

Sentinel  
North



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SHEDDING LIGHT ON THE NORTH  
ENVIRONMENT | HEALTH | INNOVATION

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ACTIVITY REPORT  
2019-2020



UNIVERSITÉ  
**LAVAL**

With its Sentinel North strategy, Université Laval is building on its excellence in northern and optics/photonics research to conduct transformative research, develop innovative new technologies, 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 a major funding from the Canada First Research Excellence Fund.



Sentinel North receives financial support from the Fonds de recherche du Québec.



Fonds de recherche – Nature et technologies  
Fonds de recherche – Santé  
Fonds de recherche – Société et culture





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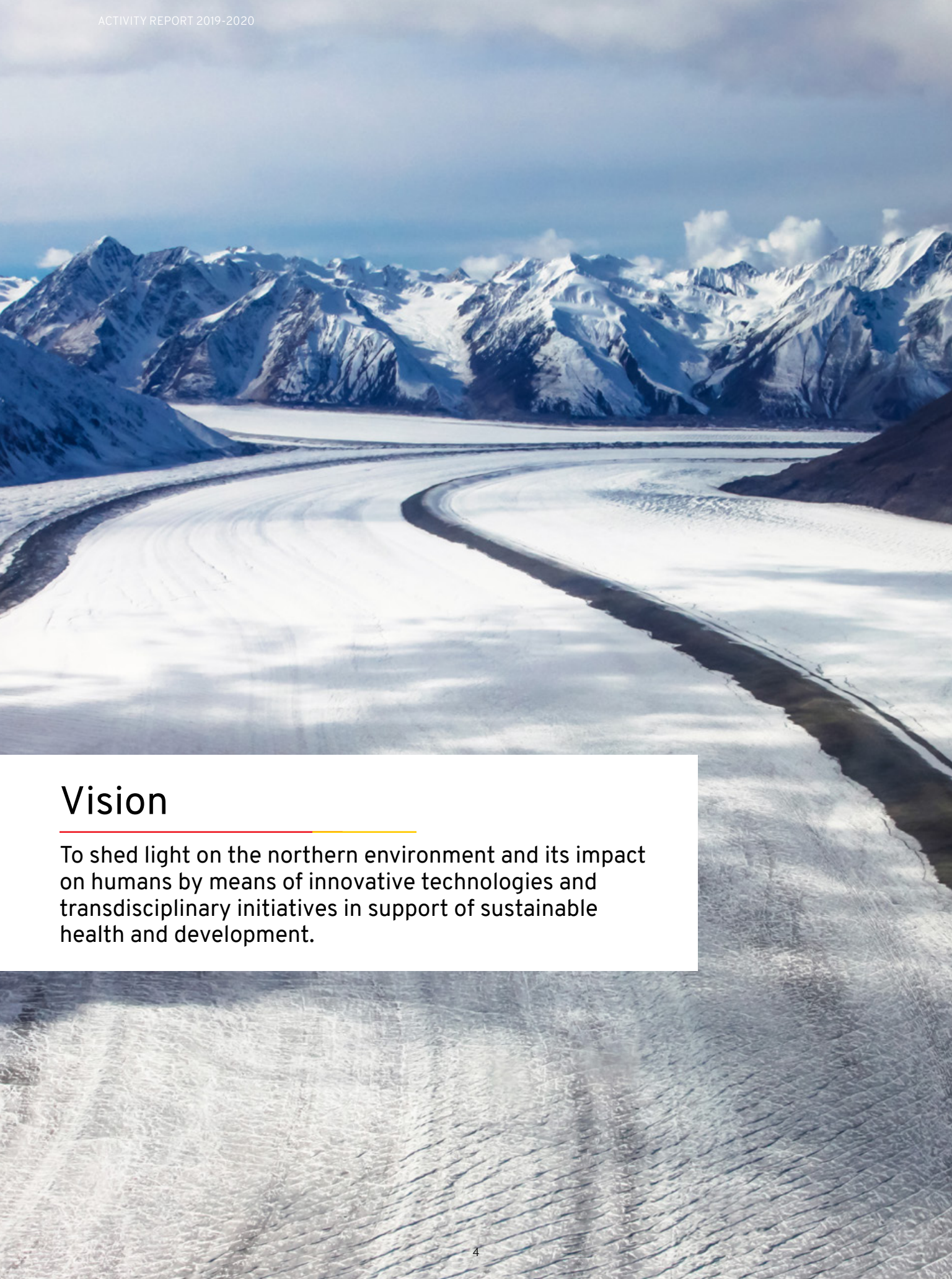


Students in chemistry, biophotonics, physical engineering and mechanical engineering are working together to develop a field portable nano-tool for contaminant identification in northern country food.

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## Vision

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

# Message from Management

The past year has been prolific for Sentinel North, as evidenced by the funding of several new research projects, the recruitment of promising young researchers, the deployment of experiential training initiatives for our student community, and the signing of collaborative agreements with some of the best universities in the world. Our community continues to grow and diversify with more than 700 members from 40 Université Laval departments working in a spirit of convergence and innovation with over 350 collaborators and partners from 20 countries. In 2019-2020, our teams delivered more than 700 scientific communications and publications, including more than 100 peer-reviewed articles in the best journals, most of which are available in open access.

While illustrating the highlights and results emerging from our transdisciplinary research program, this activity report reflects the tremendous momentum that Sentinel North has gained since the launch of our research and training activities in 2017.

In January 2020, our accomplishments were assessed by a panel of international experts as part of CFREF's mid-term evaluation of the program. Driven by a very positive evaluation and the granting of a 2-year extension, we are now entering the second phase of the program, which will run until at least the fall of 2025.

Unfortunately, the global pandemic that has disrupted our lives has also hindered some of our research and training activities, particularly those in northern regions and communities that remain inaccessible. Despite this period of uncertainty, the majority of our members are continuing their work and we are adapting our training, knowledge transfer and communication initiatives to our new virtual world. Several teams will join the program, following the selection of projects submitted under our second \$10 million major call for proposals launched in the fall of 2019.

During this next phase of Sentinel North, we wish to further foster the production of high-impact scientific results, support the new generation of young researchers, consolidate the culture of transdisciplinary research that we have established, and build a lasting legacy for our institution grounded on our research centres and institutes. By working closely with our partners in the North and South, in Quebec, Canada and abroad, we are determined to pursue our mission to bridge disciplines and push back the frontiers of knowledge for a better understanding of the northern environment and its impact on human health, while consolidating Université Laval's leadership role in the convergence of research fields that inform and support the sustainable development of the 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



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



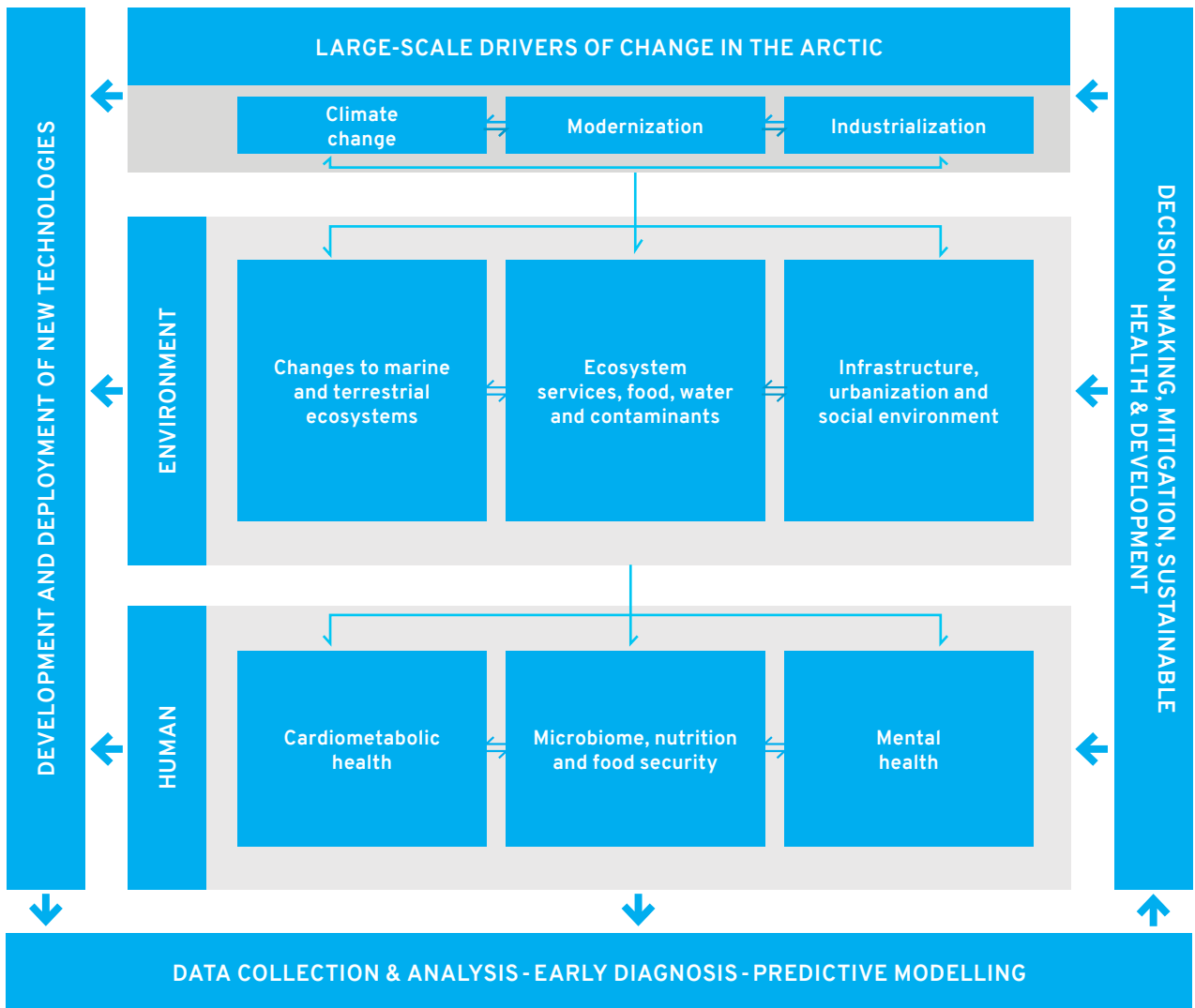
**Marcel Babin**  
Scientific Co-Director,  
Sentinel North  
Laureate of the CERC in  
Remote Sensing of Canada's  
New Arctic Frontier

# Sentinel North at a Glance

In the face of accelerating climate change and socioeconomic development in the Arctic and sub-Arctic, the Sentinel North research program helps generate the knowledge needed 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.

