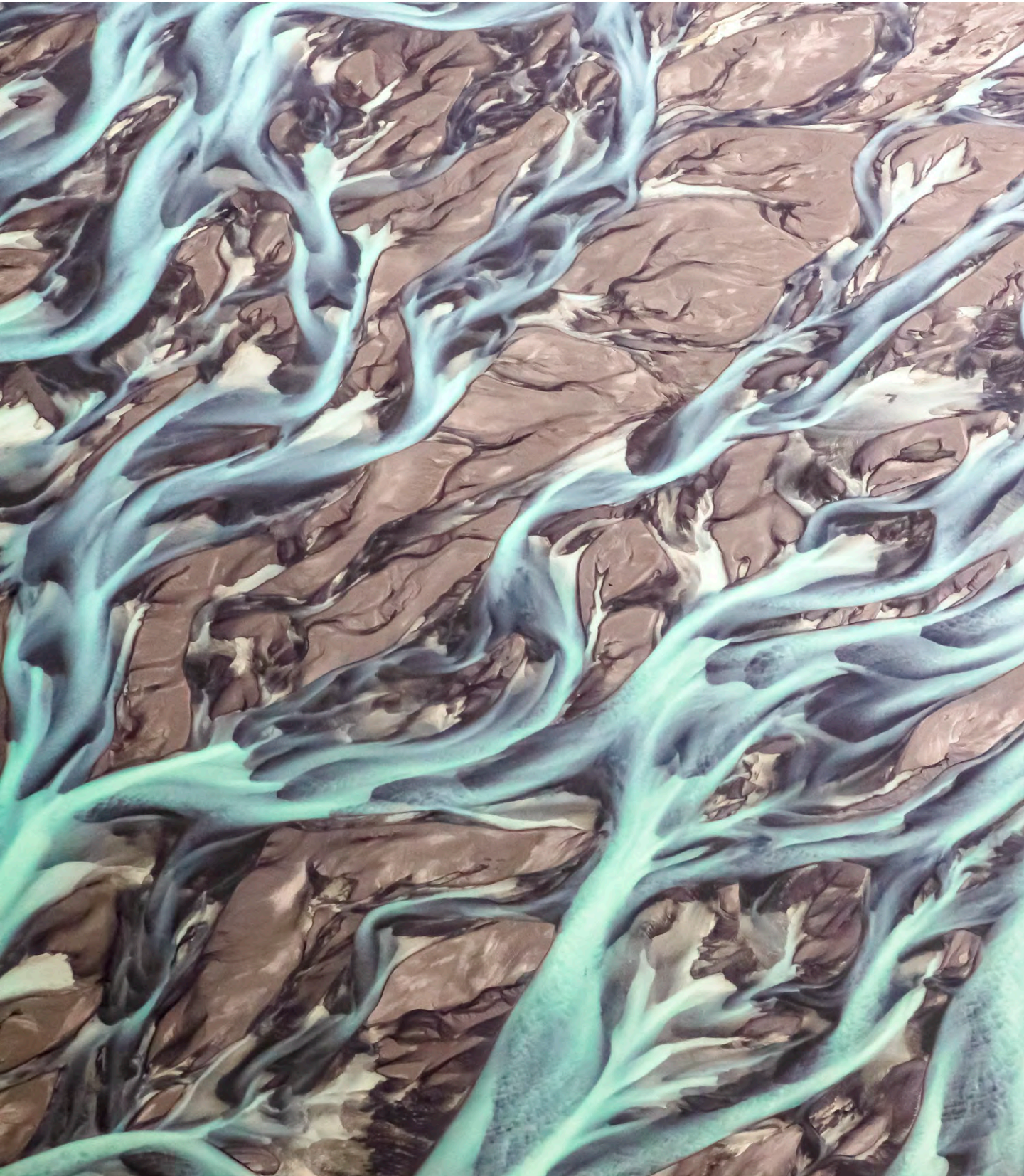
The aim of this project is to develop and test new photonic platforms capable of automatically collecting data on disturbances caused by climate change in order to better anticipate their impact on infrastructure, industrial activities, and the natural environment. A fibre optic sensing system will be deployed deep underground, and a 3D adaptive camera will monitor the surface movements of a frost mound. The researchers will also develop autonomous sensors powered by batteries that use soil microorganisms as an energy source and are capable of continuously monitoring groundwater parameters and emissions of various greenhouse gases.

1.5

### **Pitutsimaniq, networked sensor sentinels for real-time surveillance of infrastructures and ecosystems**

Principal investigators:  
**Michel Allard, Geography; Leslie Ann Rusch, Electrical and Computer Engineering**

Pitutsimaniq, or “network” in Inuktitut, is a project aimed at connecting the numerous sensors installed in the community of Salluit over the past 15 years, but that currently don’t really “talk” to each other. All of the data recorded by sensors used to monitor weather, infrastructure, and the permafrost will be centralized and made sharable via a wireless connection and fibre optic link that will soon connect northern communities to each other and the rest of the world. The same strategy will then be applied to other communities. The project also seeks to develop new compact sensors to improve road, airstrip, and permafrost surveillance.





Light is an essential vector of energy and is both the object and instrument of study for Thematic Project 2.

THEMATIC PROJECT 2

# Light as a driver, environment, and information carrier in natural environments and human health

At high latitudes, major seasonal variations in photoperiod and snow and ice cover cause significant variability in the availability and quality of light affecting northern ecosystems and societies.

The objective of this thematic project is to study the propagation of light through different substrates, its interaction with matter, and its influence on physiology and biorhythms.

The design and use of new optical sensors and technologies will also allow the study of biochemical and geochemical processes, the detection of climatically active compounds, and sustainable energy production.

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SUB-PROJECTS OF THEMATIC PROJECT 2

2.1

## Optimizing biophilia in extreme climates through architecture

Principal investigators:  
Claude Demers, Architecture; Marc Hébert, Ophthalmology and Otorhinolaryngology

The built environment in the North has traditionally been adapted to significant variations in the availability of natural light. However, the buildings that local residents and temporary workers live in today largely ignore biophilia – humans' innate attraction to light. Based on this observation, researchers specializing in architecture and the study of how photoperiods affect humans are analyzing the availability of light in existing buildings and its impact on human well-being. Researchers are rethinking building design and working to make the most of new technologies such as LED and smart lighting, with the aim of modelling potential solutions.

2.2

## Innovative optical systems to track winter life in the cryosphere

Principal investigator: Gilles Gauthier, Biology

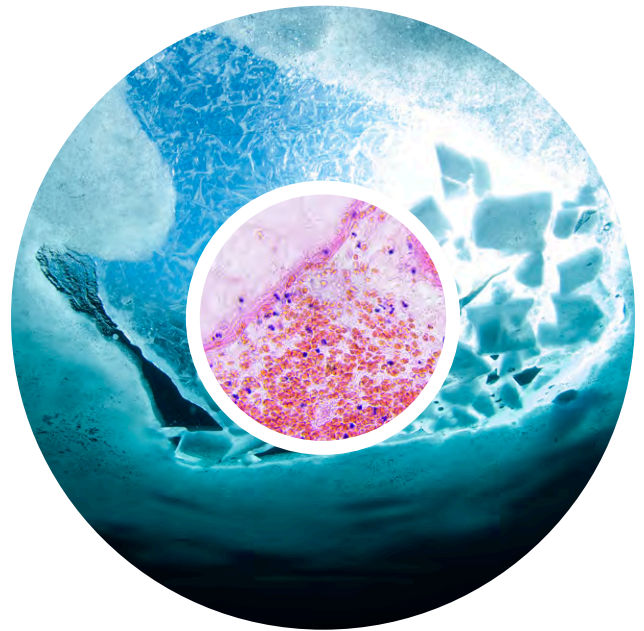
How are ecosystems affected by changes in snow and ice conditions due to climate warming and the resulting impacts on the transmission of light? This project will use newly designed optical systems capable of operating in extreme winter conditions to further our understanding of Arctic ecosystems in winter. Sensors will measure the properties of snow and of the under-ice water column, track small animals living under the snow, and be fitted on large animals to monitor snow and environmental conditions *in situ*.

## 2.3

### The use of diatom microalgae for improving the treatment of the light-driven dysfunctions of the biological clock in Arctic human populations

Principal investigator: Johann Lavaud, Biology

In winter, the lack of natural light affects northern workers and residents, who are at greater risk of developing mental health or behavioural disorders. Treatments using artificial blue and red light are known to help re-establish a healthy, more balanced circadian rhythm. Arctic diatom microalgae are also sensitive to variations in light and make a good model for studying the effects of artificial light. In this project, researchers will test new non-invasive medical light treatments on diatoms. They will also study the ecophysiology of these microalgae, which are both sentinels of climate change and a potential source of compounds of nutritional interest such as carotenoids and polyunsaturated fatty acids.



