Sentinelle Nord

Sentinel North

Réunion scientifique Sentinelle Nord

Sentinel North Scientific Meeting

Résumés

Abstracts

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Sentinelle Nord permet à l'Université Laval de puiser dans plus d'un demi-siècle d'excellence en recherche nordique et en optique-photonique pour développer de nouvelles technologies et améliorer notre compréhension de l'environnement nordique et de son impact sur l'être humain et sa santé.

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Sentinel North allows Université Laval to draw on over a half-century of northern and optics/photonics research to develop innovative new technology and improve our understanding of the northern environment and its impact on human beings and their health.

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STRESS FACTORS RESULTING FROM THE ARCTIC VERNAL SEA ICE MELT: IMPACT ON THE VIABILITY OF THE BACTERIAL COMMUNITIES ASSOCIATED WITH SYMPAGIC ALGAE

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Early studies, suggested that the high percentage of dormant or inactive bacteria in the Arctic (25-80%) results from the perennially cold environment. Although this dogma has been questioned many times, to the best of our knowledge, no study has yet highlighted the underlying processes of such low bacterial activity. In the present study, we monitored the viability alongside various enzymatic stress signals of the bacterial community associated with sympagic algae in sea ice and sinking particles sampled during an Arctic melting season. Our study suggests that at least for the bacteria attached to sympagic algae, their inactivity is derived from chemical and physical stress factors acting at different timescales. During the first stage of ice melting (brine release), the bacterial community undergoes an osmotic stress inducing at least, a strong reduction of their activity. In the following stages, the snowmelt and thereby increasing irradiance enables the well-known spring sympagic algal bloom within the bottommost centimetres of sea ice but also an enhanced production of free fatty acids. Production of such bactericidal compounds induced the mortality of up to 75% of the bacterial community associated with sympagic algae. Further, the end of the ice-covered season is characterized by the flush of most ice biota (including the stressed bacteria). Due to the strong aggregation of sympagic algae (shortening residence time within the water column) and the high mortality or inactivity of their attached bacteria (limiting mineralization), ice biota should significantly contribute to the Arctic carbon export.

ESTABLISHMENT OF A SURVEILLANCE NETWORK FOR CHARACTERIZING INFLUENZA VIRUS DISTRIBUTION, EVOLUTION AND PATHOGENICITY IN MIGRATORY BIRDS IN THE NORTHERN REGIONS OF CANADA

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Avian influenza virus infections can be highly pathogenic to humans with high fatality rates. In 2014, H5N8 was found to have spread from Asia to Europe and the USA. The intercontinental spread of H5N8 from Asia to North America was found to have occurred through Beringia, meaning these birds must have passed through northern Canada before entering the USA. Canada is crossed by 4 flyways of migratory birds, and these birds are known to be a potential source of highly pathogenic viruses. Indeed, influenza viruses are able to evolve in asymptomatic carrier birds by single nucleotide polymorphism and rearrangement of influenza virus segments of RNA. Surveillance of circulating viruses in migratory birds in northern Canada is essential to provide the earliest warning against a potential influx of highly pathogenic influenza. Predictions on how viruses are circulating through birds are essential to evaluate the risk of widespread diffusion and to provide information for pandemic preparedness surveillance. Knowing which viruses are a threat for humans will allow for the development of suitable antiviral drugs and vaccines. The main goal of the research project will be to establish a surveillance network in order to determine the distribution, evolution and pathogenicity of influenza viruses in migratory birds in northern Canada (Yukon, Northwest Territories, Nunavut and northern Quebec). In particular, we have to determine strategic sampling sites

(easy to access, near large lakes and human settlements), implement collaborations with scientists studying birds (we have already contacted researchers Gilles Gauthier, Jim Leafloor, Jean Rodrigue and Josée Lefebvre Yves Aubry who band birds and participate in this project and gather samples from geese at 7 sampling points in the Northwest Territories, Nunavut and Nunavik. We still need collaborators for sampling in Yukon and the Northwest Territories). We want to collect cloacal and nasopharyngeal swabs from apparently healthy wild birds including wild ducks, geese, swans and gulls. Environmental samples, and if available, the major organs from wild birds that could have died from AIV infections will also be collected. Then we will characterize in the lab the viruses sampled via PCRs and genome sequencing to find out potential mutations which may change pathogenicity, transmissibility, or confer resistance to anti-influenza drugs in the strains collected. We will analyze and chart the evolution of the viruses and their origins and be able to estimate, with the collaboration of Gilles Gauthier (Université Laval), through bird populations analysis, the survival rate of influenza viruses infected birds compared to uninfected birds. We will also evaluate the effects of these mutations in cell culture to chart viral kinetic growth and for the mutations suspected to impact virulence, viruses can also be tested in mice (assessing survival, time to death, clinical signs, or viral loads). In conclusion, we will get a spatial and temporal map of influenza viruses in northern Canada and are willing to find collaborators interested in emerging viruses. Indeed the network, once established, doesn't have to be restricted to influenza viruses and our samplings could reveal other risky pathogens present in northern Canada.

SCREENING FOR EMERGING ARCTIC HEALTH RISKS TO CIRCUMPOLAR HUMAN POPULATIONS (SEARCH)

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Although levels of several contaminants in Arctic human populations have been decreasing during the last decades, there are clear indications that the complexity of the contaminant mixture is increasing as concentrations of several compounds are on the rise. Recognizing that contaminant exposure among circumpolar populations is affected by regional differences in local sources, long-range transport, diet and legislation, there is an urgent need to establish a collaborative framework within circumpolar nations to address exposure risks to humans from both emerging and unknown contaminants. The primary objective of this project is to establish a collaborative framework (SEARCH) for detecting and describing time trends for contaminants of emerging concern (CECs) in Arctic populations, which is of great importance for international environmental management. Combining analytical capabilities between the University of Tromsø / Norwegian Institute for Air Research and Université Laval/Institut national de santé publique du Québec with complementary state-of-the-art technologies, we will address analytical challenges associated with CECs and the identification of unknown exposure risks. Access to bio-banked blood samples collected during biomonitoring surveys will allow for addressing time trends and geographical differences in exposure to emerging environmental contaminants in circumpolar regions. Retrospective analysis of stored high-resolution accurate mass data obtained within SEARCH will provide a database to assess emerging exposure risks. Furthermore, established methodologies will be applied to key dietary items to assess sources of exposure to emerging chemicals from the surrounding ecosystems. Finally, we will examine how regulatory and non-regulatory actions, as well as national implementation plans adopted under the Stockholm Convention to reduce or eliminate persistent organic pollutants, affected the long-term exposure of Arctic populations. The results of this study will provide essential knowledge to policy makers for the inclusion of CECs in current legislation, in order to better protect Arctic populations from further exposure in a timely manner.

NEW MONITORING AND MEASURING TECHNOLOGIES FOR THE NORTHERN ENVIRONMENT AS PART OF A GLOBAL INITIATIVE FOR BETTER REGIONAL DATA AND POLICY DECISIONS

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Monitoring the northern environment presents special challenges for advanced sensing technology. Harsh and persistent environmental conditions, lack of sunlight for power generation, and the challenge of monitoring remote sensors in the large, isolated physical Arctic area must be overcome to acquire the data necessary to better understand and model the environment of this rapidly changing region. Photonic technology can provide essential capabilities to address these challenges. Fiber optic sensors for distributed temperature measurements, LIDAR systems for measuring trace gases over large distances, and multi-spectral imaging systems for monitoring oceanic organic material are some examples of optical technologies that can be deployed to monitor key environmental variables in the Arctic region. Governments and commercial enterprises interested in the Arctic are facing an ever-increasing need for accurate environmental data, improved measurements, and better forecasting models that can help their decision-making on adapting infrastructure to a changing environment and climate, as well as responsibly developing new economic opportunities. The technology to support more effective decision-making is constantly improving, offering important new opportunities for much improved predictions of the regional impacts of a changing climate on infrastructure, quality of life, nature, and new commercial opportunities. During this session we will discuss technologies for distributed networks of environmental monitors to measure the atmosphere, hydrosphere, cryosphere and geosphere, and how those new technologies will help measure changing environments in the Arctic and other regions around the world. We will also discuss OSA's new Global Environmental Measurement and Monitoring initiative and the potential for environmental research groups in Canada participating in this international effort. The Optical Society (OSA), the world's leading science society in optics and photonics, is leading discussions with public and private sector stakeholders around the globe to establish regional environmental measurement and monitoring (GEMM) centres aimed at better understanding and forecasting the local and regional impacts of climate change. The new centres bring together decision-makers, environmental scientists, and technology developers to provide more precise and useful information needed to measure and address regional impacts of climate change.

LA PRISE EN CHARGE DU DIABÈTE CHEZ LES INUIT : LES VOIES DE L'APPROPRIATION ET DE LA VALORISATION DES SAVOIRS NUTRITIONNELS

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Au Canada, la prévalence du diabète de type 2 est en augmentation dans l'ensemble de la population, mais surtout chez les autochtones. Le problème semble de moins grande ampleur chez les Inuit, et cela n'est pas sans lien avec leur attachement historique à l'alimentation traditionnelle. Par contre, leur consommation croissante des aliments transformés pourrait changer la donne. En effet, sans négliger d'autres aspects, la survenue du diabète et sa prise en charge sont étroitement liées à la question alimentaire. Or, les habitudes alimentaires et les formes de commensalités sont culturelles, tandis que les aliments disponibles sont en fonction des facteurs socio-économiques et environnementaux. Voilà pourquoi il est important pour les institutions et les professionnels de la santé de bien connaître les habitudes nutritionnelles des communautés pour plus d'efficacité dans la prise en charge du diabète. D'où l'intérêt actuel de la problématique du transfert et de l'appropriation des connaissances, notamment dans le suivi diététique des patients. Il se pose par exemple le problème de savoir quelle est la place des aliments traditionnels dans le régime alimentaire des patients du diabète. Comment articuler des recommandations nutritionnelles qui induiraient une meilleure collaboration des patients et de leur entourage? La présente communication essayera donc de faire le point sur la question du transfert et de l'appropriation des connaissances nutritionnelles en lien avec la santé chez les Inuit. Seront présentés succinctement quelques approches récentes de la question, et quel pourrait être l'apport de l'anthropologie pour enrichir les connaissances et les pratiques en la matière.

SELECTION OF SUMMER FEEDING SITES BY FEMALE MIGRATORY CARIBOU USING CAMERA COLLARS

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Migratory caribou (Rangifer tarandus caribou) are socioeconomically and culturally important for northern communities. Several herds have experienced sharp declines over the last decades. Female migratory caribou depend on the availability of summer habitat resources to meet the needs associated with lactation and the accumulation of reserves for other seasons, when resources are less abundant. Habitat selection of migratory caribou has been assessed at various spatial scales (e.g. population and individual home ranges) but finer scale assessments have been difficult to perform because of the large scales at which habitat data are usually available. Due to these limitations, information on how female migratory caribou select habitat and resources at a fine spatial scale (i.e. feeding sites) is lacking. To document the selection of summer feeding sites, we equipped 35 female caribou with camera collars in 2016 and 2017 in northern Quebec (Canada). We collected a total of 43,715 videos of 10 seconds between June 1st and September 1st of each year. We compared sites used for feeding (defined as used) and sites used for any other activity (defined as available) at the habitat and resource scales using resource selection functions. In both years, wetlands were highly selected as feeding sites in June and July while they were avoided in August. Shrublands were mostly selected in July and August. Herbaceous tundra was selected in 2016, but avoided in 2017. At the resources scale, lichen, birch, willow and mushrooms were the preferred resources. Our results provide precise and novel information on the feeding sites selected by female caribou. This information will help to understand foraging patterns and define essential summer habitats of female migratory caribou, and will contribute to the management and conservation of the species.

ADAPTING A BIOGEOCHEMICAL-ECOSYSTEM MODEL TO THE ARCTIC OCEAN TO STUDY PHYTOPLANKTON

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Seasonal variation of the sea ice cover is a determinant of biomass, primary productivity, phenology and community structure of phytoplankton in the Arctic Ocean. Yet, empirical data is insufficient due to the logistical challenges that sampling the remote Arctic Ocean represents. In this context, modelling becomes necessary to obtain the numerical biomass, primary productivity, phenology and community structure of modelled phytoplankton all year round. A one-dimension (1-D) global biogeochemical-ecosystem model was adapted to the extreme Arctic conditions. Initial nutrient conditions in this previous model were replaced with in situ data collected during the winters of 2003-2004 and 2007-2008 by the icebreaker CCGS Amundsen in the Amundsen Gulf (southwest Canadian Archipelago). Additionally, we improved the classical processing of the subgrid scale heterogeneity of sea ice and its impact on the underwater light field. That is, instead of considering the underwater light field as a homogeneous weighted average in each cell grid of the water column of the 1-D model, the underwater light field was kept heterogeneous when the sea ice concentration was between 0% and 100%. Accounting for this heterogeneity was done by computing one irradiance under the open water portion and a different irradiance under the sea ice portion. Then, one light limitation factor to phytoplankton growth was computed under the open water portion and another light limitation factor was computed under the sea ice portion. These two light limitation factors were then averaged. The averaged light limitation factor thus obtained is not equal to the light limitation factor computed from a mean irradiance because of the non-linearity of the processes causing light limitation to photosynthesis. We tested the spatial heterogeneity of sea ice on modelled phytoplankton biomass, primary productivity, phenology and community

structure. Using spatial heterogeneity of sea ice in the (1-D) model for the Amundsen Gulf decreased the numerical annual primary productivity by 7% compared to homogeneous sea ice. Furthermore, spatial heterogeneity of sea ice delayed the productivity bloom by 39 days compared to homogeneous sea ice. Finally, spatial heterogeneity of sea ice modified the community structure of the modelled phytoplankton compared to homogeneous sea ice by killing one of the phytoplankton groups. Pleasingly, the looser phytoplankton group is the numerical equivalent of the Prochlorococcus genera which is a prokaryotic phytoplankton absent in the Arctic Ocean.

TECHNOLOGICAL CHALLENGES FOR EQUIPMENT DEPLOYED IN ARCTIC ENVIRONMENTS

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This presentation exposes challenges faced when deploying equipment in extreme environments. In a world where social media is omnipresent, IOT devices are ubiquitous; communication challenges faced in remote areas are difficult to appreciate. Similarly, power availability and sustenance are also major issues for such systems. Keeping systems and their power source active for prolonged periods is far from simple. Finally, the extremes brought about by the environment also pose a challenge to any equipment deployed. Within the technological platform group, we are addressing these three major challenges head on and have developed technology that can be used by all members of Sentinel North. Specifically we will expose some work we have done to connect devices through satellite communication and dedicated network systems. We have been testing several energy harvesting technologies as well as charging and battery technologies to adapt such systems to northern environments. Finally, we will display some design approaches for resilient system design at low cost for the northern climate paradigm.

HYBRID GLASS-POLYMER MULTICORE FIBER WITH DISTRIBUTED FIBER BRAGG GRATING SENSORS TO MEASURE DIRECTIONAL CONSTRAINT

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Due to the trend of climate warming recently observed in Nunavik (Quebec), Canada, permafrost is currently degrading with major negative impacts on the ecosystems and man-made infrastructures built on permafrost, such as the important thaw subsidence observed along the access road to Umiujaq Airport [1]. As an unforeseen and positive consequence of climate warming and associated permafrost degradation, water stored as ice is now released under its liquid phase into the ground, recharge aquifer at depth and groundwater can become an important new source of drinking water for the Inuit communities and water consumers such as the mining industry [2]. However, field observations of the physical processes related to permafrost degradation are challenging since they take place at depth in the ground, and thus are not yet well understood. To overcome this, new sensors for monitoring ground subsidence and groundwater flow are needed. Distributed fiber Bragg gratings (FBGs) written in multicore fibers are a good candidate to fulfill these needs, since they are small in size, resistant to harsh environments and capable of precisely measuring remotely physical processes such as strain and flow taking place along the optic fiber over very long lengths (hundred of km). However, the robust phase-mask writing technique that is commonly used to write FBGs lacks flexibility, as a different phase-mask period is needed for every targeted FBG wavelength [3]. This limitation can be overcome by controlling the strain applied to the fiber during writing. Since it was shown recently that trans-jacket writing of FBGs in both acrylate and polyimide coatings doesn't degrade the fiber strength using infrared femtosecond pulses, a high strain-tunability was expected from this method. We have recently used this technique and demonstrated distributed FBGs written in various fibers with straining capability close to the fiber's

maximum strength at failure [4]. Based on such distributed sensors, we have also developed and implemented a new design of a hybrid glass-polymer multicore fiber containing distributed FBG arrays that was drawn recently at COPL. Preliminary results on distributed directional strain sensing will be shown and discussed during the presentation. [1] Fortier, R. and al. "Impacts of permafrost degradation on a road embankment at Umiujaq in Nunavik (Quebec), Canada". Canadian Geotechnical Journal 2011, 48, 720-740. [2] Lemieux, J.-M. and al. "Groundwater occurrence in cold environments: examples from Nunavik, Canada". Hydrogeology Journal 2016, 24(6), 1497–1513. [3] Habel, J. and al. "Femtosecond FBG Written through the Coating for Sensing Applications". Sensors 2017, 17, 2519. [4] Boilard, T. and al. "Trans-jacket inscription of robust FBG sensors for directional and distributed strain measurement". Accepted for oral presentation at Optical Sensors and Sensing, San Jose, USA.

HYDROGEOPHYSICS OF PERMAFROST MOUNDS IN NUNAVIK (QUEBEC) AND RELIC TRACES OF PERMAFROST DEGRADATION IN AQUITAINE (FRANCE) — AN ANALOG STUDY TO UNDERSTAND THE PALEO-RECHARGE OF REGIONAL AQUIFERS IN THE AQUITAINE SEDIMENTARY BASIN

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The Aquitaine region (France) is a large sedimentary basin containing a regional multi-layer aquifer used for drinking water supply. Based on evidence from groundwater geochemistry, the last global recharge of this multi-layer aquifer occurred during the Late Pleistocene, which is characterized by a succession of climate changes due to the global glacial cycles. Such oscillations in groundwater recharge are likely to have considerably influenced modern groundwater regimes, mainly by determining the groundwater flow dynamics: one of the key parameters in evaluating aquifer capacity. Thus, neglecting past oscillations in recharge may result in an overestimation of the aquifer capacity. In order to practice proper management of these aquifers, it is necessary to better understand the past dynamics of recharge. Specifically, the major phase of recharge occurred during periods of climatic improvement before and after the Last Glacial Maximum (LGM, 20 000 years ago) with a lack of infiltration during the LGM. This phenomenon can be explained by a drier period and potentially by the presence of permafrost preventing the infiltration. The paleo-climatic reconstructions available for the Aquitaine during the LGM are consistent with a periglacial environment, possibly associated with discontinuous permafrost. But there is still no strong evidence for the development of such permafrost. However, the outcrop surface of the main deep aquifers of the multi-layer system currently hosts numerous circular ponds with morphology similar to the thermokarst ponds found in the discontinuous permafrost zone in Nunavik (Quebec), Canada. Thermokarst ponds are remnants of ice-rich permafrost mounds characteristic of permafrost environments after degradation. The purpose of this study is to search for proof of permafrost occurrence in the Aquitaine by testing the thermokarst origin of the Aquitaine ponds by means of a comparative analysis with a current periglacial environment. Since the current climate in the discontinuous permafrost zone of Nunavik is similar to that of the Aquitaine during the LGM, this periglacial region appears to be a good analogue. The Umiujaq area, which holds abundant degrading ice-rich permafrost mounds and thermokarst ponds (due to the current trend to climate warming) has thus been selected. The comparative analysis between the Aquitaine ponds and the degrading permafrost mounds in Umiujaq will be carried out using a multi-geophysical approach. Electrical resistivity tomography, spectral induced polarization, electromagnetic mapping at low induction number and ground penetrating radar will be used at both sites to obtain a complete 3D characterization of the degrading permafrost mounds in Umiujaq and of the ponds in Aquitaine. The geophysical signature of periglacial features (in particular thaw consolidation and creep structures) will be observed in the frost mounds in Umiujaq, then sought in the ponds in Aquitaine. Laboratory experiments on core samples will also be done to evaluate the frost susceptibility of the subsurface deposits in Aquitaine. Furthermore, a geothermal model will be developed for the Aquitaine site, considering that the paleoclimatic conditions were identical to the current climatic conditions in Umiujaq. This simulation will give an idea of the thickness reached by the permafrost in Aquitaine under such conditions.

OPTICAL IDENTIFICATION OF TISSUES AND OTHER THINGS

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Using light to identify substances and objects is a common technique originally used in chemistry that has spilled over to biomedical applications. Many commercial devices are available to quickly and robustly identify liquid substances. For instance, measuring the optical density of a solution in a standardized cuvette is still the accepted practice in many protocols to quantify proteins, and for a reason : it works well. Attracted by the simplicity and elegance of the technique, its use in biomedical and environmental applications has seen widespread development, especially in recent years. In this talk, I will show the state of the art techniques to provide identification from optical spectroscopy in the fields of biological and environmental science. From simple peak identificaiton to more complex machine learning techniques, I will highlight the basic concepts but also the requirements for any project hoping to take advantage of these powerful techniques.