## CONCEPTUAL FRAMEWORK

Sentinel North’s conceptual framework drives the program’s research, training, and partnership initiatives.





Sentinel North is founded on convergence, bringing together first-class research expertise and prominent research centres from Université Laval and beyond, with the goal of developing new technologies and innovative approaches to tackle pressing challenges across the North.

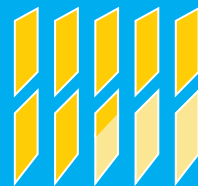
## ADVANCING CONVERGENCE RESEARCH

**50+**   
transdisciplinary teams

**175+**  
professors from  
40 departments  
from Université Laval

## DISSEMINATING RESULTS FOR KNOWLEDGE UPTAKE AND INNOVATION

**1200+** scientific communications



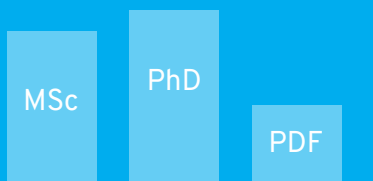
**213**  
peer-reviewed /  
338 publications

**2.09** Interdisciplinary score of SN publications

**1.00** Interdisciplinary world benchmark

## TRAINING THE NEXT GENERATION OF SCIENTISTS FOR THE NORTH

**385**



graduate students and postdoctoral fellows

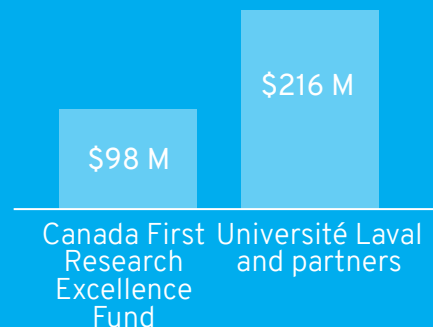
**75+**   
excellence scholarships awarded

## BUILDING PARTNERSHIPS AND COLLABORATIONS

**350+**   
collaborators from  
Canada and abroad

**2.2:1**

Research funding leveraged





Research engineer José Lagunas-Morales adjusts an autonomous underwater vehicle equipped with laser sensors and adapted to explore ice-covered seas.

# Research

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## WHERE ENVIRONMENT, HEALTH, AND TECHNOLOGICAL INNOVATION INTERSECT

The program encourages the development of collaborative research teams and projects that focus on discovery, transdisciplinarity, technological innovation, collaboration, and national and international partnerships. Sentinel North is based on a convergence of strategic research areas in which Université Laval is already a recognized national and international leader, including northern and Arctic sciences, optics-photonics, the microbiome and cardiometabolic health, and neurosciences.



## TOWARDS TRANSFORMATIVE RESEARCH

Between 2017 and 2020, the program achieved its objective of mobilizing a dynamic research community with innovative collaborations, through the establishment of 4 Joint International Research Units, 10 research chairs and 43 research projects regrouping more than 1000 participants in Université Laval and abroad.

### Joint International Research Units

Sentinel North funds Joint International Research Units (JIRUs), associated with Université Laval's four Canada Excellence Research Chairs, that allow the program to benefit from the work of exceptional teams and consolidate collaborations with leading organizations in the pursuit of its research and technological development objectives.



Takuvik JIRU  
National Centre for  
Scientific Research  
France  
Director: Marcel Babin



Consiglio Nazionale  
delle Ricerche

JIRU for Chemical and  
Biomolecular Research of the  
Microbiome and Its Impacts  
on Metabolic Health and  
Nutrition  
National Research Council  
Italy  
Director: Vincenzo Di Marzo



UNIL | Université de Lausanne

JIRU in Child Neural  
Development and  
Psychiatry  
Lausanne University  
Switzerland  
Director: Pierre Marquet



Québec-Brazil Photonics  
Research JIRU  
São Paulo State University  
Brazil  
Director: Younès Messaddeq



## Highlights

- Faster surface current velocities in the Atlantic Ocean are believed to be responsible for the recent poleward intrusion of a phytoplankton species from temperate ecosystems, confirming the biological and physical Atlantification of the Arctic Ocean.
- The combination of large-scale *in situ* measurements and large-footprint sampling of sea ice cover through remote sensing and aerial imaging gives a more accurate estimate of primary phytoplankton productivity.
- Endocannabinoidoma plays a key role in obesity (link between the intestinal microbiota, gut-brain communication, and host metabolism).
- *L-Lactates* may be important molecules for the study of nervous systems conditions with their paradoxical properties, which potentiate and protect neuronal networks.
- Phosphate and chalcogenide glasses have been 3D printed for the first time, which will allow researchers to explore new functionalities of glass and fibre optics.
- A precise tomographic cell imaging method, which allows researchers to see cellular and sub-cellular structures in 3D, reveals the relationship between functional and structural information in the human body.
- A proof of concept has been formulated, revealing the potential for fabricating new HP/HT microfluidic systems with near-UV to mid-IR transparency for spectroscopy and rapid *in situ* detection.

## Selected Communications

- Oziel et al. Faster Atlantic currents drive poleward expansion of temperate phytoplankton in the Arctic Ocean. *Nature Communications*.
- Massicotte et al. Sensitivity of phytoplankton primary production estimates to available irradiance under heterogeneous sea ice conditions. *Journal of Geophysical Research Oceans*.
- Randelhoff et al. Pan-Arctic ocean primary production constrained by turbulent nitrate fluxes. *Frontiers in Marine Science*.
- Forte et al. Obesity affects the microbiota-gut-brain axis and the regulation thereof by endocannabinoids and related mediators. *International Journal of Molecular Sciences*.
- Manca et al. Germ-free mice exhibit profound gut microbiota-dependent alterations of intestinal endocannabinoidome signaling. *Journal of Lipid Research*.
- Jourdain et al. Dual action of *L-Lactate* on the activity of NR2B-containing NMDA receptors: From potentiation to neuroprotection. *Nature: Scientific Reports*.
- Liu et al. Simultaneous dual-contrast three-dimensional imaging cells via optical diffraction tomography and fluorescence. *Photonics Research*.
- Baudet et al. 3D-printing of arsenic sulfide chalcogenide glasses. *Optical Materials Express*.
- Ari et al. Anodic bonding of mid-infrared transparent germanate glasses for high pressure-high temperature microfluidic applications. *Science and Technology of Advanced Materials*.

# Sentinel North Research Chairs

Since 2017, 10 outstanding professors have been recruited as Sentinel North research chairholders at Université Laval with the support of several partners. These young researchers are at the heart of dynamic teams that are already contributing significantly to the program's success and Université Laval's research strengths.



Applications and Theory of Network Analysis  
Antoine Allard  
*Physics, Physical Engineering and Optics*



Aquatic Environmental Geochemistry  
Raoul-Marie Couture  
*Chemistry*



Probing Life and the Environment with Light  
Antoine Godin  
*Psychiatry and Neuroscience*



Relations with Inuit Societies  
Caroline Hervé  
*Anthropology*



Economics and Brain Health  
Marie-Pier Isabelle  
*Economic*



Molecular Neurobiology of Mood Disorders  
Benoît Labonté  
*Psychiatry and Neuroscience*



Impact of Animal Migrations on Arctic Ecosystems  
Pierre Legagneux  
*Biology*



Ecosystemic Approaches to Health  
Mélanie Lemire  
*Social and Preventive Medicine*



Neurobiology of Stress and Resilience  
Caroline Ménard  
*Psychiatry and Neuroscience*



Surveillance of Avian Influenza Viruses in Migratory Birds in Northern Canada  
Gary Wong  
*Microbiology, Infectious Disease, and Immunology*



## Highlights

- Large quantities of selenoneine (a newly identified selenium compound) have been found in the skin of beluga whales and in the Inuit population of Nunavik who consume them; studies suggest that selenoneine may help reduce methylmercury toxicity.
- Exposure to long-chain PFCs is on the rise in Nunavik; these results highlight the importance of strict international regulations on these contaminants to protect the nutritional quality and cultural importance of traditional foods in the Arctic.
- The characteristics of a species, such as size and body mass, influence predator-prey interactions and explain the architecture of the natural food chains that underpin ecosystems' stability and functioning.
- Measurements of dissolved concentrations of rare earth elements in Mackenzie Delta sediments suggest that these elements respond to seasonal changes in redox conditions; concentrations measured are 10 times higher in spring than in fall.
- An analysis of historical Inuit-government relations has shone a light on the tension between the need for more public services in Nunavik and the desire for greater political autonomy.
- Inuit women occupy 83% of the positions in Nunavik's justice services and offer a model of justice based on social harmony.
- Stress-induced neurovascular pathologies should be considered in the treatment of depression.

## Selected Communications

- Achouba et al. Selenoneine is a major selenium species in beluga skin and red blood cells of Inuit from Nunavik. *Chemosphere*.
- Little et al. Determinants of selenoneine concentration in red blood cells of Inuit from Nunavik (Northern Québec, Canada). *Environment International*.
- Cordier et al. Association between exposure to persistent organic pollutants and mercury, and glucose metabolism in two Canadian Indigenous populations. *Environmental Research*.
- Brose et al. Predator traits determine food-web architecture across ecosystems. *Nature Ecology and Evolution*.
- Hervé. Services publics et autonomie chez les Inuit du Nunavik (Arctique québécois). Perspectives ontologiques sur la gouverne des communs sociaux. *Anthropologie et Sociétés*.
- Hervé et al. Les femmes inuit œuvrant au sein des services de justice au Nunavik. Report.
- Dudek et al. Molecular adaptations of the blood-brain barrier promote stress resilience vs. depression. *Proceedings of the National Academy of Sciences*.
- Dudek et al. Neurobiology of resilience in depression: Immune and vascular insights from human and animal studies. *European Journal of Neurosciences*.

## Thematic Projects

Launched in 2017 after Sentinel North's first major call for proposals, the program's 21 initial research projects are grouped into 3 research themes that promote collaboration and transdisciplinarity.



### Research Theme 1

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

More than 40 researchers and 80 students and postdoctoral fellows are exploring northern systems using powerful numerical models and a new generation of optical sensors. Their aim is to gain a better understanding of the complex systems of the North and their internal logic, which depends, among others, on their interactions with each other.