The research will greatly improve our understanding of light propagation in scattering environments such as sea ice and biological tissue

## 2.4

### A better understanding of light-matter interactions

Principal investigator: Pierre Marquet, Psychiatry and Neuroscience

In this project, researchers will examine the structure of sea ice and biological tissue with the aim of developing new theoretical models of light propagation based on the characteristics of the matter in which it is diffused. These models will be used to more accurately interpret field data from Arctic marine environments. They will also serve to help develop better diagnostic tools for problems affecting the skin and circadian rhythms.

## 2.5

### Printed solar cells for small remote instruments

Principal investigator: Mario Leclerc, Chemistry

Sensors and relay antennas deployed in the Arctic must be self-powered, but silicon-based solar cells used to power such devices are ill suited to harsh northern conditions. The chemists and physicists working on this project will develop a new system to harvest solar energy using flexible semiconducting polymers coupled with concentrators and a lightweight battery to store the energy produced. Once assembled, these components will be printed directly onto the devices they will power. These solar batteries will be much stronger and more durable than silicon-based systems.

2.6

**Beacons Of Northern Dynamics (BOND) – Developing light-based sensing technologies to monitor climate active gases in a mutating Arctic**

Principal investigators:  
 Réal Vallée, Physics, Physical Engineering and Optics; Guillaume Massé, Biology

Climate change is transforming northern environments and modifying the type and quantity of greenhouse gases naturally emitted in these regions. The purpose of the BOND project is to develop new sensors to conduct high-frequency monitoring of climatically active gases in the lower atmosphere and aquatic environments of the North. Researchers will use bioreactors coupled with mass spectrometers to better understand the behaviour of these gases in controlled conditions.

2.7

**Observing Arctic substrates: Unveiling ice, water column, and benthic physical and biological properties using laser remote sensing from autonomous underwater vehicles and unmanned aerial vehicles**

Principal investigators:  
 Philippe Archambault, Biology;  
 Michel Piché, Physics, Physical Engineering and Optics

The physical and biological properties of sea ice and the organisms living on or near the Arctic sea floor remain poorly understood due to the difficulty of accessing these environments. In order to better understand the changes underway, project researchers will analyze sea ice, the sea floor, and algae using various types of LiDAR, which are laser detectors capable of providing accurate representations of the environment being scanned. The detectors, which will be installed on an autonomous underwater vehicle, will make it possible to better quantify the physical and biological characteristics of the Arctic sea floor and biomass.

2.8

**Development, implementation, and use of miniature portable technologies for the prevention, assessment, and treatment of chronic diseases in northern areas**

Principal investigator:  
 Laurent Bouyer, Rehabilitation

Changes in the North are exposing local populations and workers to new health and safety risks. The purpose of this project is to develop portable devices equipped with movement and physiological sensors. These devices will be used to remotely monitor in real time the mobility and motor skills of northern workers, along with vital metabolic variables such as heart rate and light exposure. This technology could help prevent physical and mental health problems and improve the assessment and monitoring of those affected.



Autonomous underwater vehicles equipped with advanced optical systems are used to study the Arctic sea floor.



Thematic Project 3  
examines the influence  
of food quality on the  
health and microbiome  
of northern residents.



THEMATIC PROJECT 3

## Microbiomes: sentinels of the northern environment and human health

Microbiomes are predominant in the atmosphere, hydrosphere, cryosphere, soils, fauna, and humans. With the core objective of determining the roles of microbiomes in the northern human-environment ecosystem, this team of researchers will develop and deploy new photonic sensors and new sampling and analysis methods for a wide range of microbiological data for the monitoring of ecosystems, nutrition, and human health in the North.

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SUB-PROJECTS OF THEMATIC PROJECT 3

3.1

### Sentinel microbiomes for Arctic ecosystem health

Principal investigators:  
**Daniel Côté, Physics, Physical Engineering and Optics; Warwick F. Vincent, Biology**

The Arctic is home to countless microbial communities that play a vital but poorly understood role in ecosystem health. This project uses microbiomes as sentinels to track the changes underway in the Arctic. Biologists will examine the microbiome of Arctic char, the iconic fish of the North, as well as the biofilms and plankton blooms that form in northern aquatic and marine environments. At the same time, physicists will develop optical technologies to facilitate the monitoring of these microbial communities.

3.2

### Comprehensive environmental monitoring in the North: From molecules to microorganisms

Principal investigator:  
**Jacques Corbeil, Molecular Medicine**

The microorganisms in Arctic soils are highly sensitive to environmental changes, which can influence their growth and the compounds they excrete. In this project, researchers reveal the secrets of these microorganisms using EcoChips, miniature field labs that allow the culture of microorganisms in the environment in which they live and the continuous monitoring of ambient conditions. The research team will deploy the latest version of the EcoChip in a variety of ecosystems at different latitudes, then analyze the data collected over time from hundreds of microorganisms. The elements making up the cells of these microorganisms will also be analyzed to determine whether they secrete substances of industrial or therapeutic interest.

### 3.3

## BriGHT (Bridging Global change, Inuit Health and the Transforming Arctic Ocean)

Principal investigators:  
**Jean-Éric Tremblay, Biology; Mélanie Lemire, Social and Preventive Medicine**

The Inuit use numerous marine products. However, climate change can affect the quality and availability of local marine foods. Researchers have harvested ocean organisms at every level of the food chain, from microalgae to large marine mammals, in order to measure the presence of compounds beneficial for human health, including antioxidants and omega-3s. With digital simulations, they are studying how ocean warming and acidification can affect the synthesis and transfer of these beneficial compounds throughout the food chain. Using samples from the 2017 Qanuilirpitaa Inuit Health Survey, they will also attempt to identify blood biomarkers of food intake for these foods. In doing so, they hope to better assess and predict the impact of environmental changes on Inuit well-being and food security.

### 3.4

## Enabling Tools for the Monitoring of Food Quality in the Northern Environment

Principal investigators:  
**Dominic Larivière, Chemistry; Jean Ruel, Mechanical Engineering**

Country foods have numerous benefits for the health of the inhabitants of Nunavik, so long as they are able to avoid the contaminants the foods contain in varying levels. This project will develop a portable analysis platform that community members and health professionals can use as a decision tool to help identify foods at risk. A team with expertise in everything from microfluidics and mechatronics to public health is working to develop equipment that can be used by untrained personnel in remote locations to analyze a wide variety of samples. Optical readout and analysis of sentinel contaminants (mercury and lead) will be automated.

### 3.5

## Impact of environmental conditions on airway microbiota and respiratory health in the North

Principal investigators:  
**François Maltais, Medicine; Marc Ouellette, Microbiology, Infectious Disease and Immunology**

Indigenous populations in the North are facing a major prevalence of respiratory diseases linked to high smoking rates and overcrowded and poorly ventilated homes. For this project, researchers will evaluate the airway microbiota of young Inuit by conducting a metagenomic analysis of throat samples taken during the 2017 Qanuilirpitaa Inuit Health Survey. They will then sample air in homes in two Nunavik communities, identify the microbiota, and determine whether mechanical ventilation is working effectively. The project's main goal is to better understand the link between housing and respiratory disease in order to protect the health of occupants already dealing with high rates of cardiometabolic disease.



The health of northern populations is the main focus of several sub-projects of Thematic Project 3.

3.6

### The gut microbiome: Sentinel of the northern environment and Inuit mental health

Principal investigators:  
Richard Bélanger, Pediatrics;  
Gina Muckle, Psychology

The Inuit of Nunavik face multiple stressors (environmental contaminants, food insecurity, victimization, psychoactive substance abuse) and a very high level of psychological distress. The gut microbiome is known to influence mental health. Does it also have an impact on resilience in the face of adversity? Or, on the contrary, does it aggravate mental health problems if it is disturbed, due to changes in diet, for example? This project aims to characterize the gut microbiome of young Inuit who took part in the 2017 Qanuilirpitaa Inuit Health Survey to determine whether the microbiome can serve as an indicator of mental health status or be associated with different levels or sources of adversity.