OUTILS GÉNOMIQUES POUR DÉFINIR LES UNITÉS DE GESTION ET COMPRENDRE L'ADAPTATION LOCALE CHEZ L'OMBLE CHEVALIER (SALVELINUS ALPINUS) AU NUNAVIK (QUÉBEC)

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L'omble chevalier (Salvelinus alpinus) est un salmonidé anadrome d'une grande importance pour la pêche traditionnelle dans les communautés inuites du Nord canadien. L'omble chevalier est reconnu pour migrer vers des zones d'alimentation côtières à proximité de sa rivière natale, ce qui pourrait indiquer une adaptation locale aux conditions marines et d'eau douce. Dans le cadre du programme BriGHT et dans le but de mettre au point des unités de gestion cohérente avec la biologie de l'omble chevalier dans le sud-est de l'Arctique canadien, nous avons évalué la structure génétique et l'adaptation des populations à l'échelle locale et régionale : 800 individus ont été échantillonnés dans 25 localités au Nunavik (Québec), dans l'île de Baffin (Nunavut) et au nord du Labrador, et plus de 25 000 marqueurs SNP ont été obtenus par GBS (genotyping-by-sequencing). Les profils de diversité génétique présentent des divergences lorsqu'on compare les sites d'échantillonnage dans différents bassins hydrographiques, les valeurs de Fst par paires entre les rivières variant de 0,03 à 0,24. À des distances géographiques similaires, les populations de poissons séparées par la haute mer semblent plus divergentes que celles situées sur une même côte. L'association entre les marqueurs génétiques et les conditions environnementales dans les rivières et les estuaires a été testée pour identifier des cibles potentielles d'adaptation locale dans le génome. Ces résultats informeront les décideurs locaux et régionaux sur la conservation des stocks d'omble chevalier au Nunavik.

NUTRITION AND MENTAL HEALTH AMONG YOUNG NUNAVIK INUIT: THE ROLE OF THE GUT MICROBIOTA

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Introduction: For several decades, environmental contaminants due to human activity have converged towards the polar regions carried by atmospheric and marine currents. Inuit are highly exposed to these potentially toxic compounds by a bioaccumulation phenomenon which occurs in some traditional foods. However, these foods are of high nutritional quality, particularly rich in selenium and polyunsaturated fatty acids (n-3 PUFA, and have several benefits for the health of Inuit). In 2004, the Nunavik Inuit Health Survey (NIHS) disclosed higher blood mercury levels than those found in the Quebec population. It has also revealed a high prevalence of psychological distress among Nunavimmiut, mostly affecting young people. Although various studies have reported lower cognitive performance and behavioral dysfunctions related to a chronic exposure to contaminants, including heavy metals such as lead and mercury, the mechanisms by which these chemicals contribute to such psychological states remain unclear. The intestinal microbiota, by contributing to the presence of systemic inflammation, is one of the physiological pathways to be investigated. The beneficial effects of the nutrients of interest on the intestinal microbiota have also been reported in the literature. The objectives of this study are: 1) to verify at the individual level if there is an association between several bioactive compounds (PUFA, selenium, mercury, lead and cadmium) and the presence of depressive symptoms in the young Inuit of Nunavik, 2) to examine if distinct gut microbiota profiles are associated with these bioactive compounds, and 3) to identify the presence of bacterial metabolites as biomarkers of exposure to these bioactive compounds. Methodology: In 2017, a broad partnership including Nunavik Inuit communities and decision-makers, the Nunavik Regional Board of Health and Social Services, the INSPQ, and researchers from the CHU de Québec-Université Laval Research Center part in the new cohort of the NIHS. In this survey, 293 young Inuit between 16 and 30 years old provided a stool sample and completed a self-administered questionnaire covering several aspects and determinants of health. Levels of exposure to contaminants were documented using the blood levels (mercury, lead and cadmium) of the participants measured during the survey. Depressive symptoms were reported from a pre-tested and valid questionnaire in the population (CESD). Finally, gut microbiota profiles will be identified by Shotgun sequencing and metabolomic analysis will be performed from the stool samples collected. The association analysis between the bioactive compounds of interest will be adjusted for known confounding factors from the literature (sex, age, etc.). Anticipated Results: This study will shed light on the possible role of gut microbiota in the brain-gut axis by examining some of the potential mechanisms underlying the development of mental illnesses in a population experiencing several forms of adversity, including environmental. We are grateful to the 2017 Nunavik Inuit Health Survey – Qanuilirpitaa? (Q2017) participants, as well as to all our Nunavik partners (including the Q2017 Data management committee, Q2017 Steering committee, and the Nunavik Regional Board of Health and Social Services), the Institut National de Santé Publique du Québec, as well as all Inuit and non-Inuit investigators who have collaborated in the various steps of the project and provided their intellectual input.

PROJET D'OPTIMISATION DES PARAMÈTRES DE LA QUALITÉ DE L'AIR INTÉRIEUR (QAI) DANS LES HABITATIONS DU NUNAVIK : IMPACT SUR LA BIODIVERSITÉ MICROBIENNE

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La ventilation est un paramètre d'importance dans l'optimisation de la qualité de l'air intérieur dans les habitations. En milieu nordique, ce paramètre a d'autant plus d'importance que les nouvelles constructions se veulent plus isolées pour limiter les consommations énergétiques réduisant la ventilation par voie passive. Dans ce contexte, le CNRC en collaboration avec l'INSPQ, les facultés des sciences et génie et de médecine de l'Université Laval, la SHQ, la Direction de santé publique du Nunavik et l'Office municipal d'habitation Kativik (OMHK) mènent une étude transdisciplinaire pour évaluer l'impact de la performance et le bon fonctionnement des systèmes de ventilation sur la qualité de l'air intérieur dans les habitations au Nunavik, notamment sur la composition microbiologique de l'air. Des échantillons d'air et de poussières ont été prélevés dans 56 logements possédant différents types de systèmes de ventilation et ont été investigués (avec ventilateur récupérateur de chaleur (VRC) [n=17], avec ventilateur récupérateur d'énergie (VRE) [n=24], groupe sans VRC/VRE [n=15]). Les bioaérosols ont été prélevés avant et après une phase d'optimisation des systèmes de ventilation et de chauffage avec un SASS 3100 (20 m3 d'air avec un débit de 300 L/min) tandis que les poussières sédimentées ont été collectées avec un micro aspirateur relié à une cassette 37 mm comportant un filtre en polycarbonate (débit de 15 L/min). Après élution des particules, l'ADN a été extrait, puis séquencé par séquençage à haut débit en ciblant les régions universelles ITS pour les champignons et ADNr 16S pour les bactéries. Les résultats ont montré une biodiversité bactérienne importante à la fois dans l'air et dans la poussière (moyenne géométrique : 377 unités taxonomiques opérationnelles [UTO] et 747 UTO dans l'air et la poussière respectivement). Les genres bactériens Staphylococcus, Streptococcus, Corynebacterium, Propionibacterium, Micrococcus et Prevotella ont été retrouvés dans une grande majorité des échantillons (>98 % des échantillons d'air et de poussières). Ces genres sont habituellement retrouvés en milieu intérieur et sont associés au microbiote humain. L'indice de dissimilarité Bray-Curtis était en moyenne de 0,78, suggérant une différence de composition bactérienne entre les échantillons d'air et de poussière. Il y avait 185±2 UTO fongiques dans les échantillons de poussières. Les levures Cryptococcus, Malassezia et Candida ainsi que les moisissures Aspergillus, Cladosporium, Penicillium et Alternaria représentaient les principaux genres fongiques présents dans les échantillons de poussières. En conclusion, la biodiversité microbienne aéroportée dans les maisons investiguées au Nunavik est associée à la présence et à l'activité humaine, et ce, quel que soit le type de système de ventilation de l'habitation.

A MICROFLUIDIC METHOD FOR MULTI-MODAL CHARACTERIZATION OF NORTHERN CYANOBACTERIA

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Cyanobacteria are the dominant producers in the Arctic and sub-Arctic freshwater system. From the atmosphere, they transform carbon dioxide into polysaccharide via photosynthesis and nitrogen into ammonium via fixation, the product of which are utilized by other components further along food chain, fundamentally supporting the local ecological system. Cyanobacteria are facing changes in their inhabiting environment, such as temperature, light and salinity, as the local climate is changing now too. Yet their physiological reactions toward aforementioned changes remain largely unstudied, knowledge of which is important for understanding, modelling and predicting northern aquatic microbial community and ecological system. To understand the behavior of cyanobacteria, channel-based microfluidics can be a powerful tool based on its inherent capability to precisely and dynamically control liquid phase properties with excellent spatial resolution and temporal span. Controllable factors include hydrodynamics such as flow velocity and shear forces; control over mass and heat transfer, and chemical conditions such as concentration and type of dissolved molecular species. Though in vitro and in situ characterization remains a

challenge, the compatibility of microfluidics to multiple characterization techniques allow multiple investigation strategies and provide new insight in tackling the study of cyanobacteria physiology. In this poster, we demonstrate the integration of standardized characterization techniques into a microfluidic format. Fluorescence spectroscopy and other related measurements can now assess fluorescence information of individual cells and their collective entity. Under confocal laser scanning microscope (CLSM), cyanobacteria of different strains can be distinguished and identified in vitro, which is useful for dynamically studying the taxonomical composition within the cyanobacteria biofilm community. Infrared spectroscopy (IR) quantitatively reflects information of its synthesized chemical components such as over-excreted polysaccharides and crystallized water structure against desiccation.

PUSHING THE LIMITS OF POINT-OF-CARE TESTING TO IN VIVO MEASUREMENTS: TOWARDS THE DEVELOPMENT OF MULTIMODAL SENSING STRATEGIES FOR GUT METABOLITES DETECTION

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Changes from a traditional to a "western" diet are believed to contribute to the greater prevalence of cardiometabolic diseases (CMD) and mental illnesses among indigenous populations in the Canadian North. Dysregulation of the gut microbiota's host-bacteria interactions — the microbiota being the community of micro-organisms involved in several functions including immune system regulation and nutrient metabolism — caused by these dietary changes is suspected to be involved in these pathologies. However, investigating the link between the host's diet and his health is impeded by the inability of current analytical methods to characterize the metabolism of the gut microbiota in real-time, which causes the loss of critical information that cannot be obtained from classical a posteriori molecular analysis of fecal samples. The overarching aim of this project, by combining the expertise of chemists, physicists and health scientists, is to develop a fiber-optic sensor to probe microbial processes in the gastrointestinal tract of animal models subjected to various nutritional regimens. Lysophosphatidic acids (LPA) were selected as the target of interest due to their implication in several biological processes and their link with CMD and some cancers. In the present work, an optical sensor combining a fluorescent molecular transducer selective to LPA and plasmonic nanoparticles is developed and characterized. The transducer, inspired from a previously reported aggregation—induced fluorescence quenching dye, is designed to have a high affinity for LPA molecules via electrostatic and hydrophobic interactions. The molecular structure also comprises a silane moiety to allow covalent bonding to the surface of metal@silica concentric core-shell nanoparticles. Dipolar coupling of the electrons in the metal core with the surrounding fluorescent molecules bestows the latter with improved luminescence and photostability through an effect called Metal-Enhanced Fluorescence (MEF). Spherical silver nanoparticles with low polydispersity were synthesized by a seed-mediated growth method to obtain a plasmon band overlapping with the spectral range of the dye. They were coated by a thin layer of silica to act as a shield against chemical etching in physiological media, and the thickness of this shell was adjusted for maximum MEF. Results on sensor characterization and quantification of LPA will be presented, and the nature of the detection mechanism as well as selectivity and response time will also be discussed.

GREENDLAND ECOSYSTEM MONITORING PROGRAM (GEM)

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Greenland Ecosystem Monitoring (GEM) is an integrated monitoring and long-term research programme on ecosystems and climate change effects and feedbacks in the Arctic. Since 1995 the programme has established a coherent and integrated understanding of the functioning of ecosystems in a highly variable climate, which is

based upon a comprehensive, long-term inter-disciplinary data collection carried out by Danish and Greenlandic monitoring and research institutions. GEM consist of five sub-programmes and a number of strategic cross cutting initiatives that also includes collaboration with other complimentary operational monitoring and research activities. The long term monitoring and data collection mainly takes place at the following sites: Zackenberg in high arctic Northeast Greenland, Nuuk in low arctic West Greenland and, Disko in the low/high arctic West Greenland. The data collected by the participating institutions is updated yearly and made available on the website https://data.g-e-m.dk/ - as open data for everyone to access. See more at: http://g-e-m.dk/

REMOTE SENSING OF GASES USING BROADBAND LIGHT

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Remote gas sensing is expected to be one of the hot topics of the next decade, due to the increasing environmental regulations around the world and its high application potential in industry and applied research. Remote detection of target gases is also of prime importance for northern scientists to monitor thermokarst emissions resulting from the thawing permafrost. At the moment, there is a large number of techniques able to detect the presence and concentration of a target gas from a certain distance, most of which is based on light absorption at specific wavelengths. Since each molecule is known to possess a unique pattern of absorption wavelengths, it is possible to identify a gas either by probing a single absorption line known to belong to the target gas using a narrowband light source (i.e. tunable laser), or by measuring a whole section of the absorption spectrum using a broadband light source. While the former approach generally provides more precise measurements, the latter approach is more polyvalent by allowing the detection of multiple gas types with a single system. In the context of northern research where the deployment of an instrument can be very expensive, polyvalent systems able to gather useful data for multiple experiments can be appealing. In this presentation, a short overview of the existing optical techniques allowing for the measurement of multiple gas types from a single system will be presented, along with a novel technique developed by our group based on mid-infrared (MIR) supercontinuum. Compared to most other techniques using near-infrared light (1-3 μm), MIR supercontinuum sources can produce a very broadband laser light (between 3-5 μm) where fundamental ro-vibrational absorption lines of molecules can be up to 100x stronger than their near-infrared counterparts. Its simple design and low electrical consumption make it an interesting candidate for off-the-grid 24/7 measurements of gases such as methane or CO2 in remote areas.

DECIPHERING HIDDEN INFORMATION WITHIN COMPLEX SIGNALS TO SHED LIGHT ON LIFE

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The overarching goal of my research consists of investigating living tissue, such as the brain, using light to probe its multilevel organization from the nanoscale to the macroscopic scale. My research has focused on developing innovative solutions using light to describe neurobiological systems directly in their native environment (i.e., in situ). Studying biological organisms in their integral functioning states is crucial since they are part of complex systems. Each unit of the system interacts synergistically with others to fulfil the network purpose. In order to shed light on biological systems, we designed technological tools that could reveal hidden information within complex signals. For example, we developed techniques to measure molecular transport, distribution and receptor oligomerization in single intact cells. We then applied those quantitative approaches to study receptor distributions in rodent central nervous systems to quantify the effects of compounds in various disorders. We also studied neuronal plasticity and remodeling in situ. We recently established new strategies for deep tissue imaging with innovative fluorescent probes and nano-imaging approaches revealing the brain extracellular space structure. This allowed us to characterize the role of the extracellular matrix during neuronal communication.

Ultimately, the technology developed to study interactions and transport within single cells can be transposed across scales and levels of complexity, in biological and environmental paradigms that will be applied to northern research.

BUILDING A BETTER—AND MORE TRANSPARENT—WORLD THROUGH MICROBIOLOGY

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As DNA sequencing research continues to break new ground, scientists are ever more aware of how our planet's biochemical processes are ruled by microbes—both harmless species and those that make us sick. Understanding this unseen microbial ecology—a teeming web of trillions and trillions of organisms, on every surface, substance, creature, and in the air around us—has both micro and macro implications. Our unprecedented move to urban centers has caused a corresponding shift in the urban genome. Can we create healthier, more sustainable cities by mapping the hidden dance of microbes in our midst? What can our city structures teach us about the prevention of disease: from both airborne pandemics to illnesses caused by the spread of antibiotic resistance? Also, global supply chains are getting harder to trust. What if we could accurately trace the origin of every single product? In this mind-opening keynote, Jessica Green explores how a deeper understanding of microbiology can help build a better, and more transparent, world. This means reimagining how we design structures, air flow, plant life, and communal spaces to control allergens, viruses, bacteria, fungi, and other microbial forces. She also explains how analyzing a product's microbiomes—by combining microbiome technology with AI—can uncover invisible patterns across objects, materials, and places to track how things move around the world.

IMPACTS OF THE INTRODUCTION OF MUSKOX ON PLANT COMMUNITIES IN NUNAVIK AND DEVELOPMENT OF A MONITORING PROTOCOL

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The introduction of a new species can modify interspecific relationships and terrestrial ecosystem dynamics. Muskox (Ovibos moschatus) was first introduced in Kuujjuaq, Nunavik, in the 1960s where 54 animals were gradually released into the wild until the 1980s. Recent observations suggest that the population has now increased to several thousand individuals. Inuit communities have expressed concerns about the possible impacts of this new established ungulate species on Nunavik ecosystems, more particularly on caribou. Large herbivores can change plant communities through consumption, trampling and the addition of nitrogen to the soil by faeces and urine in the habitats they use. Our main objective is to evaluate if the introduction of muskox altered the composition and the structure of plant communities in habitat types they most frequently use. During summer 2019, we will conduct vegetation sampling of the Arctic tundra in two areas with contrasting occupancy histories. The sites with a long history of occupation are located on the Ungava Coast. Contemporary occupation sites will be located near the Inuit village of Umiujaq and Inukjuaq on the Hudson Coast. Sites were selected using GPS positions from muskox with GPS collars and local knowledge from the Inuit communities. In each area, we will compare sampling sites disturbed by muskoxen with sampling sites that are poorly or not accessible to them. This study will help with the development of a long-term monitoring protocol for muskox habitat in Nunavik and will contribute to answering Nunavimiut concerns about the effects of muskox presence on the land.

PROS AND CONS OF THE INCREASING PRESENCE OF BLUE LIGHT IN OUR LIVES

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Whether natural or artificial, light is at the center of our lives. In recent years, however, we have seen technological advances that have led to the development of new light sources such as LED, flat screen TV, computer and electronic devices such as phones and tablets that contain more blue light. How do they act differently on the human brain? Did you know that their daily use, from morning to night, carries as many risks as benefits for the child, the adolescent and the adult? Dr. Hébert will explain how light affects work performance, mood and the synchronisation of our biological rhythms. He will also address the potentially damaging effects of certain types of light on sleep. At the end of this conference, the participant will be able to better understand how the brain responds to the many light sources to which we are increasingly exposed.

RECONCILIATION AND THE PRODUCTION OF RESEARCH IN THE NORTH

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Since the publication of the Truth and Reconciliation Commission of Canada's final report, reconciliation has become a political and social preoccupation in Canada. It guides political decisions, influences actions taken within ministries and the programs they put into place, as well as research. How can we think through this concept without taking it for granted? How can a national reconciliation framework be neither too rigid nor reproductive of asymmetrical power relations? How can multiple expectations towards this process be considered if they are all situated in different subjective, historical, cultural and political contexts? The Chaire de recherche Sentinelle Nord sur les relations avec les sociétés inuit has developed several scientific activities in order to underline the diversity of perspectives on the topic of reconciliation and to lay the foundations to a critical reflection. This communication summarises the results of these initiatives in order to contribute to reflections on ways to develop more respectful research practices with Inuit communities and, beyond this, to think about the conditions to produce a "reconciliating research".

DESIGN AND IMPLEMENTATION OF WIRELESS MICROELECTRONIC SENSORS TO MEASURE MICROORGANISMS' GROWTH IN DIVERSE ENVIRONMENTS

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Understanding the impact of global warming and human activities on northern habitats and ecosystems and their influences on wildlife, human beings, and health is one of the most important challenges of our time. To this end, characterization, identification, and monitoring of sentinel microorganisms' growth and metabolic activity can provide invaluable insight into the environmental changes in northern areas. In fact, at low temperature, the activity of microorganisms like bacteria and microbes decreases dramatically. Hence, we will design a customized high-precision bioimpedance measurement system that can address a precision to measure bacteria diluted down to several millions of CFU/ml. This project aims to build a multi-technology microsystem to measure bacterial growth and environmental parameters in diverse environments, such as northern climates. We intend to design and fabricate a microelectronic chip to perform local bioimpedance measurement. Our approach will leverage the design of a new fully integrated bioimpedance measurement circuit that will enable high-precision and placement in hard to reach areas of the northern regions. Additionally, an integrated system to precisely monitor and measure the microorganisms will increase autonomy, decrease manufacturing and transport costs, and be capable of working under a temperature below -40 °C. In this research, the bacteria-sized, gold microelectrodes array (MEA), proposed to be fabricated on a 0.18 μm CMOS process with electroless gold plating technique. A high-sensitivity dual-phase lock-in amplifier (LIA) being capable of extracting the real and imaginary portions of electrochemical impedance with sensitivity to read small AC currents down to 1 pA will be designed to follow low bacteria growth rate and concentration in cold climate. This research project funded by the SMAART CREATE Program and the Sentinel North Strategy at Université Laval will enable the precise monitoring of the unique microbial ecosystems of the Arctic regions and northern environments.