### Highlights

- Trophic interactions influence the phylogenetic and functional structure of vertebrate herbivore communities in the Arctic.
- There is an increased risk of caribou mortality due to habitat alteration from spruce budworm outbreaks, which are likely to increase with climate change.
- A relationship has been observed between changes in turbidity, atmospheric temperature, and precipitation in sediment transport dynamics in permafrost environments in Nunavik's Tasiapik Valley.
- Continuous measurement of water quality using autonomous sensors: a self-powered power supply has been developed based on a microbial fuel cell using bacteria found in northern soil.
- Greenhouse gas detection with integrated silicon photonic sensors: the effect of slow light was demonstrated in a segmented silicon waveguide and a first laser emission was observed in a near-infrared laser designed with a standard silicon layer.
- Fabrication of a glass-polymer hybrid multi-core fibre and characterization of a distributed directional strain sensor for autonomous interrogation systems for permafrost sensors.

### Selected Communications

- Speed et al. Trophic interactions and abiotic factors drive functional and phylogenetic structure of vertebrate herbivore communities across the Arctic tundra biome. *Ecography*.
- Sergeant. Arctic river streamflow records: A potential indicator to predict permafrost dynamics at a regional scale. *Arctic Week conference*.
- Albers et al. Parameter sensitivity analysis of a two-dimensional cryo-hydrogeological numerical model of degrading permafrost near Umiujaq (Nunavik, Canada). *Hydrogeology Journal*.
- Zarabadi et al. Toggling *Geobacter sulfurreducens* metabolic state reveals hidden behaviour and expanded applicability to sustainable energy applications. *Sustainable Energy & Fuels*.
- Amirdehi et al. A high-performance membraneless microfluidic microbial fuel cell for stable, long-term benchtop operation under strong flow. *ChemElectroChem*.
- Gervais et al. Design of slow-light subwavelength grating waveguides for enhanced on-chip methane sensing by absorption spectroscopy. *IEEE Journal of Selected Topics in Quantum Electronics*.
- Ahmadi et al. Comprehensive modeling and design of Raman lasers on SOI for mid-infrared application. *Journal of Lightwave Technology*.
- Zhang et al. Fatigue performance of type I fibre Bragg grating strain sensors. *Sensors*.





## Research Theme 2

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

More than 50 researchers and nearly 140 students and postdoctoral fellows are developing and using new technologies and optical sensors to study the propagation of light through spaces and substrates, its interactions with matter, and its influence on physiology and biorhythms.

### Highlights

- Sensors and methodologies developed for biophilia in extreme environments: invention disclosure, start of patent process and sensor deployment workshop held with the community of Inukjuak.
- First videos recorded *in situ* with adapted near-infrared cameras to show lemming movements and activity under the snow.
- The metabolic molecular network of *Fragilariopsis cylindrus* is believed to be resilient to cellular perturbations due to its flexibility and adaptation to the extreme conditions of the Arctic.
- A miniaturized probe for the measurement of spectral radiance inside sea ice was developed.
- Organic photovoltaic cells with approximately 15% energy conversion were printed, which is beneficial for portable instruments used in extreme Arctic conditions.
- Methane detection in the North: a powerful narrow-spectrum laser source was developed with a central wavelength that can be tuned around an absorption line.
- An underwater multispectral 3D LiDAR system was designed for remote monitoring of Arctic substrates of biological interest, such as the seabed and the underside of sea ice.

### Selected Communications

- Lalande et al. Spatial representations of melanopic light in architecture. *Architectural Science Review*.
- Kalhor et al. Using near infrared for studying lemming subnival behavior in the High Arctic. *Proceedings*.
- Poirier et al. What guides lemmings' movements through the snowpack? *Journal of Mammalogy*.
- Lavoie et al. Genome-scale metabolic reconstruction and *in silico* perturbation analysis of the polar diatom *Fragilariopsis cylindrus* predicts high metabolic robustness. *Biology*.
- Perron et al. New tools for optical measurements in sea ice. *Polar Marine Science Gordon conference*.
- Yuan et al. Single-junction organic solar cell with over 15% efficiency using fused-ring acceptor with electron-deficient core. *Joule*.
- Lapointe et al. Nonlinear increase, invisibility, and sign inversion of a localized fs-laser-induced refractive index change in crystals and glasses. *Light: Science & Applications*.
- Jamet et al. Going beyond standard ocean color observations: Lidar and polarimetry. *Frontiers in Marine Science*.
- Roudjane et al. Detection of neuromuscular activity using new non-invasive and flexible multimaterial fiber dry-electrodes. *IEEE Sensors Journal*.
- Vincent. Arctic climate change: Local impacts, global consequences, and policy implications. *The Palgrave Handbook of Arctic Policy and Politics*.



### Research Theme 3

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

More than 75 researchers and 140 students and postdoctoral fellows are developing tools such as photonic sensors and collection and analysis methods for a wide range of microbiological data in marine and terrestrial ecosystems, as well as foods and humans. Their aim is to determine the roles of microbiomes in the human-environment ecosystem in the North.

#### Highlights

- Genomic analysis shows that the new *Candidate Phyla Radiation* bacteria may play a key biogeochemical role in carbon and methane cycling in aquatic environments.
- Patent pending for the EcoChip, a wireless multi-sensor platform for environmental monitoring.
- Significant variability in omega-3 and carotenoid concentrations was observed for benthic fauna between Nunavik villages.
- The genetic diversity of Arctic char populations varies according to the regions of Nunavik and their adaptation to the freshwater and marine environment. This finding could help local and regional decision-makers in fisheries management and Arctic char conservation.
- Reliable, efficient, and transferrable mercury detection in a portable instrument for northern regions: studying the behaviour of a new thionocarbonate- and fluorescein-based mercury-sensitive probe.
- Microbial contaminants in northern dwellings affect the mechanisms that regulate lung inflammation and the amplification of immune responses.
- The gut microbiome has been demonstrated to have therapeutic applications for body detoxification from persistent organic pollutants.
- Polyphenols may be beneficial in cardiometabolic diseases: role of host-microbe interactions.

#### Selected Communications

- Vigneron et al. *Candidate Phyla Radiation* bacteria are potential catalysts of carbon transformation in a thermokarst lake ecosystem. *Limnology and Oceanography*.
- Vigneron et al. Microbial community structure and methane cycling potential along a thermokarst pond-peatland continuum. *Microorganisms*.
- Lemire. Unexpected linkages between the coastal ocean and Inuit health. *Gordon Research Conference on Marine Polar Science*.
- Dallaire et al. Population structure and genomic evidence for local adaptation to freshwater and marine environments in anadromous Arctic Char (*Salvelinus alpinus*) throughout Nunavik, Canada. *BioRxiv*.
- Picard-Lafond et al. Revealing the hydrolysis mechanism of a Hg<sup>2+</sup>-reactive fluorescein probe: Novel insights on thionocarbonated dyes. *ACS Omega*.
- Choi et al. Potential therapeutic applications of the gut microbiome in obesity: From brain function to body detoxification. *International Journal of Obesity*.
- Anhê et al. Host-microbe interplay in the cardiometabolic benefits of dietary polyphenols. *Trends in Endocrinology & Metabolism*.

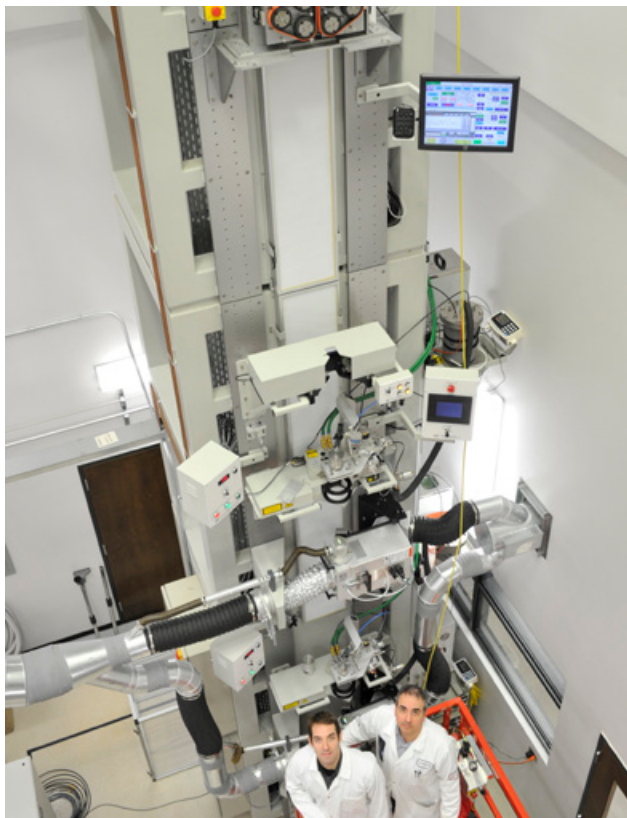
## USING TECHNOLOGICAL INNOVATION IN RESEARCH

Carrying out all the steps of designing a new technology, from developing to operating the sensors and systems, the Technological Instrument Development Platform team has worked with more than a dozen Sentinel North research projects in the past year. The members used their expertise to benefit the community, actively participating in the advancement of knowledge and the study of northern environments through technologies such as a satellite communication module, prototypes for tracking migratory mammals and birds, and a limnological probe.



*The technological developments achieved so far are world leading. CFREF funding has enabled Sentinel North to advance in the development of potentially transformational technology that is already showing great potential in the Arctic and beyond.*

[Report of the international expert panel following the Sentinel North mid-term evaluation](#)



The Technology Instrument Development Platform offers state-of-the-art infrastructure and a wealth of expertise to the Sentinel North community.

## NEW PROJECTS FOR THE NORTH

Four new research projects were launched in August 2019 following a targeted call for proposals with an envelope of \$2 million over three years. The new projects bring together experts from different disciplines who work closely with Inuit communities and organizations to address issues surrounding drinking water, housing, food security, and extreme weather events.



### **An atlas of best practices for culturally acceptable and sustainable living environments in Nunavik**

Principal investigators: Geneviève Vachon, Architecture, ULaval; Michel Allard, Geography, ULaval

### **An on-line advanced foresight tool of extreme meteorological events and natural hazards in Nunavik**

Principal investigators: Richard Fortier, Geology and Geological engineering, ULaval; Thierry Badard, Geomatics, ULaval

### **Early warning system for drinking water management and monitoring through the analysis of online and continuous environmental data**

Principal investigators: Manuel J. Rodriguez, Land Use Planning and Regional Development, ULaval; Daniel Nadeau, Civil and Water Engineering, ULaval

### **Participatory action for Inuit-led research on food production and nutrition in Inuit Nunangat**

Principal investigators: Patrice Dion, Phytology, ULaval; Caroline Hervé, Anthropology, ULaval

## PARTNERSHIP RESEARCH

Sentinel North is partnering with other institutions in Québec and abroad to develop research projects and maximize transdisciplinary collaborations. In 2019-2020, joint calls for proposals with the Institut nordique du Québec have made it possible to launch 7 new research projects, involving researchers from several Québec universities, on sustainable development and health in Northern Québec.