3.7

### Optogenetics investigation of microbiota influence on brain development and epigenetics

Principal investigators:  
Paul De Koninck and Sylvain Moineau,  
Biochemistry, Microbiology, and Bioinformatics

The intestinal microorganisms in humans and other vertebrates can impact the health of their host. Environmental changes in the North are also thought to affect ecosystem microbiotas. In both cases, however, the relationship between a microbial community and its host is far from clear. In this project, researchers are employing optogenetic techniques on zebrafish models, which are transparent in the fry phase, to study how changes in their microbiota affect their brain development and epigenetics. Researchers use new light-induced CRISPR/Cas9 gene editing technology or viruses known as bacteriophages to eliminate certain bacteria from the microbiota of transparent fry while at the same time observing neural development in the brain.

3.8

### Deciphering host-microbial interactions for cardiometabolic and mental health disorders with novel multimodal light-based sensing tools

Principal investigators:  
Denis Boudreau, Chemistry;  
André Marette, Medicine

Indigenous populations in the North are exposed to a series of stressors that result in an increased prevalence of obesity, cardiometabolic diseases, and mental health disorders. Researchers believe that the microbiome may hold the key to these challenges. This project explores a new way of studying the gut microbiome using specially designed optical probes implanted in the intestinal tracts of mouse models carrying diseases affecting northern populations. The researchers hope to observe changes in the molecules produced by the microbiome in response to constraints such as a change in diet.



Using zebrafish models, researchers are combining principles of optics and genetics to study how the intestinal microbiome affects brain development.



## Sentinel North Research Chairs

The call for applicants for Sentinel North research chairs issued in April 2017 led to the recruitment of six accomplished researchers who will reinforce Université Laval's capabilities in strategic research areas. Four of the new chairs were launched in 2017–2018, the two other laureates will join the program in the fall of 2018.

In January 2018, a partnership research chair program was created to encourage external contributions to new faculty recruitment and research funding as part of Sentinel North.

## Sentinel North Research Chair in Aquatic Environmental Geochemistry

Raoul-Marie Couture, Chemistry

The work of this chair will provide a deeper understanding of the fate of carbon in northern lakes and develop new modelling tools to improve the current understanding of the factors that control water quality.

## Sentinel North Research Chair in the Neurobiology of Stress and Resilience

Caroline Ménard, Psychiatry and Neuroscience

With the help of state-of-the-art photonic technology, this chair seeks to shed light on the biological mechanisms underlying vulnerability and resilience to stress in order to develop innovative ways to treat or even prevent depression and mood disorders.

## Sentinel North Research Chair on the Surveillance of Avian Influenza Viruses in Migratory Birds in Northern Canada

Gary Wong, Microbiology, Infectious Disease and Immunology

The goal of this chair is to develop a pathogen surveillance network in northern Canada and to investigate the ecology of avian influenza viruses in wild migratory birds.

## Sentinel North Research Chair on Relations with Inuit Societies

Caroline Hervé, Anthropology

This chair's mission is to support the development of harmonious social relationships with Inuit societies by developing training and educational tools for non-Inuit and by giving Inuit a central role in research and educational activities.



Left to right: Eugénie Brouillet, Vice Rector of Research and Innovation; François Gélinau, Dean of the Faculty of Social Sciences; Caroline Hervé; and Martin Fortier, Executive Director of Sentinel North.



# Support for Research

Over the past year, a number of initiatives were developed to support Sentinel North research teams.

## **Technological Instrument Development Platform**

A technology platform launched in 2017 with the recruitment of two experienced engineers provides Sentinel North researchers and students with access to unique expertise on the development, fabrication, integration, qualification, deployment, and operation of sensors and related systems in a northern environment.

In the platform's first year in operation, a development and prototyping lab was established at the Centre for Optics, Photonics and Lasers (COPL), and the platform team was expanded with the recruitment of three additional engineers. Platform staff have already developed 13 prototypes and 6 technology solutions, including an autonomous programmable satellite communications module, an integrated energy-harvesting technology, and a precision calibration bench for various gas sensors.

## **Access to Northern Infrastructure Fund**

Since June 2017, a fund is available for research teams in order to facilitate access to remote areas in the North. More than ten research teams have received support from the fund so far to help pay the cost of travel to northern research sites, aircraft charters, and ship time on the CCGS *Amundsen* research icebreaker.

## **Technology Maturation Fund**

Research teams at Université Laval have access to the Sentinel North Technology Maturation Fund to support projects with strong development and commercialization potential. Proponents of innovative projects can obtain valuable financial aid to assist with business startups and technology transfers to industrial partners.

Research engineer José Lagunas-Morales adjusts an autonomous underwater vehicle (AUV) equipped with laser sensors used to explore ice-covered seas.



Sentinel North training activities put forward the experiential, technological and cultural aspects of northern research.





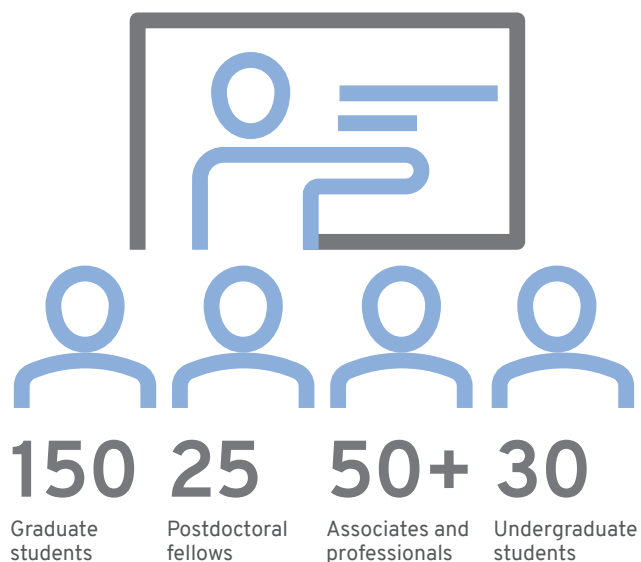
## Training

**A STRATEGY PROPELLED BY  
EXCELLENCE, ENGAGEMENT,  
AND EXPERIENCE**

Sentinel North is implementing a novel transdisciplinary training strategy that will help attract and develop highly qualified Canadian and international students with grant and research internship competitions, mobility scholarships (incoming and outgoing), international PhD schools, and a multitude of experiential training opportunities.

## Training

Thirty undergraduate students, 150 graduate students, 25 postdoctoral fellows, and over 50 research associates and professionals are currently furthering their training through the research projects funded by the program.



## International PhD School – The Changing Cryosphere: From Sensors to Decision-making

The first-ever Sentinel North International PhD School was held from March 2 to 9, 2018, in Iqaluit, Nunavut, on the theme of the changing cryosphere. The session provides a group of 19 international graduate students and 11 northern students from Nunavut Arctic College with a unique opportunity to interact with more than 15 high-level scientists and local experts as part of a transdisciplinary training program that addressed the complex and interrelated scientific and socioeconomic issues linked to the changing Arctic cryosphere.

**“The International PhD school taught me the basics of snow, glaciers, permafrost, and related circumpolar sciences so that I can use this knowledge in my interdisciplinary health sciences research with the aim of better understanding how climate change impacts northern populations’ food security, nutrition, and chronic disease management.”**

Sappho Z. Gilbert, PhD student, Chronic Disease Epidemiology Department, Yale University

**“Seeing the students from Iqaluit come together with graduate students from around the southern world, listen to one another, and learn from one another, was very cool. I feel that this is exactly the sort of thing that northern research needs.”**

Keegan Smith, M.Sc., Global Water Futures, McMaster University



Hailing from 17 institutions in 7 countries, the International PhD School students participated in a unique form of experiential training, incorporating a wide range of disciplines such as optics/photonics, Arctic ecology, chemistry, geology, and human health. The school was made possible with the support and collaboration of the Nunavut Research Institute (NRI) and Nunavut Arctic College.

## Excellence Scholarships

Two excellence scholarship competitions in 2017-2018 led to the recruitment of 16 new PhD students and postdoctoral fellows. Since March 2018, the competition is also open to master's students.

## Mobility Scholarships

Sentinel North gives young researchers the opportunity to work with the best labs and research centres in Canada and abroad. A mobility scholarship program (incoming and outgoing) is offered year-round to encourage research internships and enable students to attend international PhD schools. Since 2017, some 20 students have taken advantage of internship opportunities at renowned labs or attended training sessions in Denmark, the United States, Japan, South Africa, Austria, Scotland, Spain, France, Italy, and Norway.