FULLY INTEGRATED SPECTROPHOTOMETER IN THE VISIBLE AND NEAR-IR RANGE

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This project aims to develop a wireless microsystem for diffuse multi-wavelength spectroscopy in real time monitoring of extracellular neurotransmitter concentration or protein interactions based on fluorescent sensing principles. As an example, fluorescence resonance energy transfer (FRET) is a technique, for observing the molecular scale interactions, that depends on the distance between a donor and acceptor. In this dual readout method, the source light excites the donor to emit light in a higher wavelength. Light of the donor excites the acceptor if it gets close to the donor. Therefore, the acceptor also emits light in a higher wavelength. Such assay, which sends one excitation wavelength and receives more than one emitting wavelength, has allowed the visualization of numerous protein interactions in many different cell types and organisms and has contributed to applications like detection and quantification of DNA methylation. The direct application of this method on clinical samples offers great promise for its translational use in early cancer diagnosis, prognostic assessment of tumor behavior, as well as monitoring response to therapeutic agents. The first step of this project consists of designing, fabricating, and testing a discrete-component prototype, including a commercial micro-spectrometer integrated with a microcontroller and a wireless transceiver. This miniaturized cell spectrophotometer for the real-time determination of VERO E6 cells hybridized with anti-tubulin antibody and tagged by Alexa Flour 488 and DAPI is tested and successfully applied for trace determination of tubulin protein. The performed experiments prove the designed cell spectrophotometer capability of qualitative and quantitative detections. The device consists of a new interface platform to perform the analysis of the detected light and determine the concentration of an unknown sample. Experiments and in vitro measurements are accomplished by a 7.4 V power supply voltage at the spectral detection range of 340-850 nm. Based on measurements, the device consumes low power (88 mW) and has a minimum detection of 89 μM/L. Along with the use of a wireless system, it also has a small size and total weight of 17 g. Such a prototype and results validate prospective models and approaches to design a fully integrated cell spectrophotometer. Then, a specialized chip solution is designed and fabricated within CMOS technology to decrease power and size. This chip includes photosensor elements and mixed-signal circuits integrated within a single chip. The photo-sensing elements consist of PIN photodiodes to convert the light into electrical current and a bank of metal patterns acting as nanoplasmonic filters. New circuit techniques such as switched bias transistors are used in this design to decrease the input referred noise without increasing its size and power consumption. Having all the photo-sensing and the mixed-signal circuits implementing a complete spectrometer integrated on a single chip will lead to an unprecedented level of miniaturization for these types of instruments, making the proposed system flexible and expandable to several applications. The envisioned microsystem on a chip will be the core of an adaptive, autonomous, and smart microsystem for spectroscopy of complex structures and diverse materials like human tissues.

SPRUCE BUDWORM OUTBREAKS IMPACT THE SURVIVAL AND SPACE USE OF BOREAL CARIBOU

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The boreal populations of woodland caribou (Rangifer tarandus caribou, hereafter boreal caribou) are considered as threatened in Canada. Most plans for population recovery focus on the protection or restoration of their critical habitat. While the impact of wildfires and human activities on boreal caribou populations have been largely characterized, little information exists on how forest insect pests influence the distribution of boreal caribou. Yet, insect outbreaks affect areas larger than those impacted by wildfires and logging activities combined. Understanding the response of boreal caribou to insect outbreaks can provide critical information for their conservation, especially given that outbreaks are expected to become more severe and to occur at increasingly higher latitude following climate change. In Canada, spruce budworm (Choristoneura fumiferana) outbreaks modify

forest composition by attacking particularly balsam fir (Abies balsamea), and forest structure by creating patches with different levels of tree mortality. The canopy gaps created by tree mortality can be colonized by deciduous vegetation that provides high-quality food for moose (Alces alces), which can change wolf (Canis lupus) distribution, and impact predation risk for boreal caribou. Spruce budworm outbreaks can thus have a complex influence on food webs, and empirical research is needed to clarify the role of this insect on trophic interactions involving boreal caribou. We investigated the combined impact of spruce budworm outbreaks, wildfires and forest harvesting on the survival and space use of boreal caribou and its main predator, the gray wolf, in the Côte-Nord region of Quebec. Seventy-three boreal caribou and sixteen wolves were monitored with Global Positioning System (GPS) collars. Habitat was characterized from the Canadian National Forest Inventory (CNFI) forest cover maps that have been taken in 2001 and 2011 with 250 m resolution. The satellite image was updated every year with information on forest harvesting and wildfires. Local severity of spruce budworm infestation was estimated by the rate of defoliation of forest stands, each year since the beginning of the outbreak. Preliminary analysis revealed that boreal caribou responded to the spruce budworm infestation by decreasing the size of their home range as the area became increasingly impacted by spruce budworms. In addition, we found that caribou which died during the study were the ones selecting more strongly areas impacted by the insect. Spruce budworm outbreak also influenced wolves in their habitat selection, with individuals selecting areas impacted by the insect during most of the year. Similarities in habitat selection between caribou and wolves can explain the relatively high mortality risk that the prey experienced in forests impacted by spruce budworms. The next steps of this study will be to evaluate how the insect outbreak impacts vegetation over time. Finally, we will evaluate the proposed boreal caribou recovery strategy in the context of environmental changes by assessing the cumulative and specific impact of forest harvesting and climate-induced changes on wildfires and spruce budworm outbreaks.

SHADOWS OF THE PAST: VIRAL COMMUNITIES IN ANCIENT ARCTIC SEAWATER AND THEIR MODERN NEIGHBOURS

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Basins of marine origin are a common feature of the coastal Arctic. On the northern coast of Ellesmere Island (NU), several aquatic ecosystems illustrate how post-glacial uplift progressively traps tidal, ocean-connected waters, creating highly stratified fjords that can become meromictic (partially mixed) lakes. These ecosystems are highly dependant on the perennial ice-cover to preserve their striking gradients in water chemistry, which result in the creation of many, vertically distributed niches that are occupied by diverse microbial communities. Light, salinity, oxygen concentration and nutrient availability are important factors driving the composition of the microbial communities, but viral infection likely also plays a determining role in their top-down control and evolution, as observed in other aquatic environments. Previous research in one of these ecosystems, meromictic Lake A, has shown that the viral populations are highly stratified, abundant, but also scarcely reported in genomic databases suggesting they may be derived from the original viral communities entrapped from the ancient Arctic Ocean. Viral metagenomic studies have previously focused mainly on marine and inland freshwater samples, providing valuable sequence and functional data, and information about the geographic distribution of widespread virotypes. Here, we used a metagenomic approach to compare viral assemblages in the deep waters of Lake A (saline and anoxic) with deep waters of neighbouring habitats, specifically marine-connected Milne Fjord (saline and oxic) and freshwater Ward Hunt Lake (low salinity, seasonally anoxic), with the aim of situating the novel viruses in the ancient seawater of Lake A relative to assemblages in modern habitats. Preliminary results show clear differentiation of the bottom water viral communities among sites, with community similarities between different depths in each lake, and some similarities among the transition zones of the three lakes. The latter upper water column similarities may reflect the oxygenated

upper freshwaters in all three ecosystems, and a possible influence of snow- and land-derived microbiota.

DEVELOPMENT OF ANALYTICAL TOOLS FOR ON-SITE MONITORING OF FOOD QUALITY

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Despite the presence of imported products, traditional food originating from hunting and fishing plays an important role in the diet of northern communities, as it is an excellent source of essential nutrients. However, it may also contain high concentrations of contaminants such as lead (Pb) and mercury (Hg), which pose health risks for these communities. It is therefore important to provide food quality data to consumers to empower their decision-making processes pertaining to eating habits. As part of the Sentinel North initiative at Université Laval, this project aims to develop a portable and easy to use analytical platform to achieve on-site investigations of target elements in country food. The project draws upon transdisciplinary expertise in analytical chemistry, photonic materials, engineering and instrument design, microfluidics, toxicology, psychology and public health to empower the communities' capacity for analysis and information regarding the quality of traditional foods. As dissolution of food plays a critical role in the efficiency of the envisioned platform, the dissolution process of arctic char meat was evaluated. Alkaline dissolution using tetramethylammonium hydroxide (TMAH) and ultrasonic frequencies is a fast, simple and reliable technique requiring little energy and a limited quantity of chemicals; sought-after characteristics for on-site analysis. In collaboration with the department of mechanical engineering, an external ultrasonic probe was developed to enhance sample dissolution. Once dissolved, quantification can be performed by portable analytical techniques. Yet, compared to conventional lab-based systems, these are frequently plagued with issues such as spectral and matrix interferences. In this project, Pb, Hg and the biological matrix are isolated from each other using a resin separation technique, allowing for the selective extraction of Hg and Pb while matrix constituents are not retained. This dissolution strategy combined with the separation approach is promising for thorough on-site sample preparation. From the sensing point-of-view, high-performance optical detection of Hg is attained through the development of a chemoselective fluorescent compound, fluorescein dithionocarbonate, predesigned to undergo alterations in its emissive properties upon interaction with Hg. The performance of this new probe towards Hg-sensing has been evaluated by varying the matrix composition (pH, temperature, and interfering ions) and testing for a range of possible Hg concentrations. Overall, this presentation offers an overview of the most promising results pertaining to the analytical chemistry aspects of a field-deployable tool for metal ion sensing, i.e. dissolution, separation and sensing.

SYSTÈME DE DÉTECTION DE LA LUMIÈRE SOUS-MARINE PAR DANS LES LACS NORDIQUES

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Avec les changements climatiques, l'Arctique se réchauffe et change d'année en année. Ces transformations affectent plusieurs aspects de l'écologie nordique. Elles doivent être surveillées afin que nous soyons en mesure de les comprendre, d'évaluer leur impact, de les modéliser et d'anticiper les variations futures. L'élément principal des changements climatiques visé par ce projet est l'effet de la fonte des glaces sur l'apport en luminosité sous-marine spécifique à la photosynthèse des lacs nordiques (photosynthetically active radiation; PAR). Ce projet vise à répondre à une demande grandissante en instruments de surveillance permettant la récolte de données sur une période plus longue de l'année et avec un meilleur échantillonnage spatial. Nous proposons un prototype de système de collecte de la luminosité sous-marine pour des longueurs d'onde dans la région visible du spectre. Le système utilise la fibre optique pour recueillir la lumière et la transmettre à une unité de contrôle centrale pouvant lire les données de plusieurs sondes différentes, ce qui

permet de centraliser l'électronique et d'avoir un appareil plus autonome. L'utilisation de fibres optiques permet une plus grande flexibilité quant au déploiement de sondes sous-marines comparativement aux senseurs électroniques commerciaux, particulièrement en ce qui a trait à la distance entre le point de collecte de la lumière et le point de mesure. Nous proposons un système comprenant plusieurs sondes à fibre optique afin de mesurer la lumière à différentes profondeurs simultanément et en fonction de l'orientation. À cette fin, un premier prototype a été fabriqué afin de tester certaines parties du système final et a été testé en région arctique. Il a aussi permis de comparer les mesures avec celles prises par un instrument commercial. Nous proposons maintenant d'ajouter un système d'analyse spectrale, car la distribution de la lumière change en fonction de la profondeur. Une méthode d'analyse du signal permet de retrouver le spectre de la lumière en analysant seulement un nombre limité de bandes spectrales, ce qui réduit le nombre de photodiodes, tout en conservant la réponse spectrale du système et la quantité de lumière aux différentes profondeurs. Une analyse a aussi été complétée concernant les lentilles de concentration pour augmenter la quantité de lumière mesurée par la sonde et ainsi augmenter la sensibilité du système. À l'été 2019, un second prototype sera assemblé. Il regroupera les fonctions du premier prototype ainsi que ces nouvelles fonctions. Le système électronique a été conçu dans le but d'automatiser les prises de mesures et d'ajouter le système d'analyse spectrale au prototype. Un système de correction pour l'angle de vue de la sonde optique sera aussi appliqué aux mesures. Le second prototype est protégé par un boîtier résistant aux intempéries afin de permettre la collecte de données sur une période de temps plus longue. La présentation fera le point sur les résultats récents et présentera une analyse plus détaillée concernant les avantages de l'approche proposée et des aspects restants à améliorer.

ENERGY BUDGET OF THE ARCTIC SNOW COVER: MEASUREMENTS AND SIMULATIONS

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Numerous land surface models are coupled to a snow scheme. However, most of them are either very simple or, when they are sophisticated, they were developed specifically for alpine regions. This raises the question of their suitability for polar regions such as the shrub tundra biome, which is expanding at the expense of the herb tundra. Arctic snow differs considerably from alpine snow in terms of stratigraphy and physical properties. This makes the region interesting for testing a state-of-the-art snow model within a land surface model outside the region for which it was developed (the Alps). Here, the performance of the two models within the SURFEX modelling platform, namely ISBA (land surface) and Crocus (snow), are evaluated at a shrub tundra site near the village of Umiujaq in northern Quebec, Canada (56°32'N 76°33'W). The performance is evaluated using a dataset covering nearly two years and comprising all the terms of the surface energy budget such as the radiation fluxes, the ground heat flux as well as the turbulent fluxes of sensible and latent heat from eddy covariance measurements. First results show that Crocus does not perform adequately in this Arctic setting. For example, the density of fresh snow and its subsequent compaction are not modeled correctly and this affects the simulation of energy terms such as the heat flux through the snow. Moreover, the model overestimates sublimation and lacks reproducing condensation to the snow surface. Model modifications are being made to improve the performance of Crocus in Arctic conditions.

DECIPHERING THE TIME EVOLUTION OF DYNAMICAL COMPLEX SYSTEMS USING DEEP LEARNING MODELS

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Complex systems are ubiquitous in the North. Noteworthy examples are food webs, animal migration, and bacteria interactions, best represented by a network of interactions. These systems are often driven by external factors such as climate change or seasons so that they are constantly adapting and rewiring. However, monitoring

a network structure is typically costly. For instance, food webs are painstakingly constructed on the field by observing predation. Our project aims at developing new methods to track network adaptation through a more accessible channel. One promising avenue is to monitor the activity of the network components, called nodes, and then inferring the evolution of the network structure. The activity can be any quantity that reflects with whom the nodes interact with. The idea behind this approach is fairly simple: Anomalous behaviors of nodes are mostly caused by changes of the network structure. For example, growth in prey populations could announce that predator hunting is perturbed so that the food web data should be updated. To detect anomalous activity, we propose a novel tool that uses deep learning methods adapted for structured data. First, the deep learning model is trained to predict the time evolution of the nodes activity. During that stage, the model learns the functional relationship between neighbors' activity so that the network structure is taken into account for an accurate prediction. Second, we use the model to infer the underlying network structure for an observed time series of nodes activity. We do so by detecting anomalies, if any, between the predicted and observed node activities for a given a priori network structure. We then backpropagate the error into the a priori network structure so that we can identify which elements of the network have participated in this erroneous prediction. These elements can further be interpreted as which parts of the a priori structure should be rewired to decipher the time evolution of the network structure. Our method has been evaluated and benchmarked with causal inference methods and nearly-optimal statistical methods on different schemes: Both discrete and continuous node dynamics and different network structures and evolutions. For continuous dynamics, we use a synthetic predator-prey interplay on real food web networks. During the synthetic time series generation, we remove random edges from the network. In most cases, our model is able to accurately predict which edges have been removed. As for discrete dynamics, we find that our approach matches the performance of the statistical methods, without appealing to computationally expensive sampling methods. Our method brings deep learning to temporal networks by decoding the network structure contained in the nodes activity. Our approach is totally model-free, which means it can be used on any system without a priori knowledge on the nature of the system. This approach could simplify the data gathering of complex systems of the North and benefit existing resilience frameworks to reveal precursors of system breakdowns. This submission features the results of a 7 days workshop sponsored by Sentinel North completed in February 2019.

GENOME-SCALE MODELING OF METABOLISM IN THE COLD-ADAPTED DIATOM FRAGILARIOPSIS CYLINDRUS UNDERSCORES THE STRONG RESILIENCE OF GROWTH RATE TO CELLULAR PERTURBATIONS

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Diatoms are major primary producers in polar environments where they can actively grow in extremely variable conditions notably of light and temperature. Integrative modelling using genome-scale metabolic model (GSM) is a powerful approach to decipher the complex interactions between components of diatom metabolism and can provide insights into metabolic mechanisms that explain their evolutionary success in these extreme environments. Here, we developed the first GSM for a cold-adapted diatom, Fragilariopsis cylindrus. The model allowed us to analyze the resilience of growth rates to changes in biochemical composition or model structure. Local and global sensitivity analyses of the cell biochemical composition and nutrient uptake rates show that the predicted growth rates are most sensitive to variations in carbon uptake and total cellular proteins, lipids or carbohydrates. Yet, 100 000 random combinations of model parameters varying by ± 40% for 64 out of 65 parameters affected growth rates of F. cylindrus by less than 14%, leaving carbon uptake rate as the most important parameter controlling the growth rate. Sensitivity analyses of intracellular reaction fluxes and reaction deletions on the metabolism also demonstrated the strong resilience of F. cylindrus growth. Normalization of stoichiometric

coefficients per total mass involved per reaction as well as constraints on total cellular C could buffer the effect of changes in the input parameters on reaction fluxes and growth rate and partly explain the strong model resilience to variations in model parameters. Analyses of network structure (i.e., centrality indices and degree distribution of metabolites as well as differential reaction activation) suggest that activation of compensatory reactions can explain network robustness to reaction deletion. Our results support the general assumption that measured growth rates during ecophysiological studies are robust estimators of cell physiological states, and they underscore the importance of resilience of metabolism in F. cylindrus, a feature that undoubtedly helps to maintain cell homeostasis under extremely variable polar environmental conditions. On a more general note, the GSM we developed will help further analyze the effect of photoperiod and light spectrum on algal metabolic diel rhythmicity in order to propose new (and more effective) light therapy treatments in humans, who surprisingly share some molecular components of the diatom putative circadian clock.

MACHINE LEARNING APPROACHES APPLIED TO QUANTITATIVE VOLUMETRIC IMAGE ANALYSIS OF THE ZEBRAFISH BRAIN

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Model organisms such as the zebrafish, are powerful tools to investigate the mechanisms underlying the gut-brain communication and hows it affects brain development, mental health and neurological disorders. Using fluorescence two-photon microscopy and optogenetics methods, it is possible to study how brain cells communicate and respond to various types of stimuli in living zebrafish larvae (5-6 days old). Using fish lines that express fluorescent sensors reporting neuronal activity in brain cells, we can monitor the activity and morphology of a large population of neurons (> 1000) with a very high spatial (< 5 μm) and temporal (> 5 Hz) resolution. This gives rise to very complex datasets necessitating the development of high throughput quantitative analysis methods. We developed machine learning approaches to assess different tasks of volumetric image analysis of the zebrafish brain. We compared how convolutional deep neural network (CNN) and Random Forests perform for class specific segmentation in fluorescence microscopy images. To generate reliable training datasets, we developed a user-friendly image annotation application adapted to volumetric imaging of the zebrafish brain. We then applied our methods to high throughput quantification of different features such as cell types, cellular morphology, subcellular structures, calcium activity. Another important step is to identify the cell types, according to their location in the brain, where the neuronal activity has been recorded. For this purpose, zebrafish brain atlases from 6 day old zebrafish have been developed by a few laboratories. We characterized how the generated segmentation maps can be used for image registration with those zebrafish brain atlases, in order to identify the specific circuits in which neuronal activity was recorded. These technical developments will help accelerate the investigation of the impact of manipulation on gut microbiota on neural circuit development and function.

SENTINEL NORTH RESEARCH CHAIR IN ECOSYSTEM APPROACHES TO HEALTH

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Northern and rural ecosystems are changing rapidly and Indigenous and coastal populations are particularly vulnerable to these changes. While older persistent organic pollutants are declining, mercury remains a topical issue in the North. Each year, several new chemicals are also placed on the market and subsequently found in the North, with unknown impacts on health. Global changes also exert increasing pressure on marine ecosystems and eventually on food security, which is precarious in several Indigenous and coastal communities. Local foods are important for health, social cohesion, cultural continuity, and food sovereignty. Foods from the sea also are exceptionally rich in nutrients such as selenoneine, an anti-oxidant selenium compound that we recently identified in Arctic marine foods. These may help prevent diabetes and cardiovascular diseases, enhance brain development and/or counteract the harmful effects of environmental

contaminants on health. As a continuation of the Nasivvik Chair, this new Sentinel North Research Chair aims to pursue interdisciplinary research and intervention projects, in close collaboration with Indigenous Peoples and coastal populations, to act in prevention and minimize the emergence of non-communicable diseases, to improve resilience to global changes and to promote healthy ecosystems to cultivate Indigenous and coastal health and well-being.