### **Dynamics of the Innu ancestral territory through the morpho-sedimentary and socio-cultural study of Lake Manicouagan**

Principal investigator: Patrick Lajeunesse, Geography, ULaval

### **Linking the marine environment and the nutritional quality of shellfish and beluga near Quaqtaq**

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

### **Housing and energy transition in Nunavik: A better understanding of human, technical and environmental issues**

Principal investigator: Louis Gosselin, Mechanical Engineering, ULaval

### **Impacts of climate change and browning on salmonid oxythermal habitat and greenhouse gas emissions in Arctic regions**

Principal investigator: Isabelle Laurion, Aquatic Ecology and Bio-optics, INRS-ÉTÉ

### **The use of liquid biopsies for monitoring the health of coastal marine ecosystems**

Principal investigator: Yves St-Pierre, Molecular Immunology, INRS-IAF

### **Nunatsiavut coastal interactions project: Climate, environment and Labrador Inuit subsistence strategies**

Principal investigator: James Woollett, Historical Sciences, ULaval

### **Technical-social solutions to expand the use of renewable energy from Whapmagoostui-Kuujuarapik to other regions of Nunavik**

Principal investigator: Jasmin Raymond, Hydrogeology, INRS

Projects co-funded with the Arctic University of Norway (UiT) and France's Université Côte d'Azur in 2018 - 2019 pursued their activities in the last year.

#### **Net-zero energy buildings in the High North**

Principal investigators: Louis Gosselin, Mechanical engineering, ULaval; Raymond Riise, Construction, Energy and Materials Technology, UiT

#### **The characterization of underneath sea-ice light field variability in the Arctic Ocean using underwater and aerial autonomous vehicles**

Principal investigators: Marcel Babin, Biology, ULaval; Jørgen Berge, Marine and Arctic Biology, UiT

#### **The impact of light and temperature on Calanus activity patterns in the Arctic**

Principal investigators: Louis Fortier, Biology, ULaval; Malin Daase, Marine and Arctic Biology, UiT

#### **Artificial intelligence application for to the identification of functional traits of zooplankton from high-resolution images**

Principal investigators: Frédéric Maps, Biology, ULaval; Eric Debreuve, Biotechnologies, UCA

#### **Characterization of essential oils and new natural products from the North**

Principal investigators: Normand Voyer, Chemistry, ULaval; Xavier Fernandez, Chemistry, UCA

#### **Frame shift mutation-induced ATI influence on the microbiome**

Principal investigators: Arnaud Droit, Molecular Medicine, ULaval; Guillaume Sandoz, Biology, UCA

#### **Screening for emerging Arctic health risks to circumpolar human populations**

Principal investigators: Pierre Ayotte, Social and Preventive Medicine, ULaval; Torkjel M. Sandanger, Community Medicine, UiT

#### **Calanus redness index from artificial intelligence applications to image analysis**

Principal investigators: Frédéric Maps, Biology, ULaval; Sünnje Basedow, Marine and Arctic Biology, UiT

#### **The role of circadian clocks in seasonal synchrony in the Arctic**

Principal investigators: Johann Lavaud, Biology, ULaval; David Hazlerigg, Marine and Arctic Biology, UiT

#### **Development of photonic devices to generate mid-infrared laser pulses suitable for remote gas spectroscopy**

Principal investigators: Martin Bernier, Physic, Physical engineering and Optics, ULaval; Bernard Dussardier, Photonics, UCA

#### **Pinealocyte-derived melatonin: A chronobiotic hormone that modulates the effects of photoperiod on energy homeostasis and metabolic dysfunctions**

Principal investigators: Denis Richard, Medicine, ULaval; Carole Rovère, Molecular and Cellular Pharmacology, UCA

**UiT** / THE ARCTIC UNIVERSITY OF NORWAY

UNIVERSITÉ CÔTE D'AZUR 



The training activities offered by Sentinel North promote the technological, experiential and cultural components of northern research.

# Training

## A STRATEGY DRIVEN BY EXCELLENCE, ENGAGEMENT AND EXPERIENCE

Sentinel North is deploying an innovative training strategy to attract and train the best students from Canada and abroad, fostering a new generation of scientists who are capable of using transdisciplinary work to tackle the complex and changing issues of the North.



## UNIQUE EXPERIENTIAL TRAINING

Sentinel North's unique experiential training allows students and postdoctoral fellows from around the world to immerse themselves in northern research. The program also offers numerous workshops that promote the development of future skills such as complex thinking, problem solving, creativity, adaptability, communication, and social responsibility.

In 2019-2020...

**140+** participants furthered their knowledge of the changing North through Sentinel North's international PhD schools.

**30+** internationally renowned experts collaborated on these cutting-edge training sessions, which focused on transdisciplinary collaboration.



Students, professionals, and mentors further developed their skills during a unique experiential training opportunity in the North. Local Cree and Inuit communities were involved in the implementation of this school, greatly encouraging multicultural exchanges and contributing to the success of the training.

In 2019-2020, the three international PhD schools [Permafrost Engineering Applied to Transportation Infrastructure](#) (Inuvik, Northwest Territories), [Arctic Microbiomes: From Molecules and Microbes to Ecosystems and Health](#) (Whapmagoostui-Kuujuarapik, Nunavik) and [Complex Networks: Networks of the North, Structure and Function](#) (Quebec) allowed participants to collaborate with their peers from other disciplines, develop theoretical and practical knowledge, and interact with northern communities.

Sentinel North has also collaborated and actively participated in local, national, and international training initiatives, including Institut nordique du Québec's Introduction to Research and Northern Issues, Frontiers in Neurophotonics with the CERVO Brain Research Centre, and the North American Summer School on Photonic Materials organized by the Centre for Optics, Photonics and Lasers.



## SCHOLARSHIPS AND FELLOWSHIPS TO SUPPORT THE NEXT GENERATION

Sentinel North encourages qualified candidates to undertake or pursue transdisciplinary research activities through excellence scholarships and student mobility support grants, facilitating the sharing of knowledge and experience across borders. A new mobility fund for postdoctoral fellows was launched in April 2019 to allow recipients to travel outside Québec to acquire new knowledge and develop research partnerships.



The new excellence scholarship recipients were highlighted at the 2019 Sentinel North Scientific Meeting.



The Sentinel North Student Association (AÉSN) aims to improve the educational experience of Université Laval's students by promoting a transdisciplinary learning ecosystem and providing networking opportunities between the students, researchers, and partners. By participating in the development and dissemination of Sentinel North's activities, the AÉSN contributes to the success of the program's training strategy.

In 2019-2020, the AÉSN organized a transdisciplinary challenge with students and postdoctoral fellows from some 20 disciplines that had to combine their complementary strengths to solve a complex technical problem focused on northern issues.



Congratulations to the winners of the transdisciplinary challenge: Audrée Gilbert (MBA in Business Management), Floriane Bretheau (Molecular Medicine and Neurosciences), Pascal Paradis (Physics), and Catherine Gravel (Food Science and Technology)!



Collaborations between northern communities and researchers drive results for a more sustainable North.

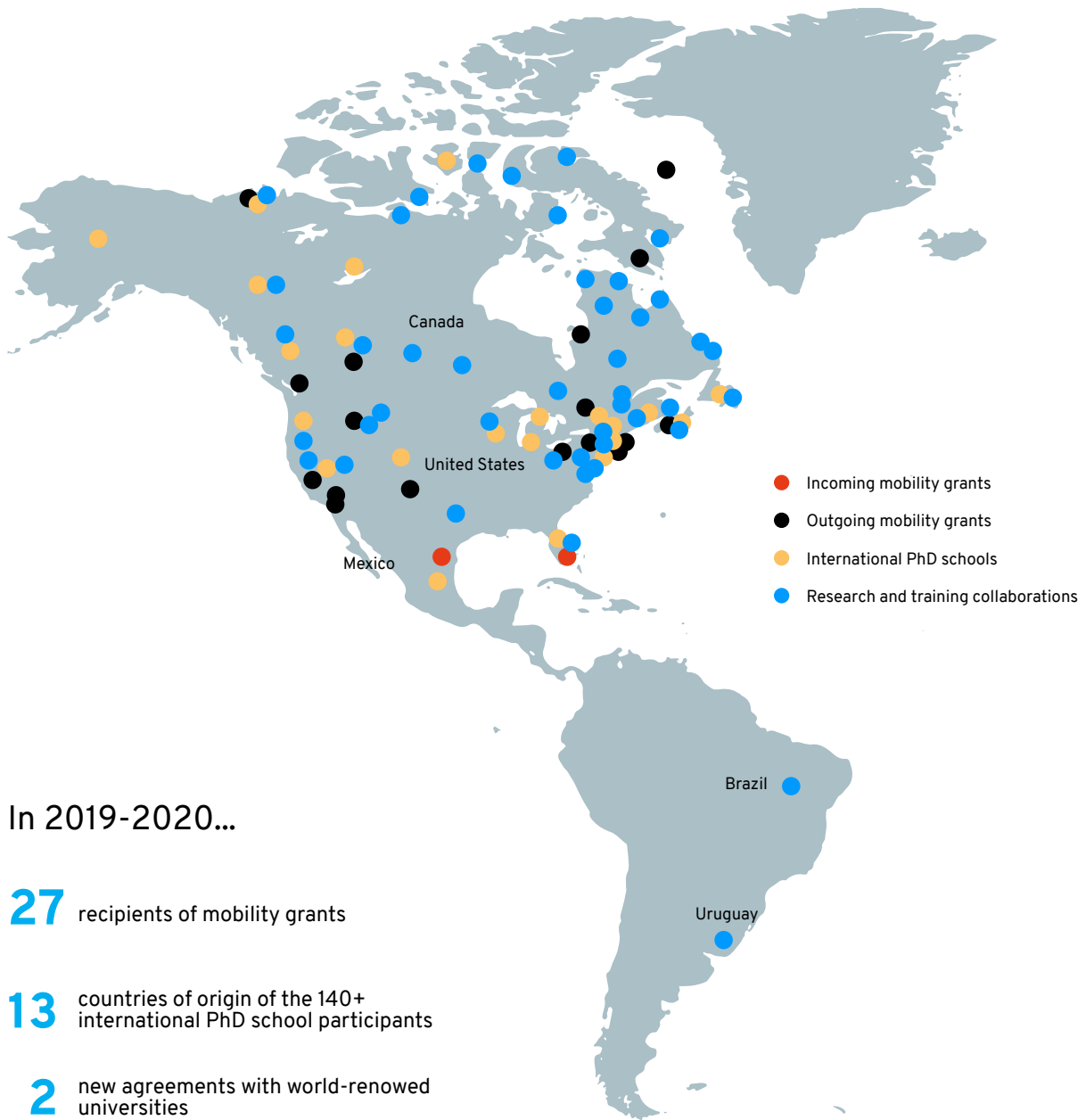
# Partnerships and Collaborations

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## SYNERGISTIC RELATIONS IN RESEARCH AND TRAINING

Sentinel North relies on a network of northern, academic, public, and private partners, supported by many research centres and clusters, to sustain its research and training activities. Collaborations are based on a willingness to work with world-renowned institutions and researchers to develop innovative joint projects that foster long-term cooperation.