Eugénie Brouillet, Vice Rector of Research, Creation and Innovation, with four Sentinel North scholarship recipients: Stéphanie Guilherme, Pascale Blais-Lecours, Michel Lavoie, and Charleen Salessé.

## Graduate Program in Biophotonics

With a goal of offering students top-level transdisciplinary training, Sentinel North contributes to enhancing graduate programs in biophotonics at Université Laval. These interfaculty programs at the crossroads of environmental science, life sciences, and optics/photonics are unique in Canada.

## CREATE Program (NSERC)

In March 2017, a team of 11 Sentinel North researchers led by Professor Daniel Côté was awarded a National Sciences and Engineering Research Council of Canada (NSERC) grant under the Collaborative Research and Training Experience (CREATE) Program. Their initiative, entitled “Smart, Autonomous and Adaptive Sensing,” complements the Sentinel North training program with lab exchanges, hands-on workshops, and industry internships designed to enhance students’ professional skills in preparation for the job market.

## Sentinel North Student Association

Established in the Fall of 2017, the Sentinel North Student Association (AÉSN) aims to strengthen students’ sense of belonging to the Sentinel North community and foster a transdisciplinary network of contacts. AÉSN plays a crucial role, connecting members from different faculties, departments, and research centres and disseminating valuable information on training opportunities, social and professional activities, and decision-making processes within Sentinel North.



AÉSN student leaders actively participate in organizing program outreach, training, and communications activities.



Sentinel North's 2017 scientific meeting was the first annual meeting for the program's community of researchers, students, and partners.



## Communication and Outreach

### MOBILIZING TO DISSEMINATE AND PROMOTE KNOWLEDGE

In 2017–2018, the Sentinel North community actively promoted knowledge dissemination and program outreach through numerous national and international knowledge-sharing activities.

## 2017 Annual Meeting

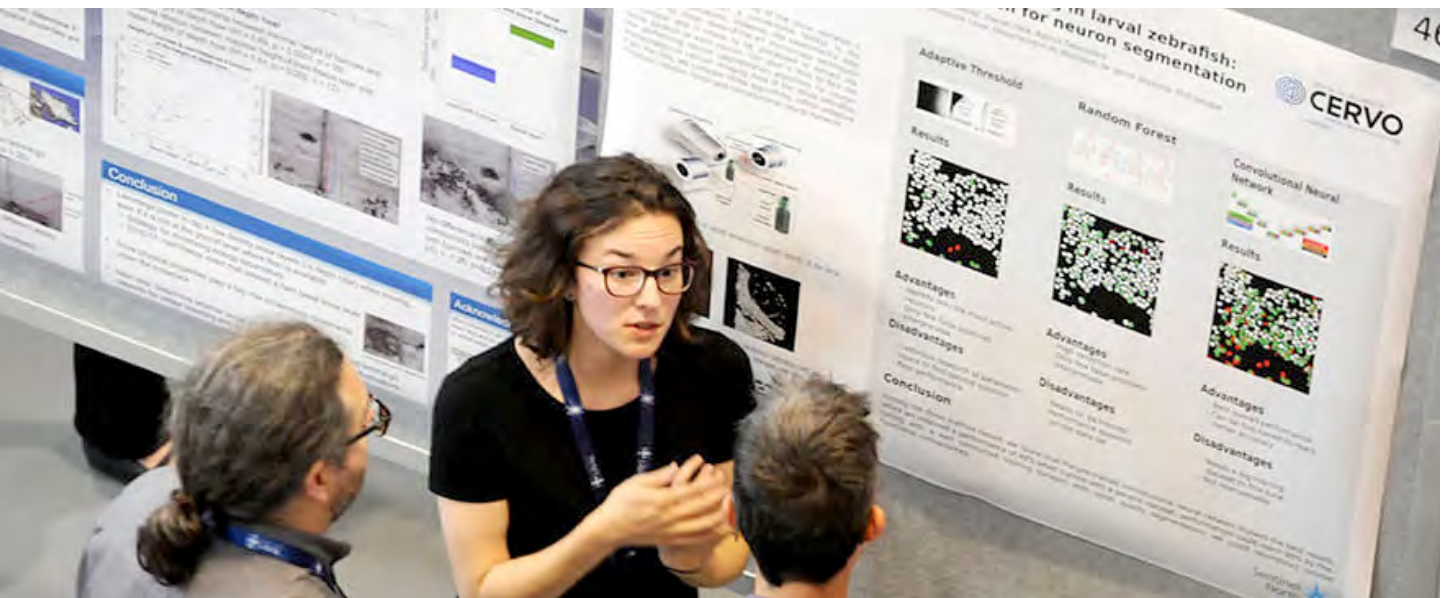
On August 29 and 30, 2017, nearly 300 Sentinel North researchers, students, research professionals, and collaborators came together for the first time for the program's first annual scientific meeting. The meeting gave participants the opportunity to learn more about the 21 research projects underway under Sentinel North's three main themes and to discuss various issues related to transdisciplinary research, partnerships, training, and northern research. Sentinel North's four Canada Excellence Research Chair holders presented their research and the work of the related international joint research units with institutions in Brazil, Switzerland, France, and Italy.



Université Laval rector Sophie D'Amours addressed the members of the Sentinel North community.

Research professional Martine Lizotte presented the BOND project, which is developing new optical methods for measuring climate-active gases.

Students played a central role at the annual scientific meeting.





## Event Support

Sentinel North supports research and training events that can enhance its influence, visibility, and mission. Since its inception, the program has contributed to the successful organization of a number of symposia, workshops, and national and international conferences, including Arctic Change 2017, the 4<sup>th</sup> World Conference on Marine Biodiversity, the 21<sup>st</sup> International Symposium on Non-Oxide and New Optical Glasses (ISNOG), BÉNÉFIQ2017, and annual symposia at various interuniversity research centres affiliated with Sentinel North.

## Brockhouse Canada Prize

On May 1, 2018, Professors Yves De Koninck (Psychiatry and Neuroscience); Daniel Côté, Younès Messaddeq, Michel Piché, Réal Vallée (Physics, Physical Engineering and Optics); and Benoît Gosselin (Electrical and Computer Engineering) received the NSERC Brockhouse Canada Prize, which recognizes outstanding Canadian teams of researchers from different disciplines who have combined their expertise to produce achievements of outstanding significance in the natural sciences and engineering.

This prestigious award recognizes more than 15 years of collaboration between the Centre for Optics, Photonics, and Lasers (COPL) and the CERVO Brain Research Centre, a partnership that has helped establish Université Laval as a world leader in neurophotonics and optics/photonics.

These six researchers continue to draw upon their experience and transdisciplinary vision under the Sentinel North research program.

The 2018 Brockhouse Canada Award winners: Daniel Côté, Yves De Koninck, Michel Piché, Younès Messaddeq, Benoît Gosselin, and Réal Vallée.





In pursuing its objectives, Sentinel North works with a vast network of public and private research centres and academic partners in Canada and abroad.



# Partnerships and Collaborations

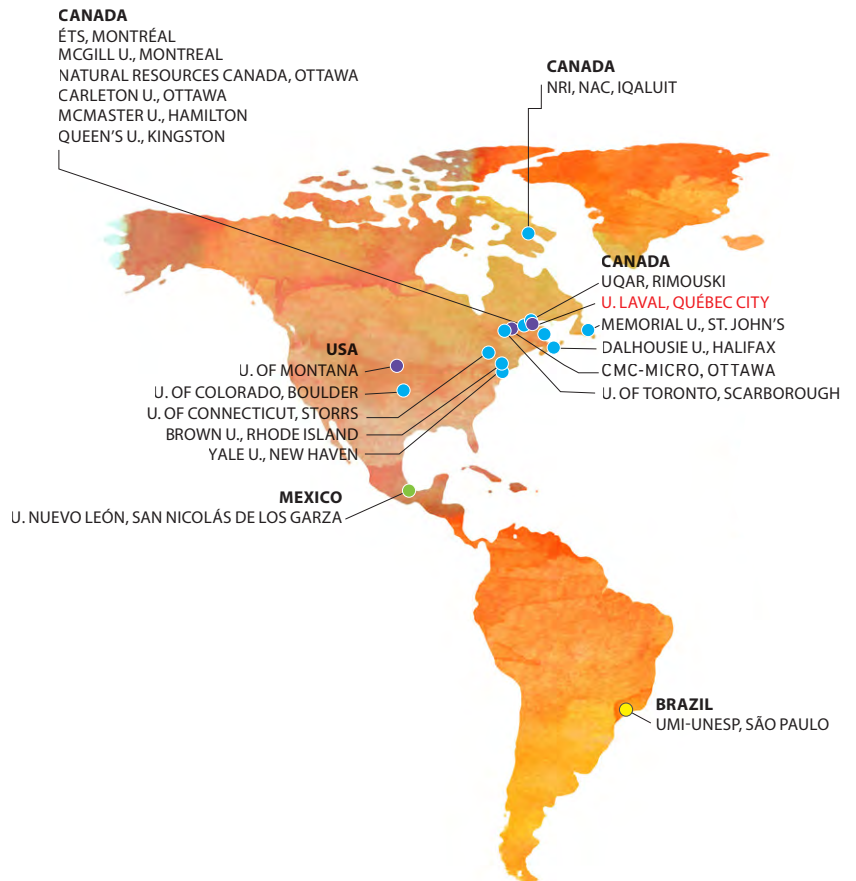
## SYNERGISTIC RELATIONS IN RESEARCH AND TRAINING

Sentinel North's partnership and collaboration strategy is based on a vast network of academic, public, and private collaborators backed by numerous research centres and groups. At the international level, research and training partnerships are based on the desire of internationally renowned institutions and researchers to work together on innovative joint projects with a view to building long-term collaborative relationships.