DEVELOPMENT OF AN OPTICAL PROBE FOR CONTINUOUS POROSIMETRY OF SNOW

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Lemmings, an important part of the Arctic food chain, do not hibernate. During the winter these rodents live in the snow where they dig tunnels that allow them to seek for food and reproduce. The ease with which they dig these tunnels will partly determine the evolution of lemming populations. Physical properties of snow, such as its density, are fundamental spatiotemporal data to measure. Snow density is currently measured by weighing a known volume. This process requires the presence of scientists in the field, which is complex and expensive given logistics constraints in the Arctic. Then, this property cannot be characterized throughout winter and over a large area. This project focuses on developing an optical method to measure snow density without human intervention. Light propagation in the snow, a complex medium composed of air and ice grains, depends on its density and on the size and the shape of the grains that compose it. Here, we demonstrate that snow density can be optically measured using time-resolved radiative transfer. We developed a theoretical framework supported by numerical simulations to relate the effective refractive index of snow to its density. We then show that snow density can be optically obtained by measuring its effective refractive index when a shape parameter of the snow grains is characterized. An experimental method to measure the effective refractive index of the snow will be presented. Using empirical relationships, this optical technique could retrieve the porosity and the specific surface area of the snow. This paves the way for an robust, fast, and non-destructive method to measure snow physical properties in the Arctic.

GERM FREE MICE AS A MODEL TO INVESTIGATE NEW MECHANISMS INVOLVED IN CARDIOMETABOLIC DISORDERS IN THE NORTH; HOW THE GUT MICROBIOTA IMPACTS THE ENDOCANNABINOIDOME

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Improvements in communications and transportation to and from southern regions caused rapid social transitions in northern populations that led to a progressive shift from their traditional diet rich in proteins and essential vitamins to a more westernized one. This transition has been associated with an increased prevalence of cardiovascular risk factors such as obesity, high blood pressure, elevated blood lipid levels and diabetes, even if the associated mortality rates are lower compared with southern populations. The development of metabolic disorders is influenced by an interaction of genetic, environmental, behavioral and microbial factors. In northern populations, the exposure to cold and the variation in the daily light cycle results in adaptive responses and management of fuel that profoundly affect human physiology. It has been reported that transplantation of caecal material from mice reared at low temperatures to germ free (GF) recipients improved their metabolic phenotype, reduced obesity and improved insulin sensitivity. Gut microbiota "interact" with adipose tissue development and metabolism through the

endocannabinoidome (eCBome)-a complex lipid signaling system with important functions in cardiometabolic health-by modulating the expression of endocannabinoid metabolic enzymes as well as the expression of the cannabinoid receptor type-1 (CB1) in the intestine and adipose tissue of mice. The intestinal microbiome and the eCBome also show differences in sex and age that may affect people's susceptibility to obesity-related complications. Given the interconnection between the microbiome and eCBome, we aimed at gaining evidence for a strong link between these two systems by investigating how the eCBome is altered by the lack of a functional microbiome in the gut of GF mice, and by the subsequent restauration of a functional microbiome in these mice following faecal microbiome transfer (FMT). We measured the basal eCBome gene profiles and lipid levels using qPCR and LC/MS, respectively, within metabolically relevant tissues of germ free and conventionally reared male and female mice at juvenile and adult ages. Our preliminary qPCR and LC/MS results show that the absence of the gut microbiome is accompanied by profound modifications in eCBome gene expression and lipid mediator levels in the small and large intestine. These results are consistent with the phenotype of GF mice and the roles that various eCBome components are known to play in intestinal motility, absorption and inflammation. FMT from healthy donor to age matched GF male mice was able to reverse most of these alterations, reinforcing the concept that the gut microbiome directly impacts the host eCBome, with possible implications for the regulation of metabolism. Our study is providing us with more information on how the microbiome can impact the eCBome, allowing us to better design and perform studies in which we will investigate microbiome changes induced by different dietary regimes, cold and photoperiod and consequent modulation of the eCBome in metabolically relevant tissues and their impacts on cardiometabolic health of northern populations.

CHARACTERIZATION OF MGLL-/-MOUSE MICROBIOTA TO HIGHLIGHT THE MICROBIOME-ENDOCANNABINOIDOME AXIS IN METABOLIC HEALTH

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The microbiome is involved in many pathological processes, including diabetes, though the molecular mechanisms through which it acts remain to be elucidated. As such, the relationships between the microbiota and various signalling systems such as the endocannabinoidome (eCBome) are growing fields of study. The eCBome—a network of lipid signalling molecules, their receptors and regulatory enzymes that are related to, endocannabinoids—is involved in many of the same biological functions as the gut microbiota, including regulation of glucose metabolism. Recent work indicates that the interaction between the gut microbiome and the eCBome is bidirectional, suggesting the existence of a biologically relevant microbiome-eCBome axis. To study this axis, we will utilize eCBome genetic mouse models such as monoacylglyceride lipase (MGLL) knockout mice (Mgll-/-). MGLL degrades the endocannabinoid 2-arachidonoyl-glycerol (2-AG), which activates cannabinoid CB1/2 receptors, and related mono-acyl-glycerols, which instead often activate GPR119. Mgll-/-mice exhibit high tissue levels of these signalling lipids, with subsequent CB1 desensitization and/or altered GPR119 activity and are resistant to high fat diet-induced insulin resistance. Mgll-/-mice are therefore an interesting model in which to study the relationship between metabolic disorders and the gut microbiome-eCBome axis, with the aim of identifying bacterial species, which, may be partly responsible for its metabolic phenotype. In this work, we first characterized the microbiota of Mgll-/- mice under normal and high-fat diet by 16S metagenomic sequencing. Then, we used culturomics in order to determine whether 2-AG, which is abundant in the intestine and present at even higher levels in Mgll-/-mice, has an impact on intestinal microbial diversity. We cultured stool samples from normal mice supplemented with 2-AG in liquid media; these cultures were then analyzed by 16S and on agar plate through culturomics to identify direct effects on the microbiome in vitro and identify responsive bacterial species. The preliminary results show that the gut microbiota of Mgll-/- and wild-type mice are clearly separated according to genotype by 16S sequencing, suggesting that the presence or absence of MGLL may interact with the gut microbiome of mice. Further, the Roseburia and Parabacteroides genera, which

have been associated with improved glucose homeostasis, were increased in Mgll-/—mice. This analysis opens up the prospect of identifying and characterizing commensal bacteria influenced by altered levels of mono-acylglycerols and the activity of their receptors, which possibly mediate the phenotype of Mgll-/-mice and play a role in metabolism. Funding: We thank the Canada Excellence Rsearch Chair on the Microbiome-Endocannabinoidome Axis in Metabolic Health (CERC-MEND), Université Laval.

THE ECOCHIP: A WIRELESS MULTI-SENSOR PLATFORM FOR COMPREHENSIVE ENVIRONMENTAL MONITORING

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The EcoChip is being developed in the course of the Sentinel North sub-project 3.2 - Comprehensive environmental monitoring and valorisation: From molecules to microorganisms. Sentinel North's Technology maturation fund is now allowing our team to address some remaining technical challenges before we can undertake the next steps towards final validation and technology transfer to industry. The EcoChip has been jointly developed and validated in the laboratory by our multidisciplinary team, and utilized to collect bio-environmental data in the field from the northern soils and ecosystems of Kuujjuarapik (2017) and Puvirnituq (2018), during two expeditions. We are currently working toward the development of a precommercial version, thanks to the Technology maturation fund, and we plan to release a prototype and test it in the field this summer. We believe the EcoChip will fill the gap in the field of bioremediation and global bio-environmental monitoring, which both may represent major markets. The technology has reached a development stage that justified recently filing a provisional patent application. We are now seeking industrial partners that could use this technology in commercial applications. The EcoChip is a new autonomous wireless sensor platform intended for culturing and monitoring the growth of microorganisms and their environmental conditions in situ, in harsh environments, such as in northern climates. This platform includes a layered multiwell plate that allows the growth of single strain microorganisms, within a well of the plate, isolated from environmental samples from northern habitats. It can be deployed in the field for continuous monitoring of microbial growth within 96 individual wells through a multichannel electro-chemical impedance (EIS) monitoring circuit. The EIS monitoring system uses high-performance off-the-shelf electronic components, presents low excitation voltage signal not to harm the cells and has a calibration network for high-precision. Additional sensors are provided for measuring environmental parameters such as luminosity, humidity, and temperature. The embedded electronic board is equipped with flash memory to store sensor data over long periods of time, as well as with a low-power micro-controller, and a power management unit to control and supply all electronic building blocks. When a receiver is located within the transmission range of the EcoChip, a low-power wireless transceiver allows transmission of sensor data stored in the flash memory. The performance of the system was successfully measured in vitro in a laboratory setting. The EcoChip can perform EIS analyses over an excitation frequency range of 750 Hz to 10 kHz with an accuracy of 2.35%. The complete system presents an average power consumption of 114.6 mW in normal operating mode and of only 0.14 mW in sleep mode.

TOWARDS AN ULTRAFAST ALL-FIBER LASER SOURCE FOR MID-INFRARED SPECTROSCOPY

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Recently, there has been much interest in environmental monitoring to quantify and model the climatic changes affecting our planet. One of the objectives of the BOND project within Sentinel North is to develop mid-infrared lasers to detect and quantify atmospheric pollutants fluxes escaping from thermokarsts in the Arctic in real time. These devices could enable year-round real time flux measurements by replacing more expensive setups such as Eddy towers or devices such as closed or dynamic chambers that require more work force and that cannot stay in place year-round [1]. In the last few years, efficient supercontinuum emission in the transparency window of the atmosphere between 3 μm and 5 μm and efficient ultrafast laser emission tunable up to 3.6 μm have been generated from laser oscillators emitting ultrafast pulses near 2.8 μm [2, 3]. These kinds of laser sources are promising for probing the strong fundamental ro-vibrational resonances of multiple atmospheric pollutants at the same time such as CH4 and CO2 over long distances, but they must be robust and reliable if they are to be used in harsh environments such as Arctic regions. In this contribution, we study alternative designs using either a semiconductor saturable absorber mirror (SESAM) or a Dy3+-doped silica fiber for generating ultrafast pulses with a linear laser cavity to design a robust ultrafast all-fiber laser operating near 3 μm to replace previous sources for broadband mid-infrared laser emission. The mode-locked Er3+-doped fluoride fiber laser generates pulses as short as 15 ps with an average power of 58 mW at a repetition rate of 55 MHz using a SESAM (BATOP, GmbH) and is stabilized at 2791 nm by a fiber Bragg grating. By butt-coupling the SESAM directly to the fiber tip, an all-fiber design could be implemented to provide the robustness and reliability required for field applications. Alternatively, the use of a Dy3+-doped silica fiber as saturable absorber to generate ultrafast pulses will be studied. The measured absorption spectrum of this fiber should provide enough saturable absorption, and its form factor makes it very durable. Moreover, numerical simulations show promising results with at least passive Q-switching occurring. Finally, the ultimate objective of this project is to generate a broadband laser emission tuned for methane spectroscopy by amplifying the shortest pulses generated by the ultrafast laser and integrate it into a remote sensing device to quantify the fluxes of methane.

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BIOPHILIC DEVELOPMENT OF ADAPTIVE FAÇADES FOR HEALTHY AND ENERGY-EFFICIENT BUILDINGS IN QUEBEC'S NORTHERN TERRITORIES

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This research aims at developing biophilic adaptive façades as a promising solution to promote occupants' health and building energy efficiency in the extreme-cold climate of Quebec's northern territories. Adaptive façades point to the (self-) adjustment of façade components (such as shading panels, windows and blinds) to occupants' needs and environmental conditions in order to improve the overall performance of the building. Meanwhile, biophilic design offers several recommendations to promote human-nature relationships in buildings.
The biophilic development of adaptive façades has considerable potentials to deal with the challenging state of living and working in northern latitudes. Strong seasonal light/dark cycles (photoperiods) come with very low average weather temperatures creating an extreme climate for living and working in northern latitudes. In such harsh climates, occupants spend most of their time inside buildings and their health is highly affected by the indoor environment. More specifically, accessibility to natural light and cycles affects occupants' health and behavior as well as energy consumption of buildings. In this regard,

photobiological research shows that the lighting ambiance and local photoperiods have significant impacts on the biological clocks, alertness and performance of building occupants. Thus, northern buildings should mediate the extreme climate and satisfy occupants' needs through offering them a sufficient accessibility to natural cycles and providing them a healthy lighting ambiance. These issues have thus far received negligible attention in designing buildings in Quebec's northern territories. The southern imported models of buildings have been constructed to mainly respond to thermal comfort dependent on mechanical systems. Occupants' access to outdoor environment and natural cycles is severely limited in such building models. This research develops biophilic adaptive façades which could respond to northern occupants' needs and climate conditions. The research particularly focuses on lighting adaptation strategies. The study produces several prototypes of such adaptive façades optimized for northern Quebec. The research uses experimental methods and runs a parametric study to analyze and assess the productivity of such façade systems. The results of this research could be used by designers and developers to promote the living and working ambiance in northern territories which result in significant benefits in terms of public health, environmental footprints and economy.

DEVELOPMENT OF A REFLECTANCE PROBE TO MEASURE SEA ICE INHERENT OPTICAL PROPERTIES

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More detailed characterization of the spatially and temporally varying inherent optical properties (IOPs) of sea ice is necessary to better predict sea ice energy and mass balance and under ice primary production. Here we present the development of an active optical in situ probe for measuring IOPs of a small volume of ice (mm3 to cm3) non-destructively and within short time. The precision, efficiency and ruggedness of the concept allows scientists obtaining sea ice IOPs values within a 2" hole directly in the field within minutes. It provides high-resolution vertical profiles of sea ice IOPs and allows for the investigation of IOPs' relationship to other physical sea ice properties. The probe is based on the diffuse reflectance technique used to measure IOPs of human tissues. Conceptually, the instrument emits light into the ice by an optical fiber. Backscattered light is measured at multiple distances from the in situ source using other fibers. Measured reflectance vs distance curves are compared to values derived from Monte Carlo simulations of radiative transfer. A pre-computed look-up table and an inverse algorithm allows for inferring the absorption coefficient, the reduced scattering coefficient and the asymmetry parameter of the scanned sea ice. Here we present the design of the instrument, as well as first results from field tests acquired in the Canadian Arctic in 2018 and 2019. This includes the first vertically resolved in situ measurements of sea ice IOPs.

DISTRIBUTED OPTICAL GAS SENSOR ON CHIP FOR ENVIRONMENTAL MONITORING

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We present an optical nose on chip made of a matrix of optical gas sensors. Optical noses integrated on chip present numerous advantages over electronic noses such as low power requirements, robustness, and immunity to electromagnetic fields, remote sensing and lower price. Miniaturized on chip sensors, designed to detect airborne compounds, are essential for inexpensive monitoring systems that are portable and deployable on a large scale. The optical sensing device is based on a reversible absorption of a gas with a dedicated polymer matrix. The sensor is integrated on chip and is therefore small, compact, and can be distributed in a network enabling low power consumption. We demonstrate that it can monitor several volatile organic compounds (VOCs), such as alcohols, aldehydes, ketones, carboxylic acids, amines and aromatics, that it operates in a reversible fashion under different environmental conditions (temperature and

humidity), and that it detects concentrations in the order of parts per million (ppm).

A SYSTEMIC ANALYSIS OF ARCTIC SECURITY

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This paper will focus on the governance of the Arctic ocean system, through the prism of security. By analyzing security policies and treaties from coastal countries around the Arctic ocean we aim at understanding how they apprehend the changing Arctic. A series of interviews conducted in Norway and Canada in the winter and spring of 2019 - as part of a Sentinel North mobility grant - will complete this discourse analysis. We argue that when tackling the issue of the governance of an ocean system, two key processes must be taken into account: environmental processes on the one hand, and social processes on the other. Both are currently undergoing important changes in the Arctic, implying new variables in the security equation. Two main challenges can characterize security and its governance in the Arctic: climate change and globalization. Each can be declined manyfold, at different scales, implying a wide array of variables. We aim at (1) broadly delineating the state of the security system in the Arctic today, through a cross-analysis of the actor network at play and the referent objects for security put forward in Arctic strategies. Doing so, we will focus on the coastal states around the Arctic Ocean. This will allow us, then (2) to conduct a multiscalar analysis of this security system. Still focusing on the ocean as a core territory of study, we want to question the scale of 'Arctic Security' and how it faces external powers becoming increasingly interested in the region

POLYCHROMATIC MICROSCOPY USING THE SPECTRAL BANDWIDTH OF ULTRASHORT LASER PULSES

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A good understanding of the northern ecosystem starts with a good knowledge of its microorganisms. These organisms, such as protists, prokaryotes, and viruses, which are the most abundant specimens, play a significant role in regulating the nutrients and the energy of this environment. A better comprehension of their dynamic, their interaction, and their biodiversity is vital for a good insight into the northern ecosystem. To achieve this higher understanding, it is of utmost importance to improve and develop new microscopy techniques capable of investigating the structure and dynamic of these specimens. It is however difficult to do so since these structures are often on the scale of tens of nanometers. It is then necessary to surpass the diffraction limit and use techniques that are said to be of superresolution. Furthermore, this task is even more challenging in a marker-free modality. Marker-free microscopy techniques have gained a lot of traction in the latest years because of their ability to image microscopic samples without disturbing them with fluorophores, dying agents, or high laser power. This allows for studying the sample without altering its properties or destroying it. To achieve a better understanding of the structure and dynamic of northern microorganisms, it is therefore necessary to develop new label-free microscopy techniques and improve existing ones. To achieve this, the present project proposes to use the spectral modulations in ultrashort laser pulses as signatures to reconstruct the structures of microorganisms in the context of marker-free microscopy. More specifically, since ultrashort laser pulses have a wide spectral bandwidth, we plan on using this feature as a marker to image these structures in 3D. We utilize the analogy that these transparent organisms have with a superposition of thin films to investigate the spectral modulations induced by the interference between the reflections at different depths to retrieve the structures in 3D. To achieve a better understanding of the interaction of these pulses with a microscopic organism, finite-difference time-domain (FDTD) simulations were performed to simulate the propagation of the pulses through this type of sample. Spectral modulations that correspond to the size of different structures were indeed found and were also measured in the lab on different sized fiber tapers as a confirmation of this behavior. This presentation will review these simulations and experiments, and how it is indeed possible to use these spectral modulations to retrieve

information about the structures of microorganisms in 3D without altering the sample with any kind of marker, labeling agent, or high laser power. Further works will focus on using actual northern microorganisms as samples and improving the sensitivity of the technique.

DISTRIBUTION OF A UNIQUE ARCTIC CYANOPHAGE IN ELLESMERE ISLAND'S FRESHWATERS

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The lakes on Ellesmere Island in the Canadian High Arctic have a rich and fragile microbial flora, and microbial communities generally dominate the flora of these lakes. Viruses are the most abundant and diverse microorganisms in aquatic environments. Their lytic activity allows them to control microbial populations and redistribute the organic compounds used by these populations, thus enhancing the microbial loop and contributing to the distribution of carbon in the aquatic environment. However, very little is known about the viral communities in the Arctic. In Ellesmere Island's freshwater lakes, cyanobacteria are very abundant. Despite this, the distribution of their corresponding phage, cyanophages, has been little studied. Consequently, the proportion of this type of virus in the Arctic environment is unknown. In 2008, the cyanophage S-EIV1, infecting a polar strain of Synechococcus, was isolated from the freshwater of lakes in the northern Ellesmere region and would represent a new evolutionary line of cyanophages. The project presented here aimed to use the results of recent viral metagenomic studies to assess the abundance and distribution of S-EIV1 sequences in freshwater samples from lakes on Ellesmere Island. Preliminary results indicate that the freshwater viral communities of these lakes are similar, despite significant differences in their watersheds and lake chemical structure, both of which will be critically affected by climate change in the future. Finally, since cyanobacteria are often the main primary producers in polar oligotrophic ecosystems, it is essential to determine the distribution and diversity of the phages that infect them.

ADAPTIVE LIQUID CRYSTAL-BASED CAMERA FOR SUBNIVAL OBSERVATION OF LEMMINGS IN THE CANADIAN ARCTIC

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Lemmings are essential species in the Arctic ecosystem and their role in the food chain is fundamental. It is known that their population fluctuates intensely, peaking about every four years and then decreasing almost to extinction. The key to understanding such oscillations is the winter dynamics of reproduction, and now most studies of subnivean processes use comparisons of data before and after the snow season. This is the reason why we are working on creating an adaptive camera that can be used for continuous lemming observation under the snow during winter. We prepared the first prototype devices and installed them in the field in 2018. They have been working in the field over 9 months in sites with a high probability of lemmings' presence. Meanwhile the improved second-generation cameras were being prepared for next year data collection (2019-2020). To prevent depth hoar formation on the camera lens due to temperature gradient and high humidity, we place our cameras on the lateral sides of the boxes. However, for this configuration, distance to the object varies, so optical power should change to achieve the maximum image quality and assess relative size of observed individuals in order to categorize them. To achieve this, we are working on a liquid crystal (LC)—based tunable lens with an autofocus algorithm. Liquid crystal lenses are widely used in imaging applications thanks to their tunability, miniature size, low cost and power consumption. However, these lenses are often characterized at constant (room) temperature and adapting a LC lens to large temperature variations remains a challenge (few research efforts have been devoted to address the problem of using LC lenses at low temperatures). To study the effect of temperature change, we start with a traditional modal control lens design. Main material parameters of such a lens were measured at a wide range of temperatures in order to optimize the lens design by choosing appropriate materials and control parameters. We propose an approach allowing

to “athermalize” a LC lens by adapting the working AC frequencies to temperature variations. Experimental prototypes of LC lenses were created and characterized in the range of temperatures from -20oC to +40oC. It was shown that it is possible to achieve almost the same values of optical power (OP) despite different environmental conditions. To decrease the response times, low-viscosity LC was used. The effect of thermal expansion/contraction has been studied and additional OPs were measured and compared with the theoretical estimation in order to compensate them by adjusting the working frequency. Other factors and limitations affecting lens optical performance are also discussed. The present study is useful to evaluate lens operation at various temperature ranges (including the low temperature applications of LC lenses), in particular when low power consumption is required. Implementation of this technology will help us to explore the subnivean reproduction cycle of lemmings and fully understand the factors affecting it.