In 2019-2020...

**27** recipients of mobility grants

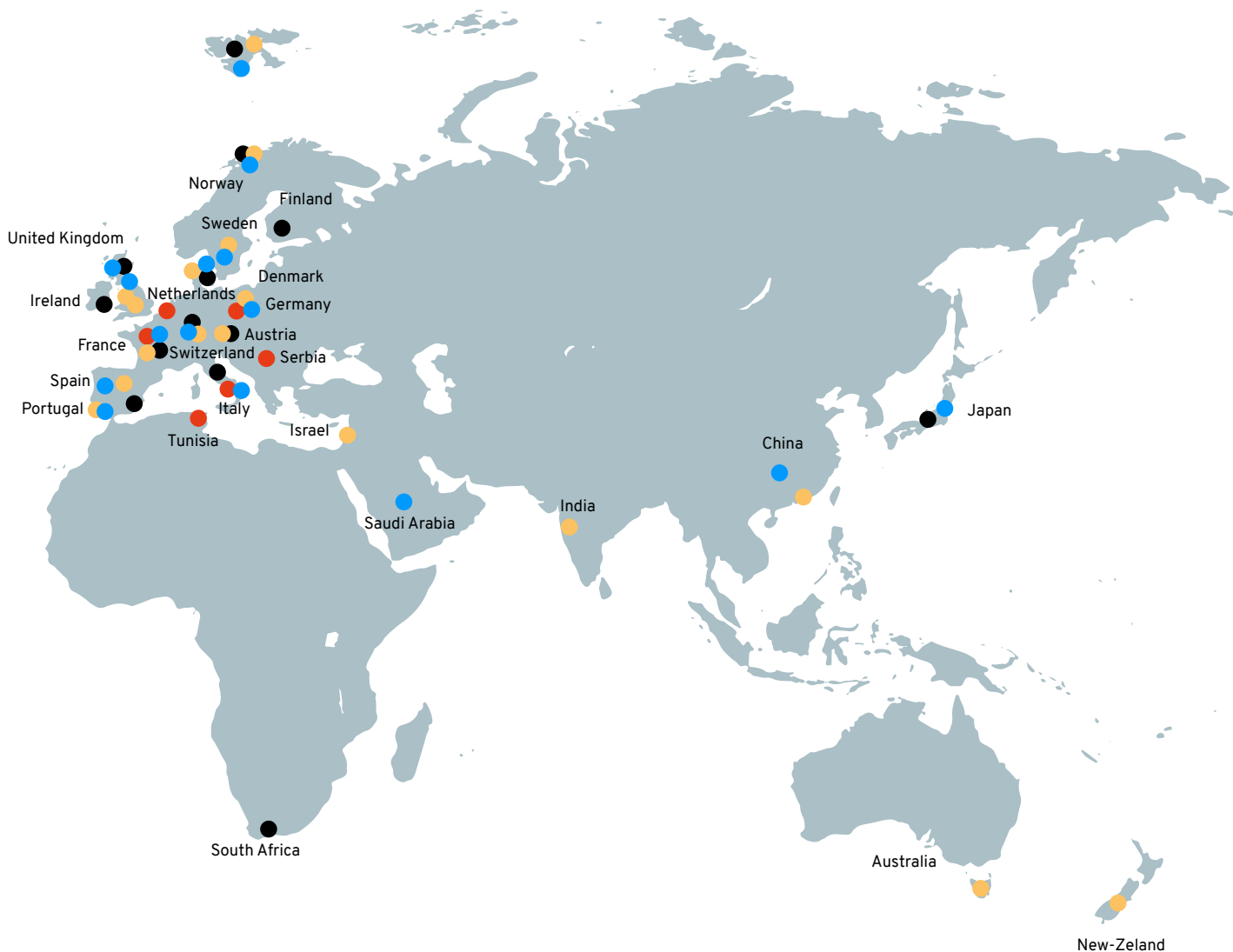
**13** countries of origin of the 140+ international PhD school participants

**2** new agreements with world-renowned universities

## INTERNATIONAL COLLABORATIONS

Since its inception, Sentinel North has encouraged transdisciplinary research with academic, public and private partners, as well as northern and indigenous organizations. More than 350 collaborators in 300 institutions in Canada and abroad enhance the program by bringing additional expertise to the table.

Several of Sentinel North’s international collaborations are part of the 4 Joint International Research Units (with research centres and universities in France, Brazil, Switzerland and Italy) and the 11 joint projects funded with The Arctic University of Norway (UiT) and Université Côte d’Azur (France).



Eugénie Brouillet, Vice-Rector, Research and Innovation at Université Laval, and Jean Chambaz, President of Sorbonne University, signed a letter of intent for a preferred partnership between the two institutions in December 2019.

## NEW AGREEMENTS WITH TOP-RANKING UNIVERSITIES

Over the past year, Sentinel North has helped Université Laval establish new partnership agreements with top-ranking French universities with the goal of uniting the institutions' complementary talents in response to international issues.

A delegation from Sorbonne University visited Québec City in April 2019; in December of that year, senior management from Université Laval and Sentinel North visited Paris and signed a partnership letter of intent.

A strategic partnership agreement is also being developed with Université PSL (Paris Sciences & Lettres) to consolidate the collaborations between the institutions, particularly in oceanography of ice-covered seas and neurosciences.



The Sentinel North Scientific Meeting is an opportunity to share research results to improve our understanding of the northern environment and its impact on human beings and their health.

# Communication and Outreach

## MOBILIZING TO DISSEMINATE AND PROMOTE KNOWLEDGE

Sentinel North's communications initiatives are part of a strategic plan to highlight transdisciplinary and innovative research and training, as well as Université Laval's institutional strategy. The success of the program's outreach and knowledge dissemination efforts stems from the contributions of an engaged community, high-impact publications by Sentinel North's researchers, and numerous national and international activities.



## SPOTLIGHT ON RESEARCH

### Scientific Publications and Communications

Over the past few years, Sentinel North teams have joined forces to generate knowledge and technological advances that lead to a better understanding of the changing northern environment and its impact on health. As a number of research teams funded in 2017 near the completion of their projects, scientific results and publications are increasing.

In 2019-2020...

**700+**

scientific publications and communications, including more than 100 scientific papers and over 500 oral and poster communications.

### Research Community in the Media

Recent scientific advances have attracted media attention in Canada and abroad. The presence of researchers in newspapers, on television or radio increases the dissemination of knowledge to a wide audience.

In 2019-2020...

**70+**

publications in the media

- Le dollar américain dicte le destin du caribou, *ICI Québec, Radio-Canada*
- Des recherches pour lutter contre la contamination d'aliments consommés dans le Nord, *Espaces autochtones, Radio-Canada*
- Microbes in the Canadian Arctic, *Nunataryuk News*
- Pole-to-pole study of ocean life identifies nearly 200,000 marine viruses, *Science News, Science Daily*
- Could climate change help the Arctic's kelp flourish? Researchers are trying to find out, *CBC News*
- Plonger dans l'étude des lacs de thermokarst, *Le Devoir*
- L'océan arctique, berceau de la diversité virale, *Le Monde*
- Entrevue avec Sylvain Moineau, un microbiologiste qui a joué un rôle fondamental dans la compréhension de CRISPR-Cas9, *Découverte*
- Un projet architectural qui ne laisse personne de glace, *Le Fil*



# COMMITMENT TO OPEN ACCESS

Sentinel North and Université Laval are committed to promoting open access as part of the worldwide movement to support the dissemination of scholarly publishing and open science in order to democratize knowledge.

213

Sentinel North peer-reviewed publications

Sentinel North has launched an Authors Fund available to its research teams to help cover their costs of publishing articles in open access and to encourage 1<sup>st</sup> author publications by graduate students and postdoctoral fellows.

Corpus<sup>UL</sup>, Université Laval's institutional repository, preserves and enables easy and open access to scientific literature.

60%

of Sentinel North publications available in open access

World Level Benchmark 37%

Sentinel North



Open access increases the visibility and impact of research, stimulates interdisciplinary collaboration and innovation, and promotes diversity and equality of access to scientific knowledge to help advance and improve society.

## SHARING KNOWLEDGE

Sentinel North's researchers, students and postdoctoral fellows are working to make science accessible by participating in major conferences, exchanging their knowledge with their peers, and sharing their findings with various stakeholders.

### Convergence Research to Address an Urgent Issue

By uniting their strengths in ecology, population health, and infectious disease research, teams from three Sentinel North research chairs, led by professors Pierre Legagneux, Mélanie Lemire, and Gary Wong, demonstrated, in May 2020, the absence of coronavirus in snow geese, an important species for food security in the North. This study addressed the concerns of the teams' northern partners and the results were quickly shared with the communities through coordinated efforts with the local authorities.