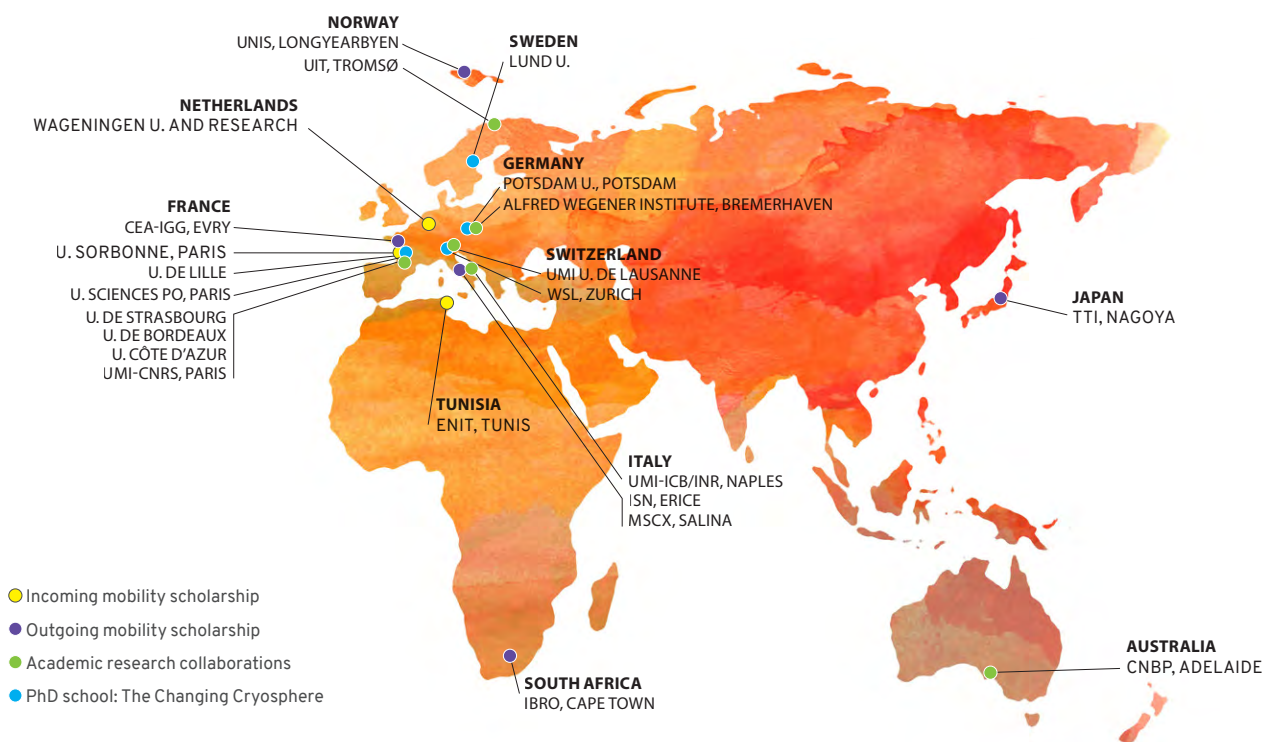
## International Collaborations in Research and Training

Over the past year, the Sentinel North strategy was presented to a number of international institutions and research centres with the aim of encouraging research partnerships. These visits to the National Centre for Scientific Research (CNRS, Paris), Université de Bordeaux, Université Côte d'Azur (UCA, Nice), Université de Strasbourg, the University of Tromsø (UiT, Norway), and the Alfred Wegener Institute (AWI, Germany) have already resulted in funding for joint projects with CNRS and calls for joint research projects co-financed with UCA and UiT.

In 2017–2018, more than 20 young Sentinel North researchers were awarded mobility scholarships (incoming and outgoing) to do research internships or attend international PhD schools. Hosting international students and mentors in our own labs and field schools is another way to expose our students to high-level international training opportunities.



A collaboration agreement between Sentinel North, Université Laval, and the University of Tromsø (UiT) in Norway was signed by UiT rector Anne Husebekk and our executive director.



## International Joint Units

In association with the four Canada Excellence Research Chairs (CERCs) active within the program, Sentinel North took steps to reinforce two existing international joint research units (UMIs) in partnership with the French National Centre for Scientific Research (CNRS) and Sao Paulo State University (UNESP) in Brazil, and to establish two new UMIs with the University of Lausanne in Switzerland and the Italian National Research Council (CNR).

These research chairs and joint research units are led by internationally renowned researchers in their fields, enabling Sentinel North to draw upon outstanding international teams in pursuing its research and technology development objectives:

- Takuvik International Joint Research Unit (UL/CNRS, France), associated with the CERC in Remote Sensing of Canada's New Arctic Frontier (Chairholder: Marcel Babin)
- Québec-Brazil Photonics Research International Joint Research Unit (UNESP, Brazil), associated with the CERC in Photonic Innovations (Chairholder: Younès Messaddeq)
- International Joint Research Unit in Child Neural Development and Psychiatry (Université de Lausanne, Switzerland), associated with the CERC in Neurophotronics (Chairholder: Pierre Marquet)
- International Joint Research Unit for Chemical and Biomolecular Research of the Microbiome and Its Impacts on Metabolic Health and Nutrition (CNR, Italy), associated with the CERC in the Microbiome-Endocannabinoidome Axis in Metabolic Health (Chairholder: Vincenzo Di Marzo)