ARCTIC MID-WINTER PHYTOPLANKTON BLOOM INITIATION REVEALED BY AUTONOMOUS PROFILERS

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It has widely been believed that Arctic marine phytoplankton blooms cannot develop until sea ice and snow cover melt and permit sufficient irradiance for algae to photosynthesize. To the extent that under ice blooms have been observed, they were linked to light penetration through leads and melt ponds in the ice cover. Logistical challenges complicate observing annual phytoplankton dynamics in ice-covered Arctic waters, particularly in winter. In the last years, Takuvik has been deploying autonomous so-called biogeochemical Argo floats in Baffin Bay, an Arctic sea fully covered by thick sea ice for most of the year. Equipped with a novel ice avoidance system that allows continuing sampling through winter, these floats measure vertical profiles of among other things, chlorophyll fluorescence, particle backscattering, nitrate concentrations, and irradiance. Data from winter 2018 reveal net phytoplankton growth even under 100% ice cover at extremely low light levels, highlighting both the sophisticated adaptation of Arctic phytoplankton to the harsh environment and the low grazing pressure due to diapause of dominant Arctic zooplankton. Notably, our results are consistent with recently emerged hypotheses on phytoplankton-grazer coupling and extend them to Arctic waters, thus contributing to a reinterpretation of global phytoplankton dynamics.

A MULTISPECTRAL PULSED LASER LINE SCANNING SUBSEA LIDAR FOR ARCTIC AUV APPLICATIONS

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The physical and biological properties of Arctic sea-ice and coastal benthos remain poorly understood due to the difficulty of accessing these substrates in ice-covered waters. A LiDAR system deployed on an autonomous underwater vehicle (AUV) can interrogate these 3D surfaces for physical and biological properties simultaneously. Using our understanding of the absorption, inelastic scattering (e.g., chlorophyll fluorescence at 685 nm), and elastic scattering properties of photosynthetic micro- and macro-algae, we present the results of initial field tests of a pulsed laser line scanning subsea LiDAR utilizing a single excitation wavelength (532 nm) and two detection wavelengths (532 nm, 685 nm). We evaluate the 3-D imagery of calibration, man-made, and macroalgal targets using elastic and inelastic fluorescence returns from the LiDAR during pole-mount ship-based testing. AUV deployment constrains LiDAR power (1-24 kWh) and volume (<20 L). To resolve Arctic macroalgae on the coastal seafloor as well as O(10 cm) patches of Arctic micro-algae on the bottom of sea-ice, a ground sample distance of ~2 cm is required. Arctic bio-optical conditions at a distance of 10-15 m requires laser energy

of ~10 μJ / pulse. These design constraints are met by using a commercially-available pulsed fiber laser (200-400 kHz), scanned horizontally at 200 lines/sec using a rotating polygon mirror. To minimize collection of near-field scattered light, four overlapping optical receiver assemblies are used, each with a narrow (~15º) instantaneous field of view. Analog-to-digital conversion of photomultiplier tube output of each detector at 2.5 GSamples/s yields O(5 cm) range resolution. The digitized time history of each pulse return is post-processed to create range and intensity images across a 60º field of view when all four detectors are used at 532 nm. Alternatively, two pairs of detectors can be aligned in parallel to achieve simultaneous elastic (532 nm) and fluorescence (685 nm) imaging at 30º field of view. Calibration targets were deployed during pool tests to evaluate the contrast and resolution performance of the LiDAR under ideal conditions. Initial results from the spatial resolution targets confirm the theoretical prediction of resolving cross-track features of less than 2 cm. The LiDAR was subsequently deployed at the end of a pole mounted to a small coastal research vessel. LiDAR scans were acquired in the waters offshore of Dania Beach, Florida in April 2019 cruising at 1-2 m/s. Using the multispectral mode (30º IFOV), it was possible to resolve fine details of sub-meter size sea floor macroalgae in both elastic and fluorescence images. For classification purposes, we have five dimensions of data (x, y, range, elastic intensity, and fluorescence intensity). Per-return fluorescence information is key to confirming that a sea floor (or ice bottom) target is living (chlorophyll-containing) material. Future work will reduce the sensitivity of the LiDAR to ambient light, increase the overall FOV with additional detectors, incorporate inertial measurement unit data into LiDAR return processing, produce data in open standard LiDAR format, integrate the LiDAR into a commercially-available AUV, and apply deep learning approaches to N-D point cloud object detection, segmentation, and recognition.

DETECTING HIGHER-ORDER CO-OCCURRENCE PATTERNS WITHIN AQUATIC BACTERIAL COMMUNITIES ACROSS CHANGING NUNAVIK PERMAFROST LANDSCAPE

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Microbial ecosystems are prime indicators of health and biodiversity of northern environments. In recent years, thawing of permafrost led to the appearance of ponds and lakes in which microbial activity mediates the emission of greenhouse gases. These ponds host an unsuspected high microbial diversity and hence offer new opportunities to investigate interactions within aquatic consortia. In particular, J. Comte and colleagues sampled 38 ponds within four valleys in the eastern Canadian subarctic, Nunavik, along a north—south permafrost degradation gradient and used network analysis to detect significant co-occurrence patterns. This analysis also led to the identification of "keystone species", defined as species that co-occur with an important number of other species, indicating that they possibly play an important role in the structure of microbial communities [1]. To capture even more information about bacterial interactions in permafrost thaw ponds, we have developed a new general framework to detect co-occurrence patterns between more than two species. To do so, we have used a generalisation of the notion of networks: simplicial complexes [2]. Indeed, since networks can only encode pairwise interactions via edges, information regarding higher-order interactions, in which more than two nodes interact simultaneously, is lost. This reduction to pairwise interactions is problematic as it can lead to incomplete or wrong interpretations. The advantage of simplicial complexes is that they always include networks as substructures and encode higher-order interactions when necessary. Our method relies on log-linear models and statistical hypothesis testing. More precisely, by iterating over all pairs of species, a network of statistically significant pairwise co-occurrences is first obtained. Then, log-linear models are fitted on all groups of three interconnected species in the network. Groups in which triple co-occurrence patterns prove to be non-random are distinguished from other groups. Non-random triples are then combined to study quadruple co-occurrence patterns, and the procedure is iteratively applied to higher-order interactions. Moreover, for each pair, the association between the two species is quantified on a scale of -1 to 1: -1 meaning that both species tend to completely avoid each other and +1 meaning that they always appear together. Higher-order co-occurrences also benefit from

these measures since they can fall into various interaction categories, such as purely positive, purely negative, or a mix of both. This provides valuable information to better identify indicator species. Indeed, one could argue that "keystone species" participating in purely positive higher-order interactions are more likely to play a central role in the ecosystem. In summary, our theoretical framework provides a classification of the interactions in aquatic bacterial communities and uncovers higher-order co-occurrence patterns otherwise undetectable under standard network analysis. References: [1] Comte, J., Lovejoy, C., Crevecoeur, S., & Vincent, W. F. (2016). Co-occurrence patterns in aquatic bacterial communities across changing permafrost landscapes. Biogeosciences, 13(1), 175-190. [2] Lambiotte, R., Rosvall, M., & Scholtes, I. (2019). From networks to optimal higher-order models of complex systems. Nature physics, 15, 313–320

LE SYSTÈME DE PRODUCTION DU LOGEMENT AU NUNAVIK : VERS UNE CONCEPTION INCLUSIVE DES ACTEURS LOCAUX

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La présentation vise à aborder les systèmes actuels de production du logement au Nunavik, à la lumière des notions de complexité et d'habiter. Si certaines études analysent les politiques de logement au Nunavik et les rôles des principaux acteurs, les processus de conception et la réalisation des projets d'habitation sont peu documentés et, à notre connaissance, aucune analyse multisectorielle intégrant les champs visés (gouvernance, études nordiques, habitat et culture, gestion de projet de construction) n'a été réalisée à ce jour. Les processus actuels de production du logement semblent basés sur une logique de rationalité technique, orientée davantage vers la quantité d'unités à construire que vers leur qualité, leur habitabilité et leur signification pour les populations visées. Toutefois, au-delà de la situation « techniquement compliquée » se cache une complexité plus fondamentale qui doit être analysée et comprise, étant liée aux dynamiques et aux systèmes d'éléments interreliés. Cette complexité, plutôt que d'être vue comme une contrainte, peut aussi être perçue comme un atout pour agir et adapter de façon durable les logements aux considérations sociales, environnementales et économiques du Nord. La thèse proposée vise donc à évaluer les processus actuels de production de l'habitat et à proposer des façons de faire appropriables et résilientes, considérant également les visions de l'habiter des communautés Inuit. Ainsi, en envisageant des alternatives au modèle dominant, l'intersubjectivité devient possible et peut permettre un espace de dialogue afin de considérer aussi, dans les prises de décision, la variété de besoins et de préférences des acteurs locaux.

DOES THE CHANGING ICE DYNAMIC IN THE ARCTIC INFLUENCE THE NUTRITIONAL VALUE OF THE BENTHIC FOOD WEB IN NUNAVIK, CANADA?

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In Canada, global change is of concern for northern populations that depend on the Arctic Ocean. This ocean is affected by climate change faster than other oceans. As part of the BriGHT program, this project focuses on the benthic food web, particularly on the species consumed by Inuit populations. The primary source of food for many benthic organisms is likely to change from ice algae to phytoplankton due to the loss of ice cover. This change in food source could influence the availability of essential fatty acids and antioxidants that have important roles in the reduction of cardiovascular diseases and Inuit health. The main objective of this project is to determine if the abundance of specific fatty acids, selenium, selenoneine, and carotenoid pigments in benthic organisms changes with food source across different areas of Nunavik. We will characterize fatty acid profiles, selenium, selenoneine, and carotenoid abundance in benthic organisms and establish comparisons between regions. These results will help to better understand the impacts of climate change on the benthic food web and Inuit diet.

THE UNCULTURED UNDER-ICE MICROBIOME OF THERMOKARST LAKES

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Thermokarst lakes occur in high abundance across the Arctic. These lakes have been implicated in major climate feedbacks, including degradation of stored old carbon and subsequent release of green house gas such as methane and CO2 with major consequences for environmental health and climate warming. Although the methane-emitting nature of thermokarst lakes has been well established, the emissions show a strong temporal variability and the potential for under-ice accumulation of CH4 has been suspected. Arctic thermokarst lakes are ice-covered 8 months per year leading to large geochemical and limnological changes, with potential consequences on their planktonic microbiomes. However, despite its ecological importance, current knowledge of thermokarst lake microbiomes relies exclusively on summer open-water samples, and the under-ice microbiome remains completely unexplored. Here we applied metagenomic and genome-centric metagenomics to resolve and compare the structure and the functioning of the thermokarst lake microbiome during the winter and summer seasons. There were striking contrasts between summer and winter in both microbial community composition and metabolic potential, with methanogens, Chloroflexi and various Candidate Divisions emerging in winter. Associated with these lineages, anaerobic reactions (sulfate-, arsenic-reductions, methanogenesis, fermentations) were predominant during winter season. Ultra-small, novel candidate division bacteria were also abundant during winter. Draft genomes of the thermokarst lake uncultured lineages recovered from winter samples revealed a strong potential for syntrophic metabolism and metabolic cooperation for the degradation of refractory organic substrates coupled with potential methane production, supporting methane accumulation under ice.

INVISIBLE LIFE SUPPORT SYSTEMS: MICROBIOMES IN THE FAST-CHANGING ARCTIC

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There was a time not so very long ago when most life on planet Earth was invisible, even to biologists. The advent and application of light microscopy provided evidence that microbes were almost everywhere, but these observations could only hint at their abundance and diversity. The sense that there is an 'unseen majority' deepened as microbiologists tried to reconcile the low recovery of microbial isolates on culture plates with the increasingly apparent diversity of microbes in the natural environment, a disparity that became known as the 'Great Plate Count Anomaly'. Over the last decade, the application of high throughput DNA sequencing technologies has begun to expose not only the taxonomic richness of microbial life in the biosphere, but also its functional richness and its vital role in underpinning the food webs and nutrient cycles of our planetary system. In a recent 'Warning to Humanity', microbiologists have drawn attention to the vulnerable state of this microbial system, and its potential shift towards conditions that may disrupt the provision of ecosystem services to human society. These concerns are of particular relevance to the North, given the ongoing impacts of Arctic amplification, with the northern climate continuing to warm at rates that are two to three times the global average, and the sensitivity of ice-dependent ecosystems to small threshold effects. This talk will briefly illustrate some of the research projects within thematic project 3 of Sentinel North that are focused on environmental microbiomes in northern ecosystems, and ways that we are evaluating microbial diversity, responses to change and resources for bioprospection. These studies include the development of new instruments to track planktonic and biofilm communities, the application of metagenomics to detect novel taxa (including viruses), the organization of diverse microbes into complex networks, and their responses to seasonal and longer term change, including the arrival of noxious species that may affect environmental and human health.

MOLECULAR TREASURES FROM THE NORTH: NORTHERN NATURAL PRODUCTS TO TREAT IMPORTANT TROPICAL DISEASES

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Nature has been an amazing source of medications for thousands of years. Even today, over fourty percent of all drugs currently used in the clinic are derived from natural products. Due to its incredible biodiversity, the Amazonian forest, recognized as the drug cabinet of the planet, has been thoroughly investigated by phytochemists. By contrast, organisms from northern ecosystems have been barely studied phytochemically. As plants, lichens and other organisms from the North are under unique environmental stresses, they are forced to fabricate unique natural products, defense chemicals, to protect themselves against these threats. Such natural products are known to possess significant biological activities and could be the basis of future medications desperately needed to combat serious diseases and infections. To illustrate the importance of investigating the natural product composition of northern organisms, we will describe our most recent results on the synthesis and characterization of the antimalarial properties of mortiamides, natural products isolated from a fungus from Frobisher Bay, in Nunavut.

INTEGRATIVE POPULATION MODELS TO REBUILD AND PREDICT POPULATION DYNAMICS OF MIGRATORY CARIBOU HERDS

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Migratory caribou in eastern Canada are in sharp decline. In 2017, the Committee on the Status of Endangered Wildlife in Canada assessed these populations as Endangered. Understanding the demographic changes in these herds and the environmental determinants that influence them is necessary to improve population management and conservation. We combined the strengths of advanced Bayesian statistics and extensive ecological data to improve our knowledge of demographic changes in migratory caribou herds. We used integrative population models to rebuild the population dynamics of the Rivière-aux-Feuilles herd (RAFH) over the past 30 years and predict future changes in population size. We used multiple data types: seasonal and annual adult survival estimates, autumn recruitment rates, aerial surveys, and hunting harvest rates. Models also included weather and resource variables that we previously identified as determinants of survival. We used predicted data on these variables to formulate predictions of population dynamics in the herd. Integrative population models of the population dynamics of the RAFH narrowed the confidence intervals of previously available estimates of survival and population size, and improved our knowledge of past demographic changes. Environmental factors showed stronger effects at the individual survival level than at the population level. Population dynamics were driven more by changes in survival parameters than by a direct effect of the environment. The uncertainty of predicted population size estimates increased with time into the future. Bayesian population models offer numerous possibilities for modelling and predicting population dynamics of herds, including data and effect variables from multiple sources. In addition to providing knowledge useful for management of the RAFH, our project also aims to encourage the use of integrative population models in monitoring population dynamics of wildlife.

THE OCEAN FRONTIER INSTITUTE: NOVEL PARTNERING ACROSS THE CHANGING NORTH ATLANTIC

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The North Atlantic and Canadian Arctic Gateway are significant areas of the global ocean. The region's unique physical, chemical and biological processes make it an epicentre of international scientific interest and

a predictor for the global ocean. Its deep overturning circulation results in the most intense carbon sequestration on the planet. It has a highly productive marine ecosystem and air-sea interactions that modulate the weather and climate of North America and Europe. At the same time, climate change — specifically diminished ice cover — has increased shipping in the Canadian Arctic, raising sovereignty, security, social and environmental issues. The Ocean Frontier Institute (OFI) was established in 2016 through the Canada First Research Excellence Fund (CFREF) to bring together researchers from both sides of the North Atlantic to better understand how and why the North Atlantic is changing and to identify effective approaches to resource development that are globally competitive and sustainable. Wendy Watson-Wright, CEO of the OFI, will provide an overview of her organization, its research and expected benefits for Canada, and will discuss current and potential future connections between OFI and Sentinel North.

ARBOVIRUS HUNTING IN CANADA, SUMMER 2018

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During the last several decades, climate change, increased urbanization as well as global trade and transportation have facilitated dramatic geographical expansions of arthropod-borne viruses (arboviruses). Among over 545 known arbovirus species, 150 species are of potential public health concern. Therefore, arboviruses represent a major source of emerging and re-emerging infectious diseases threatening global public health. In addition to West Nile virus (WNV), which is endemic amongst several mosquito species in Canada, there have been imported cases of Zika virus from returning travelers. Coupled with the prevalence of arthropod-borne viruses elsewhere in the world (i.e. Yellow Fever, Japanese Encephalitis, and Chikungunya viruses), with the possibility of importation into Canada due either to travel or expansion of competent mosquito vectors, there is a global vulnerability towards these infectious diseases. A thorough spatial and temporal analysis is crucial for characterizing the exact situation of circulating arboviruses in Canada. During summer 2018, we carried out a pilot study for wildlife and domestic animal sampling and mosquito collection in established sites in Quebec, Ontario, Manitoba and British Colombia. A total of 1890 female mosquitoes belonging to 27 taxa and 5 genera were collected, in which invasive Aedes Japonicus and Culex Pipiens (important vectors carrying several medically important arboviruses) were found for the first time in Quebec. Preliminary next generation sequencing results indicate the discovery of two arboviruses, Shamonda virus and Simbu virus (Orthobunyavirus), in specimens collected during summer 2018 in Quebec. In addition, screening of dead bird samples collected during summer 2018 in Quebec led to the detection of WNV lineage 2 in 43/47 American crows as well as 2/7 mallard ducks. Laboratory analysis is ongoing and results will be presented to generate a complete picture of circulating pathogens from these collected samples.

Affiches / Posters

INVESTIGATION INTO THE EFFECTS OF VITAMIN D ON ANTIPSYCHOTIC DRUG METABOLIC SIDE EFFECTS: FOCUS ON THE ENDOCANNABINOIDOME—GUT MICROBIOME AXIS

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The main source of Vit. D is sunlight, and in northern latitudes being under the sunlight in the summer makes it possible to build up enough Vit. D stores to last through the winter. However, northern populations spend most of the daylight hours indoors, and thus do not have adequate Vit. D repletion through sunlight exposure. This is exacerbated by the westernization of society resulting in dietary changes, and thus decreased Vit. D consumption previously obtained from traditional foods. Vit. D, mediates different physiological activities, include modulating the variety and abundancy of enteric gut microbiota. Vit. D deficiency is increasingly being associated with poor metabolic and mental health, in particular with depression and psychosis, with strong correlations identified in some northern native populations. In addition, several metabolic abnormalities are associated with psychotic diseases, which are impacted upon by antipsychotic drug use. Indeed, second generation (atypical) antipsychotics in general are well known to induce weight gain and decrease insulin sensitivity. The endocannabinoidome (eCBome), which includes endocannabinoids which act at cannabinoid (CB1/2) receptors, related endocannabinoid like molecules and their target receptors and regulatory enzymes, is a significant regulator of metabolism and can also change the balance of gut microbiota. Taken together, Vit. D deficiency, gut microbiota and the eCBome are important factors for the development of the metabolic syndrome, modifying host metabolic balance. Since the relationship between Vit. D status, gut microbiota, the eCBome and the metabolic side effects of atypical antipsychotic drugs is still unknown, we are going to study the effects of different Vit. D levels and atypical antipsychotic drug (olanzapine) exposure on whole-body metabolism and the eCBome—gut microbiota axis in the attempt to identify a link relevant to the metabolic side effects associated with atypical antipsychotics. Female C57BL/6J mice will be divided into 3 groups and fed by low fat diet for 3 weeks: 1. Control, 2. With Vit. D deficiency, 3. supplemented with Vit. D. Each group will then be divided in two groups: 1. Control and 2. Olanzapine for a further 9 weeks during which the diet will convert to high fat. Levels of Vit. D will be assessed with multiplex ELISA analysis. Various metabolic parameters will be assessed (adiposity, weight gain, glucose levels etc.) eCBome levels will be quantified by LC-MS/MS and qPCR array. Gut microbiota composition will be assessed by 16S sequencing using an Ilumina MiSeq. Results will be considered statistically significant at $p<0.05$ or FDR-adjusted $p<0.1$. Analyses will be performed with R. We predict that we will observe a significant increase in metabolic abnormalities and important changes in the eCBome activity and microbiome in the olanzapine-treated group, which should be exacerbated by Vit. D deficiency and, conversely, blunted by Vit. D supplementation. The expected results may provide insight into the mechanisms by which olanzapine use induces metabolic abnormalities and point to the eCBome—gut microbiota axis as a potential therapeutic target to combat these side effects.