### Drinking Water from Source to Tap

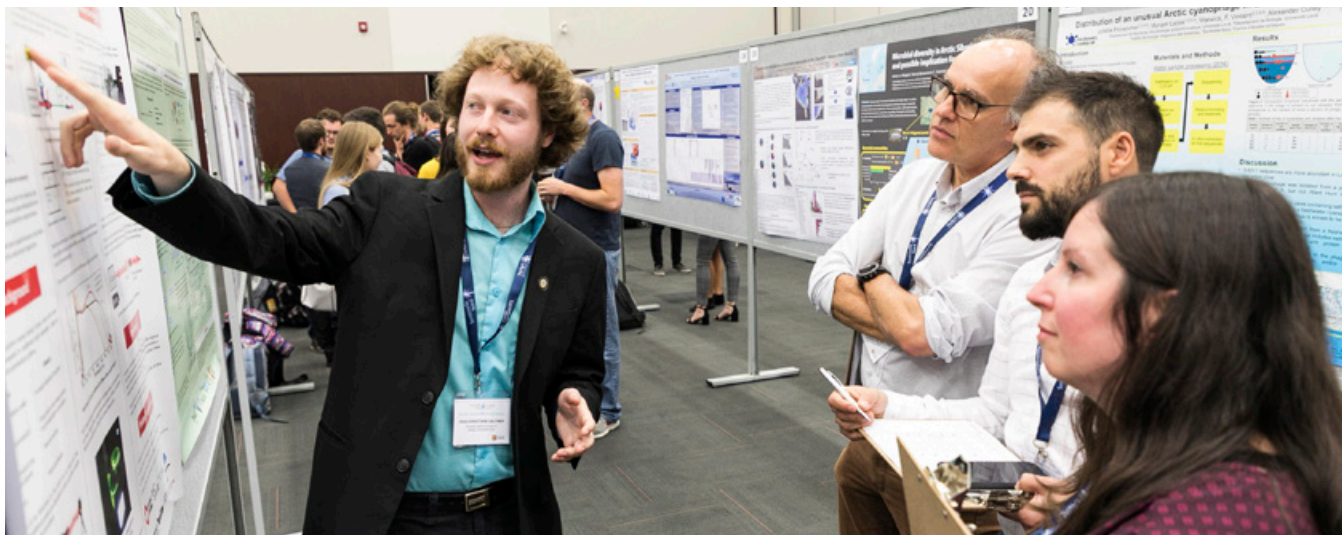
As part of her research project on drinking water management and monitoring strategies in Nunavik, postdoctoral student Stéphanie Guilherme initiated different outreach activities at the Kangiqsualujjuaq and Salluit (Nunavik) high schools. These activities ranged from presenting her project to introducing students to handling water samples for quality tests. Her theme was explored further during a day of activities focused on drinking water as part of the Expo-Sciences program in Salluit in February 2020.

### Biophilia in Extreme Climates

Under the direction of Claude Demers and André Potvin, master's students and postdoctoral fellows participated in a codesign workshop with the community of Cambridge Bay as part of their research on using architecture to optimize biophilia in extreme climates. Since 2019, several other initiatives have been deployed to exchange and share knowledge, including the deployment of sensors with Inuit youth at the Inukjuak (Nunavik) high school and presenting their findings in Inuktitut to the Innalik elementary school. Three introductory research scholarships were awarded to Inuit youth.

## Sentinel North Scientific Meeting

From August 26 to 28, 2019, Sentinel North's community discussed northern issues with national and international partners during the Sentinel North Scientific Meeting, which was attended by nearly 400 people.



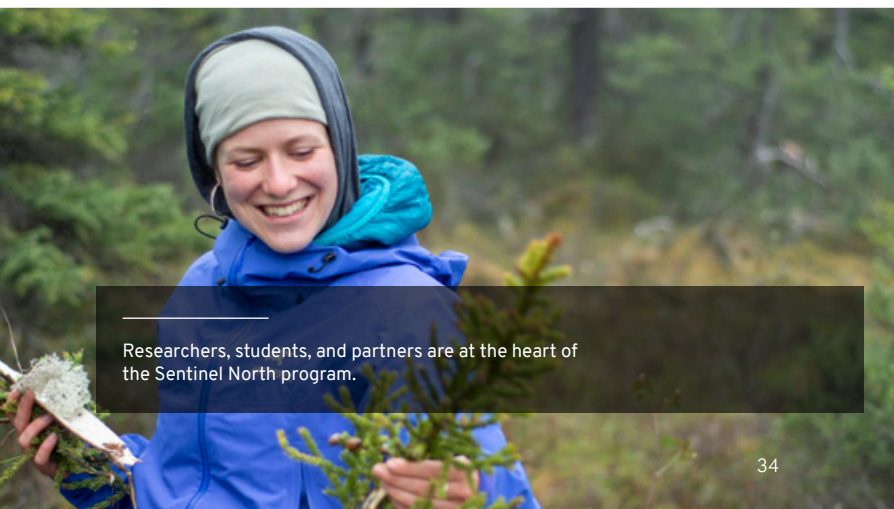
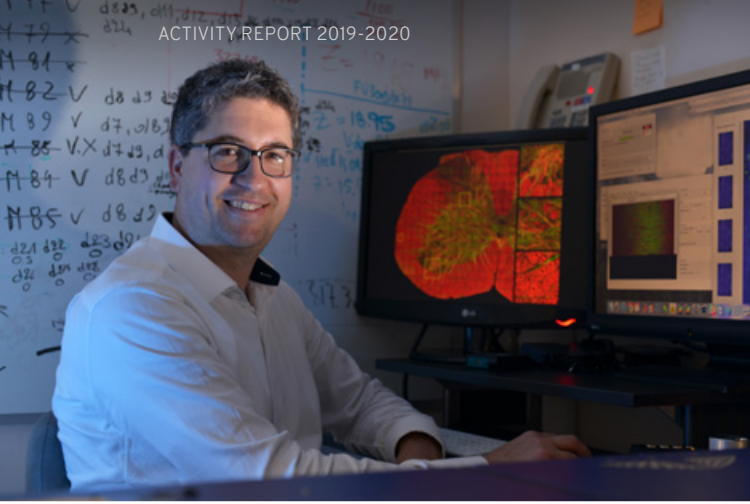
The poster sessions are key moment in Sentinel North Scientific Meeting.

## Women in Science

As part of the International Day of Women and Girls in Science on February 11, 2020, Sentinel North and its partners hosted an event that brought together various stakeholders in the academic and professional communities to discuss the place of women in science and engineering and shed light on best practices for shaping more inclusive, effective, and forward-thinking environments. The activity, led by Université Laval's rector Sophie D'Amours, was a great success, with more than 200 people attending in person and via webcast.



In accordance with Université Laval and CFREF's policies, Sentinel North does not tolerate discrimination of any kind. It is also committed to fostering a fair, diverse, and inclusive environment where people of different backgrounds, genders, sexual orientations, and ages can grow and reach their full potential.



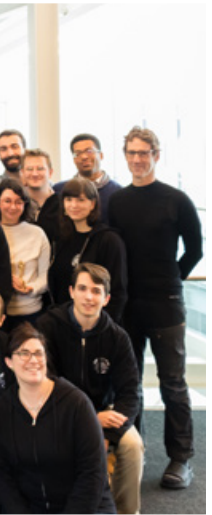
Researchers, students, and partners are at the heart of the Sentinel North program.



# The Sentinel North Community

## A NETWORK FOR INNOVATION

The Sentinel North program includes hundreds of participants from Université Laval who work with their partners from northern communities and organizations, federal and provincial agencies, and the public and private sector in Canada and abroad to improve our understanding of the northern environment and its impact on humans and their health. This vast network is developing innovative projects and deploying initiatives to promote research, training, and the sharing of knowledge.



## RESEARCHERS AND COLLABORATORS – UNIVERSITÉ LAVAL

About 200 researchers from 40 Université Laval departments are working in convergence on various Sentinel North research projects.

### ANIMAL SCIENCES

Bailey, Janice  
Vandenberg, Grant

### ANTHROPOLOGY

Bourdages-Duclos, Sarah  
Hervé, Caroline

### ARCHITECTURE

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

### BIOCHEMISTRY, MICROBIOLOGY, AND BIO-INFORMATICS

Boissinot, Maurice  
Charette, Steve  
Culley, Alexander  
De Koninck, Paul  
Duchaine, Caroline  
Frenette, Michel  
Hardy, Simon  
Lagüe, Patrick  
Moineau, Sylvain  
Paquet, Marie-Ève  
Trudel, Luc

### BIOLOGY

Archambault, Philippe  
Babin, Marcel  
Bernatchez, Louis  
Boudreau, Stéphane  
Côté, Steeve  
Derome, Nicolas  
Fortier, Louis  
Fortin, Daniel  
Gauthier, Gilles  
Johnson, Ladd  
Landry, Christian  
Lavaud, Johann  
Legagneux, Pierre  
Levasseur, Maurice  
Lovejoy, Connie  
Maps, Frédéric  
Massé, Guillaume  
Moore, Jean-Sébastien  
Saulier-Talbot, Émilie  
Suskiewicz, Matthew  
Tremblay, Jean-Éric  
Tremblay, Jean-Pierre  
Villarreal Aguilar, Juan Carlos  
Vincent, Warwick F.

### CHEMISTRY

Boudreau, Denis  
Couture, Raoul-Marie  
Dominé, Florent  
Greener, Jesse  
Johnson, Paul A.  
Larivière, Dominic  
Leclerc, Mario  
Morin, Jean-Francois  
Ritcey, Anna  
Voyer, Normand

### CIVIL AND WATER ENGINEERING

Anctil, François  
Doré, Guy  
Locat, Ariane  
Nadeau, Daniel

### COMPUTER SCIENCE AND SOFTWARE ENGINEERING

Laviolette, François  
Pomerleau, François

### DENTISTRY

Grenier, Daniel

### ECONOMICS

Doyon, Maurice  
Isabelle, Maripier

### ELECTRICAL AND COMPUTER ENGINEERING

Bélanger, Louis N.  
Deschênes, Jean-Daniel  
Fortier, Paul  
Gosselin, Benoit  
Lalonde, Jean-François  
LaRoche, Sophie  
Laurendeau, Denis  
Maldague, Xavier  
Miled, Amine  
Rusch, Leslie Ann  
Shi, Wei

### FOOD SCIENCES

Angers, Paul  
Roy, Denis

### GEOGRAPHY

Allard, Michel  
Antoniades, Dermot  
Berthold, Étienne  
Bhiry, Najat

Cloutier, Danielle  
Desbiens, Caroline  
Gagnon, Justine  
Lajeunesse, Patrick  
Lasserre, Frédéric  
Pienitz, Reinhard

### GEOLOGY AND GEOLOGICAL ENGINEERING

Fortier, Richard  
Lemieux, Jean-Michel  
Molson, John  
Therrien, René

### GEOMATICS

Badard, Thierry  
Pouliot, Jacynthe

### HISTORICAL SCIENCES

Woollett, James

### KINESIOLOGY

Després, Jean-Pierre  
Tremblay, Angelo

### LAND USE PLANNING AND REGIONAL DEVELOPMENT

Cloutier, Geneviève  
Rodriguez-Pinzon, Manuel J.

### LAW

Krolik, Christophe

### MANAGEMENT

Garand, Denis J.