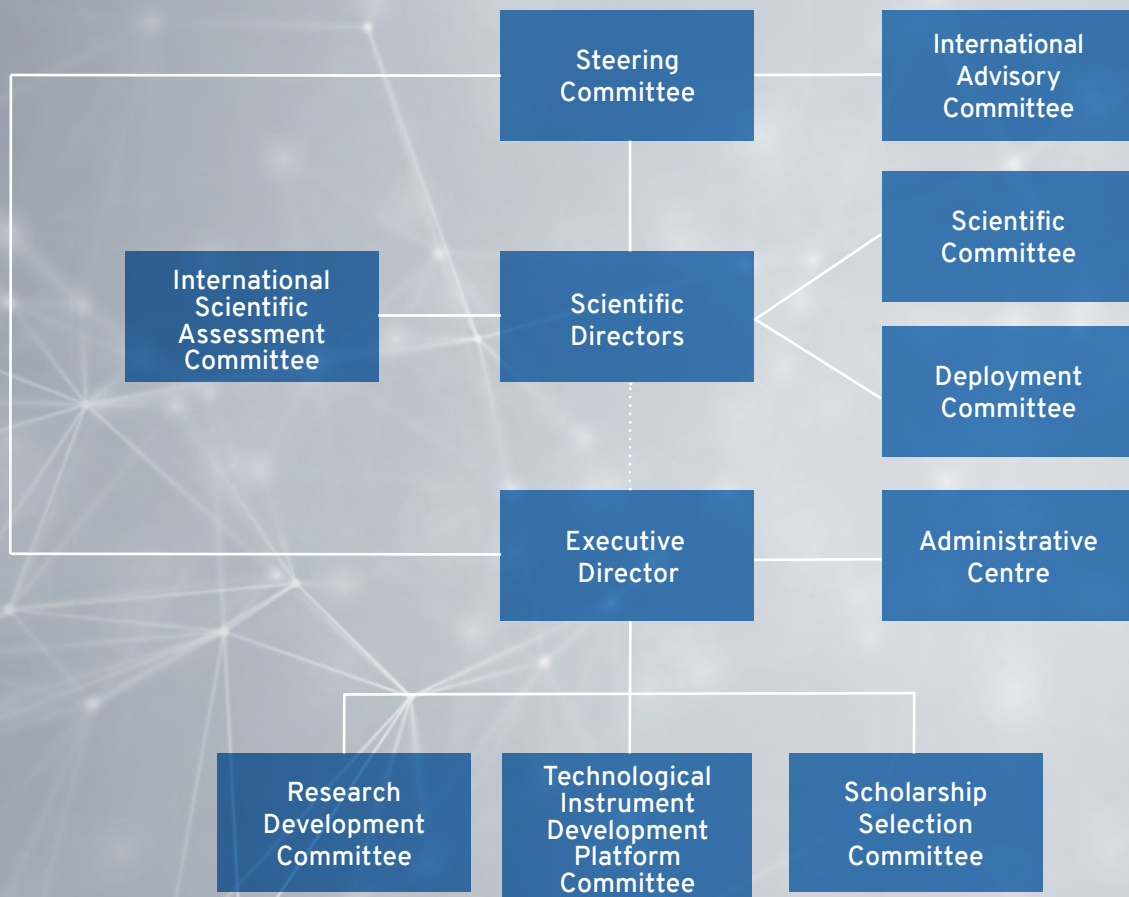
# The Sentinel North Community

## A NETWORK FOR INNOVATION

The Sentinel North program includes hundreds of participants from 7 faculties and over 30 departments at Université Laval who work with their partners from northern organizations, federal and provincial agencies, and the private sector to improve our understanding of the northern environment and its impact on humans and their health. In 2017–2018, this vast network of stakeholders developed innovative research projects and implemented numerous Sentinel North training, knowledge translation, partnership, and research support programs.

## Governance and Committee Membership

The Sentinel North governance and management structure is designed to provide the resources and vision the program needs to achieve its strategic objectives and ensure leadership, sound management, and scientific coordination at every level.





## Steering Committee

The Steering Committee is responsible for implementing the Sentinel North strategy. It ensures the program is progressing with respect to its objectives, performance indicators, and deliverables. It makes the final decisions on the recommendations made by the scientific directors, the executive director, and all Sentinel North committees.

**Marcel Babin**, Scientific Co-Director, Sentinel North and Laureate, CERC on Remote Sensing in Canada's New Arctic Frontier

**Régnald Bergeron**, Vice Rector, External and International Affairs and Health

**Eugénie Brouillet (chair)**, Vice Rector, Research and Innovation

**André Darveau**, Vice Rector, Administration

**Yves De Koninck**, Scientific Co-Director, Sentinel North and Director, CERVO Brain Research Centre

**Jean-Claude Dufour**, Dean, Faculty of Agriculture and Food Sciences

**Martin Fortier (non-voting)**, Executive Director, Sentinel North, and Assistant to the Vice Rector, Research and Innovation

**François Gélinau**, Dean, Faculty of Social Sciences

**Julien Poitras**, Dean, Faculty of Medicine

**André Zaccarin**, Dean, Faculty of Science and Engineering

## Scientific Directors

The two scientific directors are appointed by the Steering Committee to provide the leadership necessary for the vitality of the program, the active participation of its members, and the relevance and scientific quality of its activities. They establish a strategic development plan and a scientific program in keeping with the program's objectives in consultation with the Steering Committee and with input from the Scientific Committee and the Deployment Committee.

**Marcel Babin**, Scientific Co-Director, Sentinel North and Laureate, CERC on Remote Sensing in Canada's New Arctic Frontier

**Yves De Koninck**, Scientific Co-Director, Sentinel North and Director, CERVO Brain Research Centre

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## Executive Director

The executive director oversees operations and day-to-day activities and works with the Steering Committee and Scientific Directors to develop and implement the Sentinel North strategic and operational plan. The executive director liaises with funding agencies, government, industry, and other non-governmental organizations.

**Martin Fortier (non-voting)**, Executive Director, Sentinel North and Assistant to the Vice Rector, Research and Innovation

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## International Advisory Committee

The International Advisory Committee provides high-level advice to the Steering Committee and scientific directors regarding the program's strategic and scientific thrusts. The advice is used to conduct comparative analysis in accordance with international standards and to address conflicting interests within the network structure.

## Scientific Committee

The Scientific Committee provides advice and makes recommendations to the Steering Committee through the scientific directors with regard to Sentinel North's scientific priorities and calls for projects.

**Marcel Babin (co-chair)**, Scientific Co-Director, Sentinel North and Laureate, CERC on Remote Sensing in Canada's New Arctic Frontier

**Yves De Koninck (co-chair)**, Scientific Co-Director, Sentinel North and Director, CERVO Brain Research Centre

**Vincenzo Di Marzo**, CERC in the Microbiome-Endocannabinoidome Axis in Metabolic Health

**Martin Fortier (non-voting)**, Executive Director, Sentinel North and Assistant to the Vice Rector, Research and Innovation

**Pierre Marquet**, CERC on Neurophotonics

**Younès Messaddeq**, CERC on Photonic Innovations for Information and Communication

## Deployment Committee

The Deployment Committee provides advice and makes recommendations to the Steering Committee through the scientific directors on the deployment and status of research, collaboration, training, partnership, and networking activities within the program.

**Marcel Babin (co-chair)**, Scientific Co-Director, Sentinel North and Laureate, CERC on Remote Sensing in Canada's New Arctic Frontier

**Eugénie Brouillet**, Vice Rector, Research and Innovation

**Yves De Koninck (co-chair)**, Scientific Co-Director, Sentinel North and Director, CERVO Brain Research Centre

**Louis Fortier**, Scientific Director, ArcticNet Network of Centres of Excellence, Amundsen research icebreaker, and Institut nordique du Québec

**Martin Fortier (non-voting)**, Executive Director, Sentinel North and Assistant to the Vice Rector, Research and Innovation

**André Marette**, Scientific Director, Institute of Nutrition and Functional Foods (INAF) and Co-Director of Thematic Project 3

**Gina Muckle**, Professor, Nasivvik Centre for Inuit Health and Changing Environments

**Denis Richard**, Research Director, Quebec Heart and Lung Institute

**Stéphane Roche**, Professor, Geomatics Research Centre

**Thierry Rodon**, Director, CIÉRA

**René Therrien**, Vice Dean, Research, Faculty of Science and Engineering and Director of Thematic Project 1

**Jean-Marie Trudeau**, Coordinator, Technological Instrument Development Platform, Sentinel North

**Sylvie Turgeon**, Director, INAF

**Réal Vallée**, Director, Centre for Optics, Photonics and Lasers (COPL) and Director of Thematic Project 2

**Warwick Vincent**, Centre for Northern Studies (CEN) and Co-Director of Thematic Project 3

### **International Scientific Assessment Committee**

The International Scientific Assessment Committee provides assessments, monitors the progress of funded projects, and makes recommendations to the Steering Committee through the scientific directors for funding applications received through Sentinel North calls for projects. The committee is composed of scientists and international stakeholders external to Université Laval.

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### **Research Development Committee**

The Research Development Committee helps identify discoveries with application and commercialization potential as part of Sentinel North's research activities. It guides the implementation of knowledge mobilization and transfer activities that maximize the use of research results by users.

**Martin Fortier (non-voting)**, Executive Director, Sentinel North and Assistant to the Vice Rector, Research and Innovation

**Jean-François Haince**, Director, SOVAR

**Marie Nadeau**, Research Development Advisor, Faculty of Sciences and Engineering

**Sébastien Prince-Richard**, Research Development and Technology Transfer Advisor, Office of the Vice Rector Research and Innovation

**Béatrice Saint-Cricq**, Partnerships and Technology Transfer, CNRS/Sentinel North

**Tommy Seaborn**, Research Development Advisor, Faculty of Medicine

**Jean-François Simard**, Director, Community-University Liaison Office (BLUM)

**Jean-Marie Trudeau**, Coordinator, Technological Instrument Development Platform, Sentinel North

### **Technological Instrument Development Platform Committee**

The Technological Instrument Development Platform Management Committee oversees the activities of the platform, reviews the operating budget and the strategic and operational objectives proposed by the coordinator, and ensures that the platform has the appropriate resources to achieve its goals.