BIOMARKERS OF CARDIOMETABOLIC DISEASES: FROM DISCOVERY TO DETECTION

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Cardiometabolic diseases (CMD) are the second leading cause of death in Canada and the major one among indigenous populations in northern Canada. Prevalence of these disorders has increased over the past 20 years among indigenous populations and is probably partly related to the adoption of a Western diet. In this context, it becomes urgent to discover better diagnostic markers of CMD that could be detected with innovative opto-photonic tools. It is known that CMD are associated with an alteration of gut microbiota structure, function and production of microbial metabolites. Metabolites (molecules less than 1500 Daltons in size) are the end products of genome, transcriptome, and proteome activities. They also represent exogenous inputs via alimentation and interactions between gut microbiota and its host. Metabolites are therefore good candidates to be predictive biomarkers of CMD. Untargeted metabolomics is a non-biased experimental approach that attempts to measure all of the metabolites in a biological sample. With this method, it is possible to compare metabolic profiles of healthy and CMD individuals in order to identify metabolites characteristic of CMD. After validation of these biomarkers in vitro and in animal models, opto-photonic tools capable of detecting these biomarkers in vivo will be created to enable early and effective in situ diagnostic of CMD.

ON THE DESIGN OF AN OPTICAL SENSOR TO MEASURE NITRATE IN SEA ICE

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The intricate balance between nutrients, specifically nitrate in the Arctic ocean, and light availability has been shown to control the dynamics of primary production. The amount of available nutrients for ice algae depends on the flux of nutrients from the upper ocean to sea ice, and transport within sea ice. In a context where the Arctic icescape is profoundly changing together with sea-ice biology, this research project aims to develop an optical sensor for measuring in situ sea ice nitrate concentration at small space and time scales, to better understand how the flux of nutrients from the upper ocean to sea ice and their transport within sea ice are controlled by the physical properties of the two media. Current in situ oceanographic nitrate measurements are performed with UV absorption spectroscopy. Unfortunately, conventional instruments are bulky, and require tricky signal deconvolution and correction. Two new technological approaches are being assessed for measuring nitrate concentration in sea ice while perturbing the environment as little as possible: transmission dip fiber probe and surface-enhanced Raman spectroscopy. A transmission fiber dip probe consists of an excitation and a collection of fibers which transmit light through an open cavity to interact with the medium in order to measure the absorption spectrum. Surface-Enhanced Raman Spectroscopy is a promising new approach to amplify weak Raman signals by the use of nanoparticles assembled together to form a plasmonic surface, which generates a highly localized and intense electric field when excited by a laser. The selected new nitrate sensor is intended to be integrated onto a Sea Ice Endoscopic (SIE) platform, a non-destructive multimodal probe which will be used to characterize sea ice optics, physics, biology and biogeochemistry.

ARCTICNET: RENEWED SCIENTIFIC PROGRAMS AND NEW ORIENTATIONS

ArcticNet Inc. (1)

(1) ArcticNet Inc.

Established in 2004, ArcticNet is an Academic-Inuit-Government-Industry research effort aimed to help prepare for the impacts and opportunities brought by climate change and globalization in the Arctic. ArcticNet's updated vision for the next funding cycle is to promote the sustainable development of northern Canada that will foster the health and biodiversity of its ecosystems; the wellbeing and empowerment of its people; the environmentally-safe exploitation of its mineral, shipping, energy and tourism resources; and Canada's international leadership in the scientific study of the changing Arctic. Over the next funding cycle(s), the environmental, economic, health and social issues faced by Inuit (and now northern First Nations and Métis) and other national issues linked to the transformation of the Canadian North will remain front and centre of ArcticNet's NCE-funded Core Research Program. The Network will continue to address fundamental scientific questions of international and global importance through its Satellite Research Program funded primarily by non-NCE sources. Inuit, First Nations and Métis self-determination in research will be a central component contributing to Canada's emphasis on Indigenous reconciliation. As clearly expressed by Inuit organizations and the territorial governments, an emerging area in need of solutions is the consolidation of postsecondary training and research capacity in the Canadian North. ArcticNet will directly support this objective through the North-by-North initiative that will provide expertise and funding in support of both Inuit-led and territory-led research and training programs. At the request of Yukon, the NWT and Nunavut, ArcticNet will initiate a fifth Integrated Regional Impact Study (IRIS) to expand its research program and knowledge mobilization strategy to include the continental Arctic and its First Nations and Métis communities. Thanks to mechanisms such as the Annual Scientific Meeting, the IRIS Portal and the North-by North initiative, ArcticNet will continue to network with the different players in the study of the Canadian Arctic. Scientifically, ArcticNet's overarching goal to inform the sustainable development of the Canadian North and the self-determination of its people is increasingly important for Canada.

ESTABLISHMENT OF A SURVEILLANCE NETWORK FOR CHARACTERIZING INFLUENZA VIRUS DISTRIBUTION, EVOLUTION AND PATHOGENICITY IN MIGRATORY BIRDS IN THE NORTHERN REGIONS OF CANADA

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Avian influenza virus infections can be highly pathogenic to humans with high fatality rates. In 2014, H5N8 was found to have spread from Asia to Europe and the USA. The intercontinental spread of H5N8 from Asia to North America was found to have occurred through Beringia, meaning these birds must have passed through northern Canada before entering the USA. Canada is crossed by 4 flyways of migratory birds, and these birds are known to be a potential source of highly pathogenic viruses. Indeed, influenza viruses are able to evolve in asymptomatic carrier birds by single nucleotide polymorphism and rearrangement of influenza virus segments of RNA. Surveillance of circulating viruses in migratory birds in northern Canada is essential to provide the earliest warning against a potential influx of highly pathogenic influenza. Predictions on how viruses are circulating through birds are essential to evaluate the risk of widespread diffusion and to provide information for pandemic preparedness surveillance. Knowing which viruses are a threat for humans will allow for the development of suitable antiviral drugs and vaccines. The main goal of the research project will be to establish a surveillance network in order to determine the distribution, evolution and pathogenicity of influenza viruses in migratory birds in northern Canada (Yukon, Northwest Territories, Nunavut and northern Quebec). In particular, we have to determine strategic sampling sites (easy to access, near large lakes and human settlements), implement collaborations with scientists studying birds (we have already contacted researchers Gilles Gauthier, Jim Leafloor, Jean Rodrigue and Josée Lefebvre Yves Aubry who band birds and participate in this project and gather samples from geese at 7 sampling points in the Northwest Territories, Nunavut and Nunavik. We still need collaborators for sampling in Yukon and the Northwest Territories). We want to collect cloacal and nasopharyngeal swabs from apparently healthy wild birds including wild ducks, geese, swans and gulls. Environmental samples, and if available, the major organs from wild birds that could have died from AIV infections will also be

collected. Then we will characterize in the lab the viruses sampled via PCRs and genome sequencing to find out potential mutations which may change pathogenicity, transmissibility, or confer resistance to anti-influenza drugs in the strains collected. We will analyze and chart the evolution of the viruses and their origins and be able to estimate, with the collaboration of Gilles Gauthier (Université Laval), through bird populations analysis, the survival rate of influenza viruses infected birds compared to uninfected birds. We will also evaluate the effects of these mutations in cell culture to chart viral kinetic growth and for the mutations suspected to impact virulence, viruses can also be tested in mice (assessing survival, time to death, clinical signs, or viral loads). In conclusion, we will get a spatial and temporal map of influenza viruses in northern Canada and are willing to find collaborators interested in emerging viruses. Indeed the network, once established, doesn't have to be restricted to influenza viruses and our samplings could reveal other risky pathogens present in northern Canada.

USING DEEP LEARNING TO EXTRACT FUNCTIONAL CONNECTOMES FROM TIME SERIES

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Fast extraction of connectomes from whole-brain functional imaging data is computationally challenging. Despite the development of new algorithms that efficiently segment the neurons in whole-brain images, the detection of individual synapses remains intractable. Instead, connections between neurons are inferred using time series that describe the evolution of neurons' activity. We compare classical methods that infer functional connectivity such as Granger Causality and Transfer Entropy to deep learning approaches such as Convolutional Neural Networks, Long Short-Term Memory and Graph Attention Networks. The comparison is done on synthetic time series since ground truth of connectivity is needed. We generate time series of activity using the Leaky-Integrate and Fire (LIF) model on the C. Elegans' connectome. This microscopic worm's neural system is the only fully mapped connectome with 279 neurons and 3113 connections. Noise, adaptation and inhibition are added to the model to promote richer and more realistic activity. To compare the performance of the inference methods, hundreds of one-hour simulations are generated by varying the LIF's variables and connectome's structure. Two main approaches of inference are compared. First, classical algorithms that are based on a theoretical understanding of the concept of causality, and second, deep learning models that learn causality from the data itself. Both Granger Causality (GC) and Transfer Entropy (TE) are well-established methods of inference in neuroscience that work by predicting a neuron's time series. If knowledge of another neuron's activity improves the prediction, then the connection is inferred. GC works by computing the difference of errors of prediction, while TE computes the difference in entropy. Convolution Neural Network (CNN) and Long Short-Term Memory (LSTM) are deep learning models that are trained to infer the pair-wise connectivity between neurons. Both architectures have intrinsic proprieties that make them ideal for time-dependent data. The CNN works by filtering the time series over and over, while the LSTM learns to remember or forget long-term and short-term features. Finally, Graph Attention Networks (GAT) is an unsupervised deep learning method that learns by finding the connectivity matrix that optimizes the prediction of the time series. The performances of all methods are compared using their average Receiver Operating Characteristic (ROC) curves. We find that the deep learning models generally yield higher true positive rates for all false positive rates but are less robust as their accuracy varies from simulation to simulation.

A GPU MONTE CARLO APPROACH TO STUDY LIGHT PROPAGATION IN DIFFUSIVE MEDIA

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An accurate knowledge of light distribution in diffusive media is invaluable to understanding how light shapes our environment (e.g. photosynthesis in the oceans) and helps us decipher it (e.g. diagnosis with light). Despite years of advances, models of light propagation in diffusive media often rely on approximations that neglect details of the microscopic structure. Therefore, our models aimed at providing a comprehensive understanding of important phenomena resulting from these light-matter interactions in diffuse media fail in different situations, from northern environments to biological tissues. This is illustrated by our inability to obtain reliable predictions of light distribution under the ice cap. In addition, with the design of ever-smaller optical probes aimed at providing a very local characterization of ice sea and biological tissues, the shortcomings of the current light transport models become a major drawback. The goal of this project is to develop efficient Monte Carlo simulations of photon migration in diffusive media having the capacity to take into account some important aspects of the microscopic structures of these media. This has been done by considering the different moments of the phase function which describes the angular distribution of the scattering events. Specifically, thanks to the massively parallelizing of Graphical Processor Unit (GPU), efficient Monte Carlo simulations that consider several moments of the phase function have been started to be developed by modifying an open source program named Monte Carlo eXtreme (MCX) by Q. Fang. We chose this software for its capacity to propagate photons in 3D heterogeneous turbid media and because it already solved a lot of GPU code integration. We will present some simulation results that reveal the effects of the different moments of the phase function on the local fluence distribution corresponding to the diffuse reflectance detected by specific probe geometries.

TOWARDS A PORTABLE MICRO-CYTOMETER FOR THE QUANTIFICATION OF PICOPLANKTON IN NORTHERN LAKES AND SEAS

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The planktonic microbiome, the ensemble of microbes in natural waters and their functions, is at the base of aquatic food webs and biogeochemical cycles. Just as we now realize that the functioning of the 'human microbiome' plays a major role in human health, the planktonic microbiome controls the healthy functioning of aquatic ecosystems. It is composed of bacteria, archaea, coloured (phytoplankton) and non-coloured protists, and viruses. One of the major groups of microbes in northern waters is picophytoplankton, especially picocyanobacteria in Arctic lakes and rivers, and coloured picoeukaryotes in the Arctic Ocean. For many years, populations of these autotrophic organisms have been assessed by flow cytometry using the intrinsic fluorescence of their photosynthetic pigments in combination with genomic analysis. The flow cytometer measures the optical properties of individual cells, which in turns makes it possible to identify subpopulations within a sample. This information can then be used to produce a limnological or oceanographic profile of the studied environment. Although flow cytometers have been used in field campaigns, these instruments are generally expensive and are optimized for medical laboratories rather than environmental applications. Furthermore, they require a precise optical alignment thus making their tolerance to harsh field conditions limited. To counter this, scientists have resorted to freezing samples for analysis, several thousands of kilometres down south. These manipulations produce obvious practical challenges, can result in erroneous estimates, and limit the researcher's ability to obtain an instantaneous assessment of the microbiota in the environment being studied. Hence, this project, as a part of Sentinel North 3.1, aims at developing a portable instrument for the quantification of picoplankton in northern environments by flow cytometry. To achieve this goal, a lab-on-chip based optofluidic flow cytometer is being developed. In this talk, 3D on-chip hydrodynamic focalization, an essential component for signal standardization in flow cytometry, using Dean vortices will be presented. By combining this microfluidic approach and on-chip optical fibers a robust and alignment free micro-cytometer has been produced. Furthermore, we have integrated this technology in a portable cytometry platform

spectrally optimized for the study of phytoplankton populations. In ending, preliminary results obtained, in the field, in Whapmagoostui-Kuujjuarapik will be presented.

LA SÉPARATION DU PLOMB ET DU MERCURE SUR RÉSINE SR

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Le mercure, tout comme le plomb, est un élément toxique pour l'humain. Comme ces éléments sont retrouvés de manière significative dans l'écosystème à la suite de la bioaccumulation et de la bioamplification, ces contaminants se concentrent de façon importante dans la chair de certaines espèces animales comme le poisson. Ainsi, puisque les communautés nordiques consomment des quantités de poissons importantes, l'évaluation du risque pour leur santé demeure une priorité. Dans le cadre du programme de financement Sentinelle Nord, un projet concernant la fabrication d'une plateforme portative de terrain pour analyser le plomb et le mercure a été proposé. L'objectif de ce stage est d'effectuer la séparation du plomb et du mercure d'un échantillon de poisson avec l'objectif de faire sa quantification élémentaire. Une résine SR, constituée d'un éther couronne (4,4'(5')— di-t-butylcyclohexano-18-crown-6) dilué dans l'octanol, a été utilisée comme support de séparation. Différentes matrices et solutions d'élutions ont été évaluées afin d'obtenir le meilleur taux de récupération pour chacun des éléments, tout en considérant les limitations relatives à la mise en solution de la chair de poisson et avec l'intention de créer cette plateforme pour des personnes ayant des connaissances restreintes en chimie (risques, dangers, etc.).

IDENTIFICATION ET CARACTÉRISATION DE L'ACTIVITÉ BIOLOGIQUE DE PRODUITS NATURELS DE LICHENS NORDIQUES

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Les organismes vivants des écosystèmes du Grand Nord du Québec subissent des stress uniques et produisent des métabolites secondaires de défense en réponse à ceux-ci. Ces composés possèdent généralement de fortes activités biologiques. Ainsi, nous croyons que la flore nordique du Québec, très peu étudiée au niveau phytochimique, regorge de substances bioactives inédites. En sus, les changements climatiques menacent certaines espèces. Par exemple, certains lichens peuvent disparaître par l'action d'espèces arbustives qui poussent de manière abusive. Il y a donc urgence d'étudier la composition chimique d'organismes nordiques pour découvrir des composés bioactifs originaux qui pourraient éventuellement servir pour le développement de nouveaux médicaments. Ce projet vise à effectuer une investigation phytochimique des lichens Cladonia stellaris, Cladonia mitis et Stereaucolon paschale dans le but d'identifier leurs métabolites secondaires et ainsi de valoriser la flore nordique. La méthodologie utilisée pour l'isolement, la purification et la caractérisation des produits sera présentée. De même, nous présenterons les résultats de tests biologiques visant à déterminer l'activité antioxydante, anti-tyrosinase et anti-glucosidase des extraits et des métabolites secondaires purifiés. Les résultats attendus de ce projet sont la découverte de nouveaux produits naturels bioactifs et la détermination du profil en métabolites secondaires de chacun des lichens étudiés. Des échantillons ont déjà été recueillis à différents endroits au Nunavik par notre collaborateur le Pr S. Boudreau (Département de biologie, UL). La méthodologie utilisée consiste d'abord à sécher à l'air les lichens récoltés, puis d'effectuer un broyage cryogénique. Ensuite, des extraits bruts sont préparés par macération en utilisant trois solvants : hexane, dichlorométhane et méthanol. Les extraits sont ensuite caractérisés par HPLC-MS pour obtenir leur profil en métabolites. Par ailleurs, les extraits bruts sont fractionnés par chromatographie liquide à moyenne pression (MPLC) lorsque la séparation est optimale, puis par chromatographie liquide haute performance (HPLC) pour obtenir des produits purs. Tout au long du fractionnement des extraits, le bioguidage à l'aide de tests biologiques permet de se pencher sur les fractions qui sont actives. Ce projet transdisciplinaire nécessite l'expertise complémentaire de biologistes, de phytochimistes et de microbiologistes pour sélectionner, collecter et réaliser des investigations détaillées sur les produits naturels de lichens jouant un rôle écologique important. Le projet implique donc des chercheurs qui participent à Sentinelle Nord et tire profit des expertises

complémentaires stratégiques retrouvées au sein du réseau. Krüger, S.; Bergin, A.; Morlock, G.E. Food chem. 2018, 243, 258-268. Simoes-Pires, C.; Hmicha, B.; Marston, A.; Hostettmann, K. Phytochem. Anal. 2009, 20, 511–515.

ADAPTING A BIOGEOCHEMICAL-ECOSYSTEM MODEL TO THE ARCTIC OCEAN TO STUDY PHYTOPLANKTON

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Seasonal variation of the sea ice cover is a determinant of biomass, primary productivity, phenology and community structure of phytoplankton in the Arctic Ocean. Yet, empirical data is insufficient due to the logistical challenges that sampling the remote Arctic Ocean represents. In this context, modelling becomes necessary to obtain the numerical biomass, primary productivity, phenology and community structure of modelled phytoplankton all year round. A one-dimension (1-D) global biogeochemical-ecosystem model was adapted to the extreme Arctic conditions. Initial nutrient conditions in this previous model were replaced with in situ data collected during the winters of 2003-2004 and 2007-2008 by the icebreaker CCGS Amundsen in the Amundsen Gulf (southwest Canadian Archipelago). Additionally, we improved the classical processing of the subgrid scale heterogeneity of sea ice and its impact on the underwater light field. That is, instead of considering the underwater light field as a homogeneous weighted average in each cell grid of the water column of the 1-D model, the underwater light field was kept heterogeneous when the sea ice concentration was between 0% and 100%. Accounting for this heterogeneity was done by computing one irradiance under the open water portion and a different irradiance under the sea ice portion. Then, one light limitation factor to phytoplankton growth was computed under the open water portion and another light limitation factor was computed under the sea ice portion. These two light limitation factors were then averaged. The averaged light limitation factor thus obtained is not equal to the light limitation factor computed from a mean irradiance because of the non-linearity of the processes causing light limitation to photosynthesis. We tested the spatial heterogeneity of sea ice on modelled phytoplankton biomass, primary productivity, phenology and community structure. Using spatial heterogeneity of sea ice in the (1-D) model for the Amundsen Gulf decreased the numerical annual primary productivity by 7% compared to homogeneous sea ice. Furthermore, spatial heterogeneity of sea ice delayed the productivity bloom by 39 days compared to homogeneous sea ice. Finally, spatial heterogeneity of sea ice modified the community structure of the modelled phytoplankton compared to homogeneous sea ice by killing one of the phytoplankton groups. Pleasingly, the looser phytoplankton group is the numerical equivalent of the Prochlorococcus genera which is a prokaryotic phytoplankton absent in the Arctic Ocean.