### MATHEMATICS AND STATISTICS

Doyon, Nicolas  
Rivest, Louis-Paul

### MECHANICAL ENGINEERING

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

**MEDICINE**

Agharazii, Mohsen  
Boulet, Louis-Philippe  
Chahine, Mohamed  
Di Marzo, Vincenzo  
Dupré, Nicolas  
Flamand, Nicolas  
Maltais, François  
Marette, André  
Marsolais, David  
Maziade, Michel  
Morissette, Mathieu  
Paulin, Roxane  
Puymirat, Jack  
Richard, Denis  
Silvestri, Cristoforo  
Théberge, Julie

**MICROBIOLOGY, INFECTIOUS DISEASE, AND IMMUNOLOGY**

Bergeron, Michel  
Lévesque, Roger  
Ouellette, Marc  
Papadopoulou, Barbara  
Richard, Dave  
Wong, Gary

**MOLECULAR BIOLOGY, MEDICAL BIOCHEMISTRY, AND PATHOLOGY**

Bilodeau, Steve

**MOLECULAR MEDICINE**

Corbeil, Jacques  
Droit, Arnaud

**NURSING**

Gagnon, Marie-Pierre

**NUTRITION**

Levy, Emile  
Raymond, Frédéric  
Veilleux, Alain  
Vohl, Marie-Claude

**OPHTHALMOLOGY AND ORL-HEAD AND NECK SURGERY**

Hébert, Marc

**PEDIATRICS**

Bélangier, Richard

**PHARMACY**

Barbier, Olivier  
Calon, Frédéric  
Picard, Frédéric  
Soulet, Denis

**PHYSICS, PHYSICAL ENGINEERING, AND OPTICS**

Allard, Antoine  
Allen, Claudine  
Bernier, Martin  
Côté, Daniel  
Després, Philippe  
Desrosiers, Patrick  
Dubé, Louis J.  
Galstian, Tigran  
Lavoie-Cardinal, Flavie  
Messaddeq, Younès  
Piché, Michel  
Thibault, Simon  
Vallée, Réal

**PHYTOLOGY**

Desjardins, Yves  
Dion, Patrice  
Dorais, Martine  
Dudonné, Stéphanie  
Rocheport, Line

**POLITICAL SCIENCES**

Rodon, Thierry  
Therrien, Aude

**PSYCHIATRY AND NEUROSCIENCE**

De Koninck, Yves  
Godin, Antoine  
Kriz, Jasna  
Labonté, Benoit  
Lévesque, Martin  
Marquet, Pierre  
Ménard, Caroline  
Mérette, Chantal  
Parent, André  
Parent, Martin

**PSYCHOLOGY**

Forget-Dubois, Nadine  
Jackson, Philip  
Muckle, Gina

**REHABILITATION**

Batcho, Charles  
Blanchette, Andréanne  
Bouyer, Laurent  
Lamontagne, Marie-Ève  
Massé-Alarie, Hugo  
McFadyen, Bradford  
Mercier, Catherine  
Routhier, Francois  
Roy, Jean-Sébastien

**SOCIAL AND PREVENTIVE MEDICINE**

Ayotte, Pierre  
Bureau, Alexandre  
Fletcher, Christopher  
Lemire, Mélanie  
Lévesque, Benoit  
Lucas, Michel

**SURGERY**

Mathieu, Patrick

**WOOD AND FOREST SCIENCES**

Blanchet, Pierre  
Desrochers, André

## INTERINSTITUTIONAL RESEARCH CENTRES AND GROUPS – UNIVERSITÉ LAVAL

Sentinel North's research teams work in close collaboration with many of Université Laval's interinstitutional research centres and groups.

Aluminium Research Centre

Amundsen Science

ArcticNet Network of Centres of Excellence

Big Data Research Center

Centre for Forest Research

Centre for Interdisciplinary Research in Rehabilitation and Social Integration

Centre for Northern Studies

Centre for Optics, Photonics and Lasers

Centre for Research in Geomatics

Centre for Research in Regional Planning and Development

Centre in Green Chemistry and Catalysis

Centre intégré universitaire de santé et de services sociaux de la Capitale-Nationale

CentrEau

CERVO Brain Research Centre

CHU de Québec Research Centre

Infectious Disease Research Centre

Institut Hydro-Québec en environnement, développement et société

Institut national de santé publique du Québec

Institut nordique du Québec

Institute of Integrative Biology and Systems

Institute of Nutrition and Functional Foods

Interdisciplinary Research Group on Suburbs

JIRU for Chemical and Biomolecular Research on the Microbiome and its Impact on Metabolic Health and Nutrition (ULaval-CNR, Italy)

JIRU in Neurodevelopment and Child Psychiatry (ULaval-University of Lausanne, Switzerland)

Johnson Benthic Ecology Laboratory

Neuroscience Thematic Research Centre

Oral Ecology Research Group

Physical Ambiances Research Group

Québec Centre for Functional Materials

Quebec Heart and Lung Institute Research Centre

Quebec Mental Health Institute

Québec Network for Research on Protein Function, Engineering, and Applications

Québec-Brazil Photonics Research JIRU (ULaval-UNESP, Brésil)

Québec-Océan

Regroupement pour l'étude des environnements partagés intelligents répartis

Ressources aquatiques Québec Takuvik JIRU (ULaval-CNRS, France)

ULaval Interdisciplinary Centre for Mathematical Modeling

ULaval Machine Learning Group



## PARTICIPATING RESEARCH CHAIRS – UNIVERSITÉ LAVAL

Nearly 40 research chairs contribute to the Sentinel North program through various projects.

### 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 Neurophotronics (Pierre Marquet)

### CANADA RESEARCH CHAIRS (CRCS)

CRC in Advanced Photonic Technologies for Communications (Sophie LaRochelle)

CRC in Antimicrobial Resistance (Marc Ouellette)

CRC in Aquatic Ecosystem Studies (Warwick F. Vincent)

CRC in Aquatic Environments and Water Quality (Antoniades Dermot)

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

CRC in Bacteriophages (Sylvain Moineau)

CRC in Biophotonics (Daniel Côté)

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

CRC in Communications Systems Enabling the Cloud (Leslie Ann Rusch)

CRC in Electroactive and Photoactive Polymers (Mario Leclerc)

CRC in Evolutionary Cell and Systems Biology (Christian Landry)

CRC in Genetic Conservation of Aquatic Resources (Louis Bernatchez)

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

CRC in Lactic Cultures Biotechnology for Dairy and Probiotic Industries (Denis Roy)

CRC in Liquid Crystals and Behavioral Biophotonics (Tigran Galstian)

CRC in Medical Genomics (Jacques Corbeil)

CRC in Multipolar Infrared Vision (Xavier Maldague)

CRC in Physical Activity, Nutrition and Energy Balance (Angelo Tremblay)

CRC in Quantitative Hydrogeology of Fractured Porous Media (John Molson)

CRC in Silicon Photonics (Wei Shi)

CRC in Smart Biomedical Microsystems (Benoit Gosselin)

CRC in Statistical Sampling and Data Analysis (Louis-Paul Rivest)

### PARTNERSHIP RESEARCH CHAIRS

International Chair in Cardiometabolic Risk (Jean-Pierre Després)

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

NSERC Industrial Research Chair in Heavy Load, Climate, and Pavement Interaction (i3c) (Guy Doré)

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

NSERC Industrial Research Chair in Monitoring and Management of Drinking Water Quality (Manuel J. Rodriguez-Pinzon)

NSERC Industrial Research Chair in Optical Design (Simon Thibault)

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

NSERC/Alcoa/Hydro-Québec Industrial Research Chair on Energy Efficiency and the Advanced Modelling of Aluminum Electrolysis Cells (MACE3) (Louis Gosselin)

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

NSERC/Diana Food Industrial Research Chair on the Effects of Polyphenol Prebiotics from Fruits and Vegetables (Phenobio) (Yves Desjardins)

Research Chair on Obesity (Denis Richard)

Research Chair on the Pathogenesis of Insulin Resistance and Cardiovascular Disease (André Marette)

## COLLABORATIONS

More than 350 collaborators from 300 academic, public and private research organizations in Canada and abroad are involved in collaborative research projects with Sentinel North teams.