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### **Scholarship Selection Committee**

The role of the Scholarship Selection Committee is to select the recipients of Sentinel North graduate scholarships and postdoctoral fellowships.

## THEMATIC PROJECT MANAGEMENT AND COORDINATION

### THEMATIC PROJECT 1

**René Therrien**

Director, Geology and Geological Engineering

**Leslie Rusch**

Electrical and Computer Engineering

**Vani Mohit**

Coordinator

**Louis J. Dubé**

Physics, Physical Engineering and Optics



### THEMATIC PROJECT 2

**Philippe Archambault**

Biology

**Réal Vallée**

Director, Physics, Physical Engineering and Optics

**Claude Demers**

Architecture

**Jérôme Lapointe**

Coordinator



### THEMATIC PROJECT 3

**Warwick Vincent**  
Co-Director, Biology

**Philippe St-Pierre**  
Coordinator

**André Marette**  
Co-Director Medicine

**Pierre Ayotte**  
Social and Preventive Medicine (not shown)

**Denis Boudreau**  
Chemistry (not shown)



### ADMINISTRATIVE CENTRE

**Marie-France Gévry**  
Training Program Coordinator

**Jérôme St-Charles**  
Communications Officer and Webmaster

**Béatrice Saint-Cricq**  
Partnerships and Technology Transfer

**Martin Fortier**  
Executive Director

**Michèle Desgagnés**  
Secretary

**Keith Levesque**  
Assistant Director

**Véronique Morin**  
Communications Manager



## UNIVERSITÉ LAVAL RESEARCHERS AND COLLABORATORS

### ANIMAL SCIENCE

Vandenberg, Grant

---

### ANTHROPOLOGY

Hervé, Caroline

---

### BIOCHEMISTRY, MICROBIOLOGY AND BIO-INFORMATICS

Boissinot, Maurice

Charette, Steve

Culley, Alexander

De Koninck, Paul

Duchaine, Caroline

Lagüe, Patrick

Moineau, Sylvain

Paquet, Marie-Ève

---

### BIOLOGY

Archambault, Philippe

Babin, Marcel

Bernatchez, Louis

Côté, Steeve

Derome, Nicolas

Fortier, Louis

Fortin, Daniel

Gauthier, Gilles

Johnson, Ladd

Lavaud, Johann

Levasseur, Maurice

Lovejoy, Connie

Maps, Frédéric

Massé, Guillaume

Moore, Jean-Sébastien

Tremblay, Jean-Éric

Villarreal Aguilar, Juan-Carlos

Vincent, Warwick

### CHEMICAL ENGINEERING

Taghavi, Mohammed

---

### CHEMISTRY

Boudreau, Denis

Couture, Raoul-Marie

Dominé, Florent

Greener, Jesse

Johnson, Paul

Larivière, Dominic

Leclerc, Mario

Morin, Jean-François

Ritcey, Anna

Voyer, Normand

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### CIVIL AND WATER ENGINEERING

Anctil, François

Doré, Guy

Dorea, Caetano

Locat, Ariane

Nadeau, Daniel

---

### COMPUTER SCIENCE AND SOFTWARE ENGINEERING

Hardy, Simon

Laviolette, François

---

### ELECTRICAL AND COMPUTER ENGINEERING

Deschênes, Jean-Daniel

Gosselin, Benoît

Lalonde, Jean-François

LaRochelle, Sophie

Laurendeau, Denis

Maldague, Xavier

Miled, Amine

Rusch, Leslie

Shi, Wei

## FOOD AND NUTRITION SCIENCES

Roy, Denis  
Vohl, Marie-Claude

---

## GEOGRAPHY

Allard, Michel  
Antoniades, Dermot  
Bhiry, Najat  
Cloutier, Danielle  
Lajeunesse, Patrick

---

## GEOLOGY AND GEOLOGICAL ENGINEERING

Fortier, Richard  
Molson, John  
Therrien, René

---

## GEOMATICS

Badard, Thierry

---

## GRADUATE SCHOOL OF LAND USE PLANNING AND REGIONAL DEVELOPMENT

Rodriguez-Pinzon, Manuel

---

## KINESIOLOGY

Després, Jean-Pierre  
Tremblay, Angelo

---

## MATHEMATICS AND STATISTICS

Doyon, Nicolas  
Rivest, Louis-Paul

---

## MECHANICAL ENGINEERING

Bégin-Drolet, André  
Campeau-Lecours, Alexandre  
Gosselin, Louis  
Ruel, Jean

---

## MEDICINE

Agharazii, Mohsen  
Boulet, Louis-Philippe  
Di Marzo, Vincenzo  
Flamand, Nicolas  
Maltais, François  
Marette, André  
Marsolais, David  
Morissette, Mathieu  
Paulin, Roxane  
Richard, Denis

---

## MICROBIOLOGY, INFECTIOUS DISEASE AND IMMUNOLOGY

Bergeron, Michel G  
Ouellette, Marc  
Papadopoulou, Barbara  
Richard, Dave

---

## MOLECULAR MEDICINE

Corbeil, Jacques  
Droit, Arnaud

---

## NURSING

Gagnon, Marie-Pierre

---

## OPHTHALMOLOGY AND ORL - HEAD AND NECK SURGERY

Hébert, Marc

## **PEDIATRICS**

**Bélanger, Richard**

---

## **PHARMACY**

**Barbier, Olivier**  
**Calon, Frédéric**  
**Soulet, Denis**

---

## **PHYSICS, PHYSICAL ENGINEERING AND OPTICS**

**Allen, Claudine**  
**Bernier, Martin**  
**Côté, Daniel**  
**Després, Philippe**  
**Desrosiers, Patrick**  
**Dubé, Louis J.**  
**Galstian, Tigran**  
**Messaddeq, Younès**  
**Piché, Michel**  
**Thibault, Simon**  
**Vallée, Réal**

---

## **PHYTOLOGY**

**Desjardins, Yves**  
**Rochefort, Line**

---

## **PSYCHIATRY AND NEUROSCIENCE**

**De Koninck, Yves**  
**Marquet, Pierre**  
**Ménard, Caroline**  
**Mérette, Chantal**

---

## **REHABILITATION**

**Batcho, Charles**  
**Blanchette, Andréanne**  
**Bouyer, Laurent**  
**McFadyen, Bradford**  
**Mercier, Catherine**  
**Routhier, François**  
**Roy, Jean-Sébastien**