PLATEFORME NEURO-OPTOÉLECTRONIQUE SANS FIL AUTORECHARGEABLE POUR LE DÉVELOPPEMENT DE TRAITEMENTS EFFICACES CONTRE LES TROUBLES DE L'HUMEUR

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Les troubles de l'humeur, en particulier les troubles affectifs saisonniers, sont fréquemment observés dans les pays nordiques, y compris le Canada. À ce jour, l'absence de tests pertinents et représentatifs pour évaluer l'action et l'effet des antidépresseurs sur le cerveau d'animaux représente un obstacle majeur à l'identification de molécules et de cibles précliniques efficaces chez l'homme. Or, comme l'activité neuronale est normalement fortement corrélée avec les stimulations environnementales et avec les réponses comportementales mises de l'avant pour s'adapter, il est capital de mesurer ces effets chez un animal actif dans un contexte où il fait face à différentes situations. Il s'avère donc nécessaire de développer de nouveaux outils innovants permettant de mesurer directement l'effet de ces médicaments, en temps réel, sur les circuits cérébraux d'animaux de laboratoire. La Plateforme neuro-optoélectronique sans fil est le premier outil permettant d'étudier en temps réel les microcircuits cérébraux à l'aide de l'optogénétique et de l'électrophysiologie chez des souris en mouvement tout en incorporant une cage dotée d'un dispositif

d'induction permettant de recharger l'implant à distance. L'implant permet d'activer des populations de neurones spécifiques à l'aide de la lumière et d'enregistrer la réponse électrophysiologique de structures cérébrales complexes grâce à des optrodes placées sur la tête de l'animal. L'implant est de plus doté d'une technologie qui permet d'extraire et de transmettre des données sans fil, puis de visualiser l'état de plusieurs neurones en parallèle. Notre approche consiste à utiliser des souris transgéniques qui exprimeront une protéine photosensible, comme la Channelrhodopsin, permettant d'activer des régions précises du cerveau à l'aide de la lumière transmise par une fibre optique installée sur la plateforme sans fil. Comme le poids d'une souris de laboratoire est typiquement de quelques dizaines de grammes, le poids et la taille de la plateforme sont réduits au maximum afin que la souris puisse se mouvoir librement lors d'expériences de longue durée ne nécessitant aucune manipulation directe de l'animal, comme pour remplacer les batteries. Le dispositif est constitué principalement 1) d'un implant électronique construit autour d'une puce électronique CMOS dédiée intégrant les fonctions de stimulation optogénétique et d'enregistrement des signaux électrophysiologiques, 2) d'algorithmes spécialisés de traitement de signal numérique, permettant d'augmenter la résolution d'observation tout en diminuant la consommation d'énergie et la taille de l'implant, et 3) d'un système de recharge inductif permettant de recharger l'implant à distance. L'approche proposée s'articule autour de la miniaturisation CMOS, de la transmission sans fil de données et d'énergie et de processeurs spécialisés de traitement des signaux. Ces éléments forment une technologie unique, originale et très compétitive. Ces ingrédients permettront de fabriquer un implant dont le volume sera inférieur à 1 cm^3 et dont le poids fera moins de 1 g (sans pile), afin de permettre l'implantation de longue durée chez les souris de laboratoire. Notre équipe compte sur l'expertise de pointe de plusieurs cochercheurs en génie et en neuroscience, ainsi que sur deux technologies en voie d'être brevetées dans le domaine de la transmission d'énergie sans fil et du traitement numérique des signaux bioélectriques.

SEX-SPECIFIC ADAPTATIONS TO CHRONIC STRESS IN CORTICOACCUMBAL AND CORTICOTEGMENTAL PATHWAYS

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Males and females respond differently to chronic stress. In the brain, molecular programs are differentially modified after chronic stress in a sex-specific fashion, and potentially impact the proper functioning of the individual at cellular and behavioral levels. The medial prefrontal cortex (mPFC) is part of a complex circuit controlling stress response by sending projections to different limbic structures. Among them, the nucleus accumbens (NAc) is known to drive reward-seeking behaviors and the ventral tegmental area (VTA) to control appetitive and aversive stimuli. However, little is known about how corticoaccumbal and corticotegmental pathways are contributing to depressive-like behaviors following chronic stress exposure in males and females. Chronic variable stress was used to induce depressive-like behaviors in male and female mice. We injected retrograde adeno-associated viruses encoding different fluorophores in the NAc and VTA of male and female mice to specifically label both pathways and assess the spontaneous activity. Chronic variable stress induced depressive-like behaviors in males and females. Our dual viral approach allowed us to differentiate mPFC neurons according to their projection. Stressed females exhibited a significantly higher frequency in spontaneous excitatory postsynaptic currents in both neuronal populations and a higher amplitude in NAc-projecting neurons only. Conversely, we observed a significantly lower frequency of spontaneous inhibitory postsynaptic currents in VTA-projecting neurons in stressed males. Our results suggest that chronic stress impacts the corticoaccumbal and corticotegmental pathways differently in males and females through sex-specific functional adaptations. However, these adaptations led to similar features: a potentiation of the corticotegmental pathway in males and of the corticoaccumbal and corticotegmental pathways in females.

DEREGULATION OF SPHINGOLIPID METABOLISM MODIFIES ASTHMA PATHOGENESIS

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Asthma is a chronic airway pathology characterized by inflammation, airway hyperresponsiveness and airway remodeling. Genetic factors and environmental conditions, including hygiene and nutrition, can contribute to the inception, but also the prevention of this complex syndrome. Genes regulating metabolism of sphingolipids, which are bioactive lipids known to have beneficial impacts on inflammatory pathologies, have been strongly associated with asthma. In view of the de-traditionalization of nutritional intake of northern populations, which likely results in modified intakes of sphingolipids, the goal of this study is to elucidate if the deregulation of sphingolipid metabolism impacts at different stages of asthma pathogenesis. We used a genetic mice model that mimics increased circulating levels of sphingosine-1-phosphate (S1P), i.e. sphingosine kinase 2 (SPHK2) knock out mice, in acute and chronic allergic asthma models induced by house dust mite (HDM), an allergen that is routinely found in homes. After 10 days or 5 weeks of exposure to this allergen, we quantified inflammatory cells in bronchoalveolar lavage and measured respiratory functions using the FlexiVent apparatus in wild type and SPHK2 KO mice. As a control, we used mice lacking sphingosine kinase 1 (SPHK1) that don't have modified circulating S1P. We showed that mice lacking the enzyme SPHK2 or the control enzyme SPHK1 did not present significant differences of Th2 inflammation markers compared to wild type mice, after 10 days and 5 weeks of HDM exposure. However, SPHK2 deletion modified airway resistance to methacholine after 5 weeks of antigenic exposure, which was not observed in SPHK1 KO mice. These results highlight the potential association between sphingolipid levels and the pathogenesis of asthma.

FUNCTIONAL IMAGING OF DEVELOPING BRAIN IN A GUT-BRAIN AXIS ZEBRAFISH MODEL

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It is becoming widely accepted that the intestinal microorganisms hosted by humans and other vertebrates play a crucial role in maintaining their hosts in healthy conditions. Many circumstances can alter the microbiota ecosystem equilibrium, resulting in changes in specific bacterial populations that are able to induce negative effects. These include physiological disturbances and epigenetic modifications which may have long-term consequences on brain development and function, impacting mental health. Understanding this impact should provide important insight on the developmental factors that affect mental health. The characterization of host-microbiota interactions and their impacts requires the development of experimental contexts in which we can precisely control the relevant variables in their environment. We have identified the larval zebrafish as an ideal model for such context because it offers many advantages: many transgenic lines are available and can be easily generated, its rapid and external development allows for longitudinal follow-up, and its optical transparency during the first two weeks of life provides ideal conditions for microscopic observations and offers an opportunity for optogenetic manipulation. Using advanced optical microscopy, we are working to establish neurodevelopmental models in the zebrafish, looking at the population, distribution, activity and connectivity of neurons in various specific brain circuits. We are also working to implement existing and develop new tools to analyse our data, such as software for 3D registration to zebrafish brain atlases and methods for

automated neuron segmentation. These tools will help us to identify morphological and functional developmental markers, which will then be used to monitor changes in brain development in response to manipulation of the microbiota. The growth of characterized probiotic or opportunistic bacterial strains will be controllable in the fish digestive tract, either with optogenetics (using light-activatable CRISPR-Cas9 system), bacteriophages, or prebiotics after inoculation of axenic fish lines. To study the impact of the gut microbiota on brain circuit function, we have begun to characterize brain circuit activity in 5-7 day old larvae that express a genetically-encoded calcium sensor in the nucleus of nearly all neurons to serve as a proxy of neuronal activity. Using a two-photon resonant microscope, we have been able to record neuronal activity at any depth in the brain with good temporal resolution. These images allowed us to observe spontaneous, but also visually-evoked circuit activity using an LCD screen to convey visual stimuli to the zebrafish during imaging. When neurodevelopmental markers will be selected, we will begin to compare larvae with different microbiota conditions. We expect to observe negative impacts on neurodevelopment following exposure to environmental stress, effects that would be attenuated by the presence of probiotic strains in the fish guts. Learning more about the impact of the microbiota and environmental stress on circuit development and function may provide useful data to be translatable to human health.

OPTIMISATION D'UN SYSTÈME CRISPR-CAS9 PHOTOACTIVABLE POUR LA MODIFICATION DU MICROBIOTE INTESTINAL DU POISSON ZÈBRE

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L'édition du génome à l'aide du système CRISPR-CAS9 est un champ d'études qui est en expansion depuis les dernières années. À l'aide de ce système, il est possible de retirer et d'ajouter certains gènes ainsi que d'activer ou même de réprimer l'expression d'autres. La répression de gènes se fait par une endonucléase, dérivée de Cas9, catalytiquement inactive qu'on appelle alors dCas9. N'ayant aucune activité, elle ira seulement se poser sur la séquence visée du gène d'intérêt, sans la couper, afin d'en empêcher l'expression. Le mécanisme de ce système s'avère très utile pour l'étude du microbiote intestinal. Il est maintenant bien connu que le microbiote intestinal possède des fonctions importantes dans notre corps qui peuvent être digestives, métaboliques, immunologiques ou neurologiques. Cependant, des modifications de ce microbiote peuvent induire une dysbiose et affecter négativement ces fonctions. On croit d'ailleurs que certaines maladies ou certains problèmes de santé pourraient empirer à cause de ces dysbioses et même en découler. Le projet effectué se concentre sur l'étude de l'effet de la modulation du microbiote intestinal sur le développement du cerveau du poisson-zèbre. Pour ce faire, un système CRISPR-dCAS9 photo activable a été développé pour être utilisé dans des cellules d'E. coli qui ont été implantées dans l'intestin du poisson-zèbre axénique au stade larvaire. Des ARN guides ciblant l'ARN polymérase d'E. Coli ont été clonés afin d'en empêcher l'expression et ainsi d'induire la mort cellulaire de la bactérie. Ces ARN guides ont été conçus pour cibler les gènes codant pour les sous-unités protéiques de l'ARN polymérase d'E. Coli afin d'empêcher leur production. Cela empêche donc les sous-unités de s'assembler pour former le complexe de l'ARN polymérase puisqu'elles ne sont plus produites. L'absence d'ARN polymérase, l'enzyme transcrivant les gènes, a mené à la mort des cellules. Par la suite, l'efficacité de ces ARN guides a été évaluée en monitorant la viabilité cellulaire des bactéries à l'aide de la cytométrie en flux et de la croissance sur milieu gélosé. En parallèle, le même système CRISPR-dCAS9 photo activable étant en cours de validation in vitro avec des ARN guides ciblant un gène codant pour mCherry a été utilisé pour déterminer les conditions d'utilisations dans l'intestin du poisson-zèbre. Les bactéries portant le système CRISPR-dCAS9 photo activable, les ARN guides et le gène mCherry ont été implantées dans l'intestin du poisson-zèbre et illuminées avec une lumière bleue pour activer dCAS9 qui empêche l'expression de mCherry. Le nombre de bactéries et les niveaux de mCherry dans l'intestin ont été ensuite suivis. L'intestin du poisson a été colonisé avec plusieurs souches différentes de bactéries et le système a permis de moduler le microbiote en supprimant certaines souches ciblées tout en préservant d'autres souches. Finalement, l'activité calcique du cerveau du poisson-zèbre a été mesurée afin de déterminer si les modulations du microbiote intestinal ont des effets sur l'activité du cerveau. Ce projet a permis d'en apprendre davantage sur les effets de la présence ou l'absence de certaines souches bactériennes dans l'intestin du poisson-zèbre sur le développement de son cerveau.

REVEALING ABNORMAL OLIGOMERIZATION OF PROTEINS IN SINGLE CELLS

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Knowledge of membrane receptor organization is essential for understanding the initial steps in cell signaling and trafficking mechanisms, but quantitative analysis of receptor interactions at the single-cell level and in different cellular compartments has remained highly challenging. G protein-coupled receptors (GPCRs) are involved in several diseases and are the targets of more than 30% of all modern medicinal drugs. Therefore, investigating their activation and trafficking in living cells is essential for our understanding of diseases and for the development of new treatment strategies. To achieve this, we used two approaches: spatial intensity distribution analysis (SpIDA) and fluorescence resonance energy transfer (FRET) by fluorescence lifetime imaging (FLIM). SpIDA can measure fluorescent particle concentrations and oligomerization states within different subcellular compartments in intact cells and FRET-FLIM allows the detection of protein-protein interaction at the nanometric scale. We demonstrate that the oligomerization state of the G protein-coupled receptor Neurokin-1 (NK1-r) differs between cell culture and native tissue. For this, we performed immunocytochemical labelling of NK1-r on spinal dorsal horn neurons in fixed tissues. The analysis reveals the distributions of monomers and homodimers of NK1-r in distinct subcellular compartments. We confirmed this finding using different fixation protocols and ultrastructural approach. The surface dimer density at neurons in the dorsal horn of the spinal cord was estimated to be 39±2/μm2. The NK1-r dimer density decreased to 21±1/μm2 after we initiated massive substance P release in the dorsal horn of the lumbar spinal cord by stimulation of peptidergic nociceptive sensory fibers with injections of capsaicin in the hind foot. We then confirmed previous findings that the oligomerization states of the NK1-r receptors in expression systems (e.g. CHO-K1 and HEK293 cells) was monomeric using SpIDA and FRET-FLIM. By enabling quantitative measurements in subcellular compartments in situ, SpIDA allowed us to show that desensitization of the response to substance P can result from a decrease in receptor density on the plasma membrane. This study showcases the importance of studying receptors in their native environment.

CAPTEUR PH ULTRA-BASSE CONSOMMATION ALIMENTÉ PAR DES PILES À BACTÉRIES

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Dans le paradigme des connexions sans fil, on recherche de plus en plus à miniaturiser et à adapter les systèmes électroniques de façon à ce qu'ils soient portatifs. Téléphones, voitures, ordinateurs, maisons sont tous maintenant interreliés à travers un phénomène se nommant the Internet of Things. En revanche, ce phénomène n'inclut pas encore les sources de puissance portatives, puisque tôt ou tard, il faut toujours recharger une source d'énergie. Cela pourrait toutefois changer dans les prochaines décennies en raison de deux facteurs. Le premier est l'optimisation de l'électronique permettant l'utilisation de systèmes électroniques à ultra-basse consommation de puissance. Le second est la découverte de nouvelles sources d'énergie portatives et durables. Cette affiche portera sur les piles à bactéries et leur utilisation dans les environnements nordiques. Tout d'abord, un système a été développé afin d'extraire et d'emmagasiner la puissance des piles à bactéries en continu tout en permettant la recharge de celles-ci. Elles ont également été caractérisées afin d'obtenir les meilleurs résultats possibles en termes de puissance récupérée et de tension maximale. Un capteur pH ultra-basse consommation a également été implanté pour mesurer et afficher avec précision le pH, le tout en étant extrêmement portatif. Finalement, une interface physique a été créée pour le capteur pH ainsi qu'une interface d'utilisateur pour le contrôle et la caractérisation des piles à bactéries. De cette façon, il a été possible d'emmagasiner des tensions allant jusqu'à 6 V ainsi qu'une puissance constante de 1.7 mW des piles à

bactéries et d'obtenir des mesures de pH à une précision de 0.1 pH, et les piles à bactéries ont survécu pendant environ 2 ans sans être nourries d'aucune façon et en déchargeant leur tension en continu. Il va donc sans dire qu'elles seraient d'excellentes candidates comme sources d'énergie pour des endroits où il est coûteux de produire ou de faire parvenir de l'électricité.

THE NATIONAL BIODIVERSITY CRYOBANK OF CANADA: A GENOMIC RESOURCE COLLECTION FOR GLOBAL BIODIVERSITY RESEARCH

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The National Biodiversity Cryobank of Canada (NBCC), located at the Canadian Museum of Nature's Natural Heritage Campus in Gatineau, Quebec, opened in September 2018. The NBCC has a mandate to collect and curate genomic resources (tissues, eDNA vouchers, DNA samples) from across Canada and abroad. Collections are stored at -170°C in innovative freezers that recondense liquid nitrogen (LN2) coolant, removing the need for regular LN2 input. These energy-efficient freezers provide good temperature security, maintaining temperatures below -135°C for nine days without electricity or LN2 inputs. Currently with a 200,000-sample capacity, the facility's footprint allows for additional freezers and a one-million-sample capacity. Donations of high-quality samples are encouraged if they are accompanied by legal documentation and collection data meeting at least a basic standard. Genomic resources stored in the NBCC are available to the global research community via a loan program supported by open access specimen information through the Global Genome Biodiversity Network Data Portal. The NBCC was made possible by a donation from the Ross Beaty family.

HYDROGEOPHYSICS OF PERMAFROST MOUNDS IN NUNAVIK (QUEBEC) AND RELIC TRACES OF PERMAFROST DEGRADATION IN AQUITAINE (FRANCE) — AN ANALOG STUDY TO UNDERSTAND THE PALEO-RECHARGE OF REGIONAL AQUIFERS IN THE AQUITAINE SEDIMENTARY BASIN

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The Aquitaine region (France) is a large sedimentary basin containing a regional multi-layer aquifer used for drinking water supply. Based on evidence from groundwater geochemistry, the last global recharge of this multi-layer aquifer occurred during the Late Pleistocene, which is characterized by a succession of climate changes due to the global glacial cycles. Such oscillations in groundwater recharge are likely to have considerably influenced modern groundwater regimes, mainly by determining the groundwater flow dynamics: one of the key parameters in evaluating aquifer capacity. Thus, neglecting past oscillations in recharge may result in an overestimation of the aquifer capacity. In order to practice proper management of these aquifers, it is necessary to better understand the past dynamics of recharge. Specifically, the major phase of recharge occurred during periods of climatic improvement before and after the Last Glacial Maximum (LGM, 20 000 years ago) with a lack of infiltration during the LGM. This phenomenon can be explained by a drier period and potentially by the presence of permafrost preventing the infiltration. The paleo-climatic reconstructions available for the Aquitaine during the LGM are consistent with a periglacial environment, possibly associated with discontinuous permafrost. But there is still no strong evidence for the development of such permafrost. However, the outcrop surface of the main deep aquifers of the multi-layer system currently hosts numerous circular ponds with morphology similar to the thermokarst ponds found in the discontinuous permafrost zone in Nunavik (Quebec), Canada. Thermokarst ponds are remnants of ice-rich permafrost mounds characteristic of permafrost environments after degradation. The purpose of this study is to search for proof of permafrost occurrence in the Aquitaine by testing the thermokarst origin of the Aquitaine ponds by means of a comparative

analysis with a current periglacial environment. Since the current climate in the discontinuous permafrost zone of Nunavik is similar to that of the Aquitaine during the LGM, this periglacial region appears to be a good analogue. The Umiujaq area, which holds abundant degrading ice-rich permafrost mounds and thermokarst ponds (due to the current trend to climate warming) has thus been selected. The comparative analysis between the Aquitaine ponds and the degrading permafrost mounds in Umiujaq will be carried out using a multi-geophysical approach. Electrical resistivity tomography, spectral induced polarization, electromagnetic mapping at low induction number and ground penetrating radar will be used at both sites to obtain a complete 3D characterization of the degrading permafrost mounds in Umiujaq and of the ponds in Aquitaine. The geophysical signature of periglacial features (in particular thaw consolidation and creep structures) will be observed in the frost mounds in Umiujaq, then sought in the ponds in Aquitaine. Laboratory experiments on core samples will also be done to evaluate the frost susceptibility of the subsurface deposits in Aquitaine. Furthermore, a geothermal model will be developed for the Aquitaine site, considering that the paleoclimatic conditions were identical to the current climatic conditions in Umiujaq. This simulation will give an idea of the thickness reached by the permafrost in Aquitaine under such conditions.