### ACADEMIC AND RESEARCH INSTITUTIONS

#### Australia

Matrix Mathematical Research Institute

#### Brazil

São Paulo State University

University of São Paulo

Universidade Federal de Goiás

Universidade Federal de Pernambuco

Universidade Federal de Minas Gerais

#### Canada

Centre d'expérimentation et de développement en forêt boréale

Centre d'initiation à la recherche et d'aide au développement durable

Neurophotonics Centre

Centre de recherche du CHUS/INTER

Yukon Research Centre

Center for Research on Island and Maritime

Environments

National Centre for Scientific Research

Aurora College

Aurora Research Institute

Nunavik Research Centre

Institut de recherche Robert-Sauvé en santé et en sécurité du travail

Institut de technologie agroalimentaire

Institut national de la recherche scientifique

Origins of Balance Deficits and Falls research cluster

Carleton University

Concordia University

University of Ottawa

Dalhousie University

University of Calgary

University of Alberta

University of British Columbia

University of Saskatchewan

Université de Montréal

Université de Sherbrooke

University of Victoria

University of Waterloo

University of Manitoba

University of New Brunswick

Université du Québec à Chicoutimi

Université du Québec à Montréal

Université du Québec à Rimouski

Université du Québec à Trois-Rivières

Université du Québec en Abitibi-Témiscamingue

Université Laurentienne

McGill University

McMaster University

Memorial University of Newfoundland

University of Mount Allison

Université TÉLUQ

Trent University

Wilfrid Laurier University

#### China

Central South University

#### Denmark

University of Copenhagen

Technical University of Denmark

#### Finland

University of Turku

#### France

National Centre for Scientific Research

National Centre for Meteorological Research

Nantes National Superior School of Architecture

Institut national de recherche pour l'agriculture,

l'alimentation et l'environnement

Institut national de la santé et de la recherche médicale

Institut polaire français

La Rochelle University

Université catholique de Louvain

Université Côte d'Azur

Université d'Évry

University of Bordeaux

Université de Bretagne Occidentale

University of Lille

University of Pau and Pays de l'Adour

Université de Rennes

University of Strasbourg

Université Grenoble Alpes

Sorbonne University

University of Savoie Mont Blanc

#### Germany

Jena University

University of Bayreuth

Alfred Wegener Institute

Max Planck Institute for Evolutionary Anthropology

#### Italy

National Research Council

Institute of Sciences of Food Production

University of Cagliari

University of Pisa

#### Japan

National Institute of Polar Research

Kyoto University

#### Norway

Fram Centre

Norwegian Institute of Public Health

Norwegian Institute for Air Research

Norwegian Institute for Water Research

Norwegian Polar Institute

UiT - The Arctic University of Norway

University Centre in Svalbard

Norwegian University of Science and Technology

Norwegian University of Life Sciences

**Portugal**

Universidade de Lisboa

**Saudi Arabia**

King Abdullah University of Science and Technology

**Spain**

University of Barcelona

**Sweden**

University of Gothenburg

Lund University

Swedish University of Agricultural Sciences

**Switzerland**

Centre Hospitalier Universitaire Vaudois

École polytechnique fédérale de Lausanne

Université de Lausanne

**United Kingdom**

Centre for Ecology and Hydrology

Scottish Marine Institute

Lancaster University

University of York

**United States**

Nevada Desert Research Institute

Santa Fe Institute

Massachusetts Institute of Technology

Woods Hole Oceanographic Institution

National Institute of Mental Health

Texas A&M University

University of Cal Poly Pomona

University of California, Davis

University of Southern California

University of California, San Diego

University of Cincinnati

University of Delaware

University of Oregon

University of Central Florida

Miami University

University of Pennsylvania

Stanford University

University of Washington

University of Colorado, Boulder

University of Maine

University of Michigan

University of Montana

University of Vermont

Duke University

Florida Atlantic University

Lehigh University

Northeastern University

Northwestern University

Stanford University

**Uruguay**

Universidad de la República de Uruguay

**PUBLIC INSTITUTIONS****Canada**

Kativik Regional Government

Indigenous and Northern Affairs Canada

Canadian Space Agency

Agriculture and Agri-Food Canada

Assembly of First Nations

Nunavik Hunting Fishing Trapping Association

Nunavik Community Justice Centre

Centre de recherche industrielle du Québec

Inuulitsivik Health Centre

Ungava Tulattavik Health Centre

Nunavik Nutrition and Health Committee

First Nations of Quebec and Labrador Health and

Social Services Commission

Kativik Ilisarniliriniq

Nunavik Marine Region Wildlife Board

Social Sciences and Humanities Research Council

National Research Council Canada

Inuvialuit Regional Corporation

Kativik Regional Police Force

Direction régionale de santé publique de l'Abitibi-

Témiscamingue

Direction régionale de santé publique de la Côte-Nord

Direction régionale de santé publique de la Gaspésie-

Îles-de-la-Madeleine

Environment and Climate Change Canada

Québec Research Funds

Nunatsiavut Government

Grand Council of the Crees

Infrastructure Canada

Alberta Biodiversity Monitoring Institute

Kativik

Kitikmeot Inuit Association

Ilagitsuta Family House

Ministère de l'Économie et de l'Innovation

Ministère de l'Éducation et de l'Enseignement supérieur

Ministère de l'Énergie et des Ressources naturelles

Ministère de l'Environnement et de la Lutte contre les

changements climatiques

Alberta Environment and Parks

Nunavut Department of health

Ministère de la Santé et des Services sociaux

Department of Highways and Public Works - Yukon

Ministère des Affaires municipales et de l'Habitation

Ministère des Forêts, de la Faune et des Parcs

Ministère des Relations internationales et de la

Francophonie

Ministère des Transports

Municipality of Cambridge Bay

Municipality of Kangiqsualujjuaq

Canadian Museum of Nature

Kativik Municipal Housing Bureau

Mittimatalik Hunters & Trappers Organization

Ouranos

Parks Canada

Nunavik Parks

Fisheries and Oceans Canada

Northern Contaminants Program

Polar Continental Shelf Program

Defence Research and Development Canada

Nunavik Regional Board of Health and Social Services  
 Crown-Indigenous Relations and Northern Affairs  
 Canada  
 Eeyou Communications Network  
 Provincial Rehabilitation Research Network  
 Natural Resources Canada  
 Health Canada  
 Polar Knowledge Canada  
 Public Safety Canada  
 Canadian Wildlife Service  
 Canadian Forest Service  
 Canadian Ice Service  
 Indigenous Services Canada  
 Société d'habitation du Québec  
 Société du Plan Nord  
 Makivik Corporation  
 Transport Canada  
 Ville de Québec

#### **China**

China Scholarship Council

#### **France**

Centre National d'Études Spatiales  
 European Commission - H2020  
 Météo France

#### **Sweden**

Swedish Research Council

#### **Switzerland**

Synapsy

#### **United Kingdom**

Natural History Museum London

#### **United States**

Argans Inc.  
 Institute for Disease Modeling  
 NASA  
 Hawk Mountain Sanctuary

#### **PRIVATE INSTITUTIONS**

##### **Canada**

Agilent Technologies  
 Air Inuit  
 BD Biosciences  
 Bliq Photonique  
 C-Core  
 Ducks Unlimited Canada  
 Quebec consortium for industrial bioprocess research  
 and innovation  
 Canadian Photonic Industry Consortium  
 Coopérative forestière Ferland-Boilleau  
 CorActive  
 L'Île-aux-Oies domain  
 Doric Lenses  
 Explora Technologies  
 Exploramer  
 FlowJEM  
 Franatech  
 Fruit d'Or  
 Gas Plume Imaging Canada  
 Gibio

Groupe A/Annexe U  
 Kongsberg Maritime  
 LogR Systems inc.  
 Leica  
 Matrix Solutions Inc.  
 MXHX inc.  
 Mine Raglan  
 Mitacs  
 Peaxy  
 Pfizer  
 Jacques Cartier and Champlain Bridges Incorporated  
 Realtech  
 Reformar  
 Scientifica LLC  
 Sea-Bird Scientific  
 SiliCycle  
 Sintra Inc.  
 SyntBioLab Inc.  
 Telops  
 TeraXion  
 Thorlabs

#### **Denmark**

VELUX

#### **Germany**

Airbus Defence and Space  
 Informus  
 Schott AG

#### **Norway**

Akvaplan-niva  
 Calanus AS

#### **United States**

BeamSea LLC  
 IFOS Inc.  
 Teledyne Webb Research

#### **OTHER INSTITUTIONS**

##### **Brazil**

São Paulo Research Foundation

##### **Canada**

Action Conservation du Bassin Versant du Lac  
 Bromont  
 Canadian MSK Rehab Research Network  
 Fondation CERVO  
 Fondation de l'Université Laval  
 Fondation Institut universitaire de cardiologie et de  
 pneumologie de Québec  
 National Optics Institute  
 St. Lawrence Global Observatory  
 International Brain Research Organization  
 Quebec Photonic Network  
 Quebec Pain Research Network  
 International Society of Posture and Gait Research  
 Transbiotech

##### **Spain**

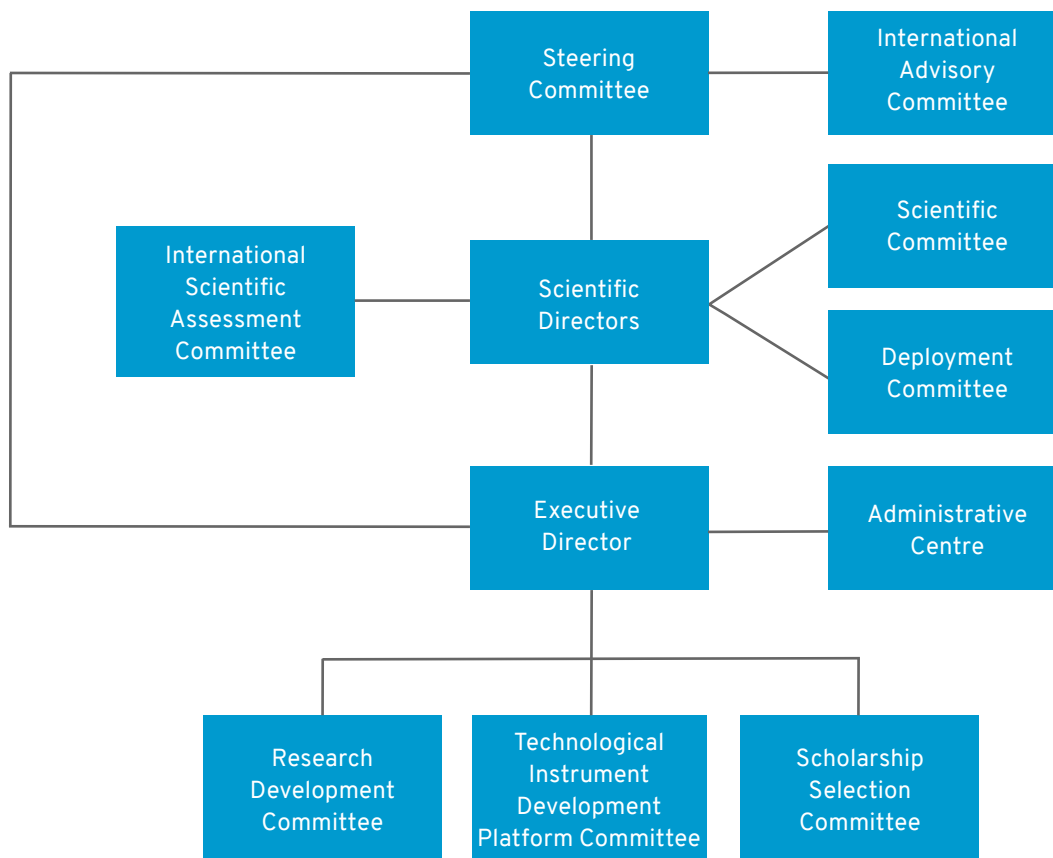
Instituto de Ceramica y Vidrio

##### **Switzerland**

Fondation de Préfargier

## GOVERNANCE

Sentinel North’s 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 Sentinel North’s strategy. It ensures the program makes progress towards 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 Chairholder, 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

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

Denis Roy, Dean, Faculty of Agriculture and Food Sciences

André Zaccarin, Dean, Faculty of Science and Engineering

## Administrative Centre

Marie-Andrée Bellavance, Operation Coordinator  
Michèle Desgagnés, Secretary  
Martin Fortier, Executive Director  
Sophie Gallais, Operation Coordinator  
Marie-France Gévry, Training Program Coordinator  
Keith Lévesque, Assistant Director  
Ahmed Lidam, Finance Coordinator  
Béatrice Saint-Cricq, Partnerships and Technology Transfer  
Jérôme St-Charles, Communications Officer and Webmaster  
Daphné Trottier, Communications Officer

## Sentinel North Student Association (AÉSN) Executive Committee 2019-2020

Mohamed Bahdine, Research Theme 1 Representative  
Marc-Antoine Bansept, Vice-President – Sociocultural  
Audrey Laberge-Carignan, President  
Valérie Langlois, Vice-President – Communications  
Alexis Lebrun, Vice-President – Sociocultural  
Félix Lévesque-Desrosiers, Research Theme 2 Representative  
Catherine Marois, Secretary

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