---

## **SCHOOL OF ARCHITECTURE**

**Blais, Myriam**  
**Demers, Claude**  
**Després, Carole**  
**Potvin, André**  
**Vachon, Geneviève**

---

## **SCHOOL OF NUTRITION**

**Di Marzo, Vincenzo**  
**Vohl, Marie-Claude**

---

## **SCHOOL OF PSYCHOLOGY**

**Jackson, Philip**  
**Muckle, Gina**

---

## **SOCIAL AND PREVENTIVE MEDICINE**

**Ayotte, Pierre**  
**Fletcher, Christopher**  
**Lemire, Mélanie**  
**Lévesque, Benoit**  
**Lucas, Michel**

---

## **SURGERY**

**Mathieu, Patrick**

---

## **WOOD AND FOREST SCIENCES**

**Blanchet, Pierre**  
**Darveau, Marcel**



## EXTERNAL COLLABORATORS

**Allard, Antoine**, University of Barcelona, Spain

**Archambault, Philippe**, McGill University, Montréal

**Avard, Ellen**, Nunavik Research Centre, Makivik Corporation, Kuujjuaq

**Azeria, Ermias**, Alberta Biodiversity Monitoring Institute (ABMI), Edmonton

**Bjerrregaard, Peter**, National Institute of Public Health (NIPH), Denmark

**Bonilla, Sylvia**, University of the Republic, Uruguay

**Boucher, Olivier**, Université de Montréal, Montréal

**Burchill, Nick**, Subsea, Kongsberg Maritime, Halifax

**Calmels, Fabrice**, Yukon Research Centre, Whitehorse

**Canario, João**, University of Lisbon, Portugal

**Cani, Patrice**, Catholic University of Louvain, Belgium

**Châteauneuf, François**, National Optics Institute (INO), Québec City

**Comte, Jérôme**, Environment and Climate Change Canada (ECCC), Ottawa

**Cordier, Sylvaine**, National Institute for Health and Medical Research (INSERM), France

**Dalgleish, Fraser**, Harbor Branch Oceanographic Institute (HBOI), Florida Atlantic University, United States

**Des Roches, Mathieu**, Institut national de la recherche scientifique (INRS), Québec City

**Elzeyadi, Ihab**, University of Oregon, United States

**Falciatore, Angela**, National Centre for Scientific Research (CNRS), Université Pierre et Marie Curie (UPMC), France

**Fortier, Daniel**, Université de Montréal, Montréal

**Fouré, Marion**, Université de Lille, France

**Fournier, Georges**, Defence Research and Development Canada (DRDC), Québec City

**Fournier, Watson**, Kativik Municipal Housing Bureau (KMHB), Nunavik

**Francus, Pierre**, Institut national de la recherche scientifique (INRS), Québec City

**Gagné, Frédéric**, Nunavik Research Centre, Makivik Corporation, Kuujjuaq

**Gosselin, Michel**, Université du Québec à Rimouski (UQAR), Rimouski

**Guegan, Émilie**, Norwegian University of Science and Technology (NTNU), Norway

**Hammil, Mike**, Maurice Lamontagne Institute (IML), Fisheries and Oceans Canada (DFO), Mont-Joli

**Hebblewhite, Mark**, University of Montana, United States

**Hébert, Christian**, Natural Resources Canada (NRCan), Québec City

**Hébert-Dufresne, Laurent**, University of Vermont, United States

**Heppell, Sandra**, Ministère des Forêts, de la Faune et des Parcs (MFFP), Baie-Comeau

**Hill, Ian**, Dalhousie University, Halifax

**Ingeman-Nielsen, Thomas**, Technical University of Denmark, Denmark

**Jones, Clayton**, Teledyne Webb Research, United States

**Jungblut, Anne**, Natural History Museum, United Kingdom

**La Roche, Pablo**, University of Cal Poly, Pomona, United States

**Laurion, Isabelle**, Institut national de la recherche scientifique (INRS), Québec City

**Leclerc, Nicolas**, University of Strasbourg, France

**Lesage, Véronique**, Maurice Lamontagne Institute (IML), Fisheries and Oceans Canada (DFO), Mont-Joli

**Levac, Charles**, Glencore Raglan Mine,  
Rouyn-Noranda

**Levallois, Patrick**, Institut national de santé publique  
du Québec (INSPQ), Québec City

**Lévesque, Benoît**, Institut national de santé  
publique du Québec (INSPQ), Québec City

**Lévesque, Martin**, Defence Research and  
Development Canada (DRDC), Québec City

**Levy, Emile**, CHU Sainte-Justine, Montréal

**Longtin, André**, University of Ottawa, Ottawa

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and Technology (NTNU), Norway

**Mainguy, Julien**, Ministère des Forêts, de la Faune  
et des Parcs (MFFP), Québec City

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Institute of Electronics, Computers and  
Telecommunication Engineering (IEIT),  
University of Pisa, Italy

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(MLI), Fisheries and Oceans Canada (DFO), Mont-Joli

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Board (NMRWB), Inukjuak

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of Evry-Val-d'Essonne, France

**Plamondon, André**, Institut de recherche  
Robert-Sauvé en santé et en sécurité du travail  
(IRSST), Montréal

**Ras, Joséphine**, Laboratoire d'Océanographie  
de Villefranche-sur-Mer (LOV), Université Pierre  
et Marie Curie (UPMC), France

**Rautio, Milla**, Université du Québec à Chicoutimi  
(UQAC), Chicoutimi

**Riva, Mylène**, McGill University, Montréal

**Roy, Nicolas**, VELUX: Energy & Indoor Climate,  
Knowledge Centre for Daylight, Denmark

**Simard, Anouk**, Ministère des Forêts, de la Faune  
et des Parcs du Québec (MFFP), Québec City

**Siret, Daniel**, Centre de Recherche nantais  
Architectures Urbanités (CRENAU), Nantes School  
of Architecture (ENSA), France

**Steenweg, Robin**, Alberta Environment and Parks  
(AEP), Edmonton

**Stern, Gary**, University of Manitoba, Winnipeg

**Tanabe, Yukiko**, National Institute of Polar Research  
(NIPR), Japan

**Tran, Lilian**, Nunavik Research Centre, Kuujuak

**Turgeon, Samuel**, Maurice Lamontagne Institute  
(IML), Fisheries and Oceans Canada (DFO), Mont-Joli

**Vallée, Claude**, Institut de technologie  
agroalimentaire (ITA), Saint-Hyacinthe

**Vernaudeau, Catherine**, Société d'habitation  
du Québec (SHQ), Québec City

**Vieira, Gonçalo**, University of Lisbon, Portugal

## PARTNERS

Ducks Unlimited Canada  
Explora Technologies  
FlowJEM  
Franatech  
Gas Plume Imaging  
LogR Systems  
Matrix Solutions Inc.  
National Optics Institute (INO)  
National Research Council Canada (NRC)  
Nunavik Hunting Fishing Trapping Association  
Nunavik Regional Board of Health and Social Services  
Nunavik Research Centre - Makivik Corporation  
Nunavut Research Institute  
TeraXion Inc.  
VELUX

## PARTICIPATING RESEARCH CHAIRS

### Canada Excellence Research Chairs (CERCs)

CERC in Photonic Innovations (Younès Messaddeq)

CERC in Remote Sensing of Canada's New Arctic Frontier (Marcel Babin)

CERC in the Microbiome-Endocannabinoidome Axis in Metabolic Health (Vincenzo Di Marzo)

CERC on Neurophotonics (Pierre Marquet)

### Canada Research Chairs (CRC)

CRC in Advanced Photonic Technologies for Communications (Sophie LaRoche)

CRC in Antimicrobial Resistance (Marc Ouellette)

CRC in Aquatic Ecosystem Studies (Warwick F. Vincent)

CRC in Aquatic Environments and Water Quality (Dermot Antoniadis)

CRC in Arctic Marine Ecosystems' Response to Global Warming (Louis Fortier)

CRC in Bacteriophages (Sylvain Moineau)

CRC in Chronic Pain and Related Brain Disorders (Yves De Koninck)

CRC in Communications Systems Enabling the Cloud (Leslie Rusch)

CRC in Electroactive and Photoactive Polymers (Mario Leclerc)

CRC in Environment and Energy Balance (Angelo Tremblay)

CRC in Genetic Conservation of Aquatic Resources (Louis Bernatchez)

CRC in Genomics Applied to Nutrition and Metabolic Health (Marie-Claude Vohl)

CRC in Liquid Crystals and Behavioral Biophotonics (Tigran Galstian)

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International Chair on Cardiometabolic Risk (Jean-Pierre Després)

L'Oréal Research and Innovation Chair in Digital Biology (Arnaud Droit)

Nasivvik Research Chair in Ecosystem Approaches to Northern Health (Mélanie Lemire)

NSERC-Coractive-TeraXion-LaserAX-TLCL Industrial Research Chair in Femtosecond Photo-Inscribed Photonic Components and Devices (Réal Vallée)

NSERC/Creaform Industrial Research Chair on 3-D Scanning: 3-D Creation (Denis Laurendeau)

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NSERC Industrial Research Chair in Integrated Resource Management of Anticosti Island (Steeve Côté)

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Sentinel North Research Chair on Relations with the Inuit (Caroline Hervé)

Sentinel North Research Chair on the Surveillance of Avian Influenza Viruses in Migratory Birds in Northern Canada (Gary Wong)

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ArcticNet Network of Centres of Excellence	International Joint Research Unit in Neurodevelopment and Child Psychiatry (ULaval – Université of Lausanne, Switzerland)
Big Data Research Centre	International Joint Research Unit Québec-Brazil Photonics Research (ULaval – UNESP, Brazil)
Center for Interdisciplinary Research in Rehabilitation and Social Integration (CIRRS)	Machine Learning Research Group (GRAAL)
Centre for Forest Research (CFR)	Neuroscience Thematic Research Centre (CTRN)
Centre for Northern Studies (CEN)	Oral Ecology Research Group (GREB)
Centre for Research in Geomatics (CRG)	Physical Ambiances Research Group (GRAP)
Centre for Research in Regional Planning and Development (CRAD)	Québec Centre for Functional Materials (CQMF)
Centre in Green Chemistry and Catalysis (CCVC)	Quebec Heart and Lung Institute Research Centre (CRIUCPQ)
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Centre interdisciplinaire en modélisation mathématique de l'Université Laval (CIMMUL)	Québec Network for Research on Protein Function, Engineering, and Applications (PROTEO)
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CERVO Brain Research Centre	Ressources aquatiques Québec (RAQ)
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Infectious Disease Research Centre (CRI)	
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