COLONISATION OF GERM-FREE ZEBRAFISH WITH HUMANIZED BACTERIA TO STUDY THE GUT-BRAIN AXIS

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Microorganisms found in the intestinal tract have a great influence on host health. These combinations of microbes, called the gut microbiota, can have beneficial or detrimental impact on the host. Recently, studies have shown that these changes in microbiota may have a repercussion on brain development. For example, specific changes in gut bacteria population have been associated with mental illness. Understanding the relationship between the gut microbiota and mental illness should help designing interventions to treat these disorders. To understand the gut-brain axis, we must develop new tools to observe and manipulate the gut microbiota, as well as brain development and function. To study the effects of the gut microbiota on the brain, we are developing a zebrafish model in which we implant fluorescent bacteria. Zebrafish larvae are transparent, allowing us to perform live imaging of the development of the gut and the brain. By transforming bacteria with genes encoding fluorescent proteins, we can monitor the colonisation of the fish's gut with fluorescence microscopy. We are developing molecular tools to disrupt the balance of the gut microbiota in order to measure the impact on brain development. The first bacteria we are using to colonize the intestinal track of the zebrafish is E. coli. This bacterium was chosen because it is extensively characterized, it can colonize an intestinal tract, and it is present in the gut microbiota early in the development of multiple living organisms. To colonize the zebrafish with fluorescent bacteria, we first treat the eggs to become axenic (germ free). We then immerse the axenic eggs with fluorescent bacteria in water for three days. Then, we examine the fish with microscopy every twenty-four hours to monitor the gut colonisation. Three strains of E. coli were tested during this project. Two of them are laboratory strains and one has been isolated from a human gut microbiota. We found that the human gut strain is more efficient at colonizing the zebrafish gut. To improve further the colonization by E. coli, we feed the larvae simultaneously with the ciliate Tetrahymena thermophila, which serves as a colonization vector. We were able to observe fluorescent bacteria throughout the entire intestinal tracks for several days, though we observed higher signal in the mid-intestine, where mucus-secreting cells are found. This mucus is used by E. coli as a nutrient source and is helpful for the adhesion of bacteria to the intestinal wall. We will next try to implant additional strains of bacteria carrying other fluorescent colors. These manipulations will set the stage to test various tools under development to control bacterial growth in the gut, including photoactivatable Cas9 or bacteriophages.

This approach should enable the control specific bacterial populations in the gut of zebrafish in order to assess the impact of disruption in the microbiota on brain development. Ultimately this model might help us at deciphering basic mechanisms of gut-brain communication and its role in mental illness.

THE EFFECT OF A CHANGING CLIMATE ON NUTRITIVE QUALITIES OF MARINE MICROALGAE IN NUNAVIK, CANADA

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In the Arctic marine environment, microalgae generally are the principal source of primary production, which then transfers to the pelagic food web, the benthos and the sediments. Due to global change, the physico-chemical parameters of the water column in the Arctic Ocean are changing, including temperature, pH, salinity, nutrient availability and light. These environmental changes are expected to affect microalgal production and the quality of the organic matter it synthesizes. This could have important consequences, as microalgae are the only organisms that can synthesize several essential molecules, such as omega-3 fatty acids and carotenoids. These molecules are vital not only for the marine food web, but for the health of the Inuit populations who harvest and feed on these resources. As part of the BriGHT program, the goal of this project is to evaluate the variability in the composition of marine, particulate organic matter and the connections between this variability and the oceanic environment in Nunavik, Canada. Results show a strong physico-chemical gradient across the coastal regions of Nunavik, especially for temperature, salinity and pH; relatively fresh, warm and low-pH conditions are found in the Hudson Bay region, whereas colder, saltier and high-pH conditions are found in the Ungava Bay and Hudson Strait regions. The Hudson Bay region also contains higher algal biomass, notably at the subsurface chlorophyll maximum. Nutrients are nearly absent at the surface in all three regions and increase with depth, with slightly higher concentrations in the Hudson Bay region. These differences and their impact on the quality of organic matter will be presented and discussed.

MARINE COUNTRY FOOD IN NUNAVIK: A BETTER UNDERSTANDING OF VARIATIONS IN ESSENTIAL ELEMENTS AND METHYLMERCURY CONCENTRATIONS IN RINGED SEALS, BELUGAS AND WALRUSES

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Inuit communities have a strong relationship with the coastal ocean and the edible marine resources it provides. In Nunavik (Northern Quebec), the meat, organs, fat and/or skin of harvested beluga, ringed seal and walrus are consumed locally. These country foods provide important health benefits through the intake of essential elements such as polyunsaturated fatty acid (PUFA, including omega-3), selenium, selenoneine and vitamin A. PUFAs are considered essential for cardiovascular health, child development and brain function, whereas vitamin A plays a crucial role in vision, growth and reproduction. The consumption of some marine foods may also lead to methylmercury exposure, a potent neurotoxin, since some parts of marine mammals accumulate and biomagnify methylmercury despite the absence of large industrial activities in the North. In this respect, the dietary intake of selenium and selenoneine is thought to play an important role in mitigating the toxic effect of methylmercury. As part of the BriGHT program, the present project aims to quantify the presence of essential elements and methylmercury in the tissues of belugas, ringed seals and walruses harvested in collaboration with Inuit hunters in communities of the Hudson Strait. Laboratory analysis for vitamin A, fatty acids, selenium/selenoneine, mercury and methylmercury are on-going. Differences in nutritional quality with respect to species, sampling site, population, sex or age will be evaluated. These results will help better understand the links between northern ecosystems, marine food nutrients and Inuit health and promote a safe consumption of these marine country foods in Nunavik.

DEVELOPING TOOLS TO CONTROL THE GUT MICROBIOTA (GNOTOXENIC) IN ZEBRAFISH LARVAE TO INVESTIGATE THE GUT-BRAIN AXIS

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Recent research studies on microbiota have shown the importance of the gut microbiota in human and vertebrate health. Its imbalance is frequently associated with significant pathologies or physiological disturbances in the host. These disturbances can intervene early in the development of the host and alter brain development, and ultimately mental health. Human activities in northern ecosystems induce significant environmental changes. These changes alter the interactions between microbiota and their hosts, and the impact of these changes on host physiology, such as brain development, is still poorly understood. The lack of models and tools to study host-microbiota interactions in detail is hindering the development of our knowledge in this area. In order to understand and characterize these complex interactions, we develop an animal model using the zebrafish (PZ). This project aims to develop a controllable intestinal microbiota in PZ. The PZ model allows for the control of factors modulating the host-microbiota interactions and to measure the impact of these parameters on the evolution of the microbiota and cerebral functions. The microbiota will be initially composed of laboratory bacteria strains made fluorescent by genetic engineering, each bacterium having its own "color". The different fluorescence will make it possible to visualize and quantify in real time the bacterial populations in the larva of the zebrafish by optical measurements. In parallel, bacteriophage cocktails (virus infecting bacteria), specific against each bacterial strain, will be selected, in order to eliminate certain bacteria at the desired time in the experiments, and thus modulate the composition of the intestinal microbiota. This will study the impact of gut microbiota on brain development and function with tools using optical techniques. PZ is a perfect model for this type of study because it allows i) to control some host responses through existing genetic lines; (ii) rapid longitudinal monitoring of a large number of individuals; iii) to follow its process of brain development by optogenetics and microscopy, through its transparency, during the early stages of their development. Currently, the strains of Pseudomonas aeruginosa, Vibrio cholerae, Aeromonas veronii and Escherichia coli have been selected to compose an artificial microbiota of PZ. These strains have now been engineered with a fluorescence gene to distinguish them in the digestive tract of PZ axenic. Axenic PZ colonization experiments are currently being conducted to determine whether these strains are capable of stably colonizing PZ, and whether phage cocktails against these different strains are effective. Once in place, this model will determine whether the gut microbiota can impact brain development, and at the same time whether the brain has an impact on the composition of the intestinal flora. This will increase our understanding in many areas of research where the microbiota may play a role, including human health, drug development, mental illnesses, northern research, etc.

MULTISCALE MODELLING SHOWS A 50% REDUCTION IN SUMMER FISH HABITAT VOLUME FOR SMALL BOREAL LAKES OVER THE NEXT CENTURY

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Habitats of freshwater fishes in the boreal region are considerate favorable when they meet specific criteria of water temperature, dissolved oxygen concentration (DO) and water clarity. These habitats have recently been subjected to degradation due to global warming and the changes in light penetration resulting from increasing dissolved organic carbon (DOC) fluxes to lakes. In these conditions, being able to quantify and predict the impact of these changes in lakes is important, especially in terms of fisheries management and species conservation. We have developed a multiscale approach to estimate the parameters required for the modelling of lacustrine physicochemical processes in an arbitrary number of lakes using the 1D lake model Mylake. A calibrated

hydrodynamic module of Mylake can be transferred from one lake to another without much loss in model performance. We first calibrated the model on a data-rich lake to learn the values of all transferable parameters. The parameters of the biogeochemical module, however, do not lead to good model performance when transferred from one site to another. To define the values of those included in the kinetic equations describing the microbial respiration of oxygen coupled with the oxidation of organic carbon in the water column and sediments, we calibrated the model on twelve lakes spanning a range of size, DOC concentrations and catchment/lake-area ratios. We then identified relationships between the model parameters and the morphometric characteristics of these lakes. These relationships were to calculate model parameters for a larger set of lakes for which little data is available beside maximum depth and area. Our approach was tested on a group of 211 lakes distributed throughout Sweden. The model was driven by climate projections from six global climate models produced by the CORDEX project, along with the two climate scenarios, for four 10-year time periods from 2010 to 2100. The results of these 10,080 individual simulations show that smaller lakes will be warmer with shorter ice cover. They also show a change in DO, with a reduction in winter anoxia and a more severe and late summer anoxia. We have tested the evolution of lake volumes meeting the following criteria based on fish metabolic and visual needs: a lake temperature below 15oC, a DO over 3 mg L-1 and a light intensity between 8 and 68 lux. Our modelling exercise predicts that under a climate change scenario, small lakes will lose 50% of habitats suitable that meet the criteria we have tested. A comparison of these results with the presence or absence of fishes in the lakes modelized is underway and will attempt to validate the multiscale approach. We propose that this approach is suitable to predict the temporal evolution of habitat volume at the scale of thousands of lakes for which only the morphometric characteristics are known.

NUTRITION AND MENTAL HEALTH AMONG YOUNG NUNAVIK INUIT: THE ROLE OF THE GUT MICROBIOTA

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Introduction: For several decades, environmental contaminants due to human activity have converged towards the polar regions carried by atmospheric and marine currents. Inuit are highly exposed to these potentially toxic compounds by a bioaccumulation phenomenon which occurs in some traditional foods. However, these foods are of high nutritional quality, particularly rich in selenium and polyunsaturated fatty acids (n-3 PUFA, and have several benefits for the health of Inuit). In 2004, the Nunavik Inuit Health Survey (NIHS) disclosed higher blood mercury levels than those found in the Quebec population. It has also revealed a high prevalence of psychological distress among Nunavimmiut, mostly affecting young people. Although various studies have reported lower cognitive performance and behavioral dysfunctions related to a chronic exposure to contaminants, including heavy metals such as lead and mercury, the mechanisms by which these chemicals contribute to such psychological states remain unclear.

The intestinal microbiota, by contributing to the presence of systemic inflammation, is one of the physiological pathways to be investigated. The beneficial effects of the nutrients of interest on the intestinal microbiota have also been reported in the literature. The objectives of this study are: 1) to verify at the individual level if there is an association between several bioactive compounds (PUFA, selenium, mercury, lead and cadmium) and the presence of depressive symptoms in the young Inuit of Nunavik, 2) to examine if distinct gut microbiota profiles are associated with these bioactive compounds, and 3) to identify the presence of bacterial metabolites as biomarkers of exposure to these bioactive compounds. Methodology: In 2017, a broad partnership including Nunavik Inuit communities and decision-makers, the Nunavik Regional Board of Health and Social Services, the INSPQ, and researchers from the CHU de Québec-Université Laval Research Center part in the new cohort of the NIHS. In this survey, 293 young Inuit between 16 and 30 years old provided a stool sample and completed a self-administered questionnaire covering several aspects and determinants of health. Levels of exposure to contaminants were documented using the blood levels (mercury, lead and cadmium) of the participants measured during the survey. Depressive symptoms were reported from a pre-tested and valid questionnaire in the population (CESD). Finally, gut microbiota profiles will be identified by Shotgun sequencing and metabolomic analysis will be performed from the stool samples collected. The association analysis between the bioactive compounds of interest will be adjusted for known confounding factors from the literature (sex, age, etc.). Anticipated Results: This study will shed light on the possible role of gut microbiota in the brain-gut axis by examining some of the potential mechanisms underlying the development of mental illnesses in a population experiencing several forms of adversity, including environmental. We are grateful to the 2017 Nunavik Inuit Health Survey – Qanuilirpitaa? (Q2017) participants, as well as to all our Nunavik partners (including the Q2017 Data management committee, Q2017 Steering committee, and the Nunavik Regional Board of Health and Social Services), the Institut National de Santé Publique du Québec, as well as all Inuit and non-Inuit investigators who have collaborated in the various steps of the project and provided their intellectual input.

A MICROFLUIDIC METHOD FOR MULTI-MODAL CHARACTERIZATION OF NORTHERN CYANOBACTERIA

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Cyanobacteria are the dominant producers in the Arctic and sub-Arctic freshwater system. From the atmosphere, they transform carbon dioxide into polysaccharide via photosynthesis and nitrogen into ammonium via fixation, the product of which are utilized by other components further along food chain, fundamentally supporting the local ecological system. Cyanobacteria are facing changes in their inhabiting environment, such as temperature, light and salinity, as the local climate is changing now too. Yet their physiological reactions toward aforementioned changes remain largely unstudied, knowledge of which is important for understanding, modelling and predicting northern aquatic microbial community and ecological system. To understand the behavior of cyanobacteria, channel-based microfluidics can be a powerful tool based on its inherent capability to precisely and dynamically control liquid phase properties with excellent spatial resolution and temporal span. Controllable factors include hydrodynamics such as flow velocity and shear forces; control over mass and heat transfer, and chemical conditions such as concentration and type of dissolved molecular species. Though in vitro and in situ characterization remains a challenge, the compatibility of microfluidics to multiple characterization techniques allow multiple investigation strategies and provide new insight in tackling the study of cyanobacteria physiology. In this poster, we demonstrate the integration of standardized characterization techniques into a microfluidic format. Fluorescence spectroscopy and other related measurements can now assess fluorescence information of individual cells and their collective entity. Under confocal laser scanning microscope (CLSM), cyanobacteria of different strains can

be distinguished and identified in vitro, which is useful for dynamically studying the taxonomical composition within the cyanobacteria biofilm community. Infrared spectroscopy (IR) quantitatively reflects information of its synthesized chemical components such as over-excreted polysaccharides and crystallized water structure against desiccation.

DESIGN OF A DIFFUSE REFLECTANCE SPECTROSCOPY PROBE FOR FUNCTIONAL EXPLORATION OF THE RODENT CEREBRAL CORTEX

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Intrinsic optical signal (IOS) of brain tissues is correlated with neuronal activity and has allowed for the visualization of functional organization of the primate visual cortex in particular. Optical methods thus offer complementary information to the widely used neuroimaging methods such as PET/fMRI and are suitable for bedside monitoring. Through the absorption and scattering processes, particularly when a spectroscopic approach is considered, IOS contains an unprecedented wealth of information about the cerebral regions probed by the photons. At the same time, as absorption and scattering contributions are intrinsically mixed in the signal, an accurate interpretation of the IOS in terms of specific underlying biological processes remains an issue, especially when in vivo measurements are considered. Consequently, developing methods to separately and quantitatively measure absorption and scattering spectra is highly relevant within this framework. Diffuse reflectance spectroscopy (DRS), coupled with Monte Carlo simulations to accurately analyze the measured reflectance spectra, represents a promising approach to attain these goals. In DRS, a broad spectrum light source illuminates a sample and the backscattered light is collected by detection fibers placed at different distances from the source. The shape and amplitude of this reflectance signal is then used to determine the optical coefficients of the sample, namely the absorption and reduced scattering coefficients. This is done by finding the best fit between the reflectance curves from the Monte Carlo simulations and the experimental measurements. Typically, DRS is used with a large source-detector separation (SDS), which allows for the use of the diffusion approximation. Working at shorter SDS requires, however, the use of more complex mathematical models to adequately describe photon migration between the injection fiber and the detection fibers. However, such short SDS, in addition to providing local characterization of cell tissues, offers the appealing possibility of developing minimally invasive and flexible miniature optical probes dedicated to providing timely health status information at the point of care.

ADVANCED NON-DESTRUCTIVE SAMPLE CHARACTERIZATION IN COMPUTED TOMOGRAPHY

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Computed tomography systems provide 3D images from 2D projections acquired at different angles around a sample. In a clinical environment, the most used algorithm is the one described by Feldkamp, Danis, and Kress. Advances in computing power have driven the development of iterative reconstruction algorithms (IR), which allow acquisitions with reduced dose, noise and number of projections. In the early stages of CT, it was proposed to use acquisitions with two different x-ray spectra (two tube voltages) to retrieve spectral information that could reveal the very nature of the constituent materials of the scanned object. These images would allow for material characterization, which is very useful in a medical and non-medical context. The presence of high-density materials in the scanned objects causes deterioration of the CT image quality. The polychromatic nature of the x-ray beam used in CT scanners is the origin of some image artifacts (e.g. dark streaks and cupping artifacts). Empirical and physics-based models for beam hardening correction were proposed to tackle this problem. In this project, we aim to develop physics-rich image reconstruction algorithms to tackle the problems inherent to highly attenuating samples. The integration of spectral information into the reconstruction process will reduce beam hardening artifacts while multi-spectral information will provide information on the effective

atomic number of each voxel in addition to their density. In order to achieve our objectives, many tools were developed to simulate the imaging process steps: virtual phantom designs and physics-rich forward projections with custom x-ray spectra and detector response. Tomographic reconstruction is performed through the OSC-TV algorithm. This IR algorithm runs on GPU, providing an acceptable computing time, and allows for the inclusion of physical models into the reconstruction process. In this sense, two frameworks were developed, based on pre-reconstruction and post-reconstruction methods. Firstly, the stoichiometric calibration technique adapted for a dual-energy approach. This method is more sensitive to beam hardening artifacts. The pre-reconstruction method from Alvarez and Macovski, which inherently corrects beam hardening artifacts by including the spectral information and a physical model of the linear attenuation coefficient into the projection data decomposition. Using both methods, we were capable of characterizing a custom virtual phantom composed of inserts of arbitrary minerals, where a virtual calibration phantom is required for determining the relationship between the reconstructed image (e.g. pixel values) and physical parameters, such as the effective atomic number and electron density. The pre-reconstruction method shows improved results when compared to the post-reconstruction method, which makes no use of spectral information for improving image quality. Both methods fail to properly characterize the edges of the different materials present in the virtual phantom. It was observed as well that a judicious choice of the reconstruction parameters of the OSC-TV algorithm can improve image quality in these situations. The characterization range can be further increased with a characterization phantom containing a wider range of material, with respect to electron density and effective atomic number.

SEX-SPECIFIC EFFECTS OF CHRONIC STRESS ON NEUROVASCULAR HEALTH: IMPLICATION FOR SEX DIFFERENCES IN DEPRESSION

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Major depressive disorder (MDD) is now considered the leading cause of disabilities worldwide, as 1 out of 5 individuals will receive a diagnosis of depression in their lifetime. Women have a roughly twofold higher risk for MDD than men, suggesting important differences in biological vulnerability, emotion regulation and coping mechanisms. Only 30% of patients completely remit, suggesting the neuron-centric traditional treatments do not address important causal biological factors including sex differences. Clinical studies report higher prevalence of MDD in patients suffering from cardiovascular diseases or stroke, indicating that increased inflammation and vascular dysfunction could contribute to depression pathogenesis. Compared to men, women experience higher rates of autoimmune diseases and inflammation, both of which could elevate depression risk. However, the great majority of studies on MDD explored biological mechanisms exclusively in males. This may lead to causal biological factors being omitted in basic and clinical research explaining high rates of relapse and treatment-resistant patients. Recent evidence shows that chronic social stress induces blood-brain barrier (BBB) leakiness in male mice, mostly in a critical structure for stress response, the nucleus accumbens. This promotes infiltration of harmful peripheral immune signals into the brain leading to establishment of depressive behaviors. Interestingly, not all stressed mice displayed depressed phenotype and loss of BBB integrity, suggesting that neurovascular adaptations may contribute to stress resilience. However, this has not yet been studied in female mice. Based on this data, I hypothesized that the higher rate of inflammation observed in women exacerbates stress-induced BBB leakiness which would explain heightened vulnerability for MDD. Therefore, I investigate BBB function under stressful conditions in a sex-specific manner, using a multidisciplinary approach. I did subject male and female mice to a 10-day chronic social defeat stress paradigm, a mouse model of depression mimicking human bullying. My first objective was to compare stress-induced transcriptional pattern of key BBB genes, using qPCR. My preliminary data suggests region-specific adaptations in the BBB of stressed males vs females which could explain sex-specific symptoms observed in human depression. Next, I will corroborate these molecular findings morphologically, using immunohistochemistry and confocal microscopy. Finally, with region-specific viral injections, I will functionally alter the expression of genes of interest and evaluate their causal role in depression-related behaviors and maladaptive stress responses. Mouse findings will be confirmed in human samples, using available brain banks. In parallel, by drawing blood from mice at different time points, I aim to establish a

peripheral blood profile correlated with behavioral and transcriptional findings, in order to look for promising BBB-related biomarkers of depression and resilience. The strength of this approach is in its translational value. By studying stress response in mice, but also cellular and/or molecular adaptations in resilient subjects, we aim to unravel biological mechanisms underlying MDD in humans. It is imperative to study depression as a whole-body disorder and not only in a neuron-centric manner, as well as considering sex differences as a variable to develop innovative therapeutic strategies to improve women and men health in Canada and abroad.

MOLECULAR ADAPTATIONS OF THE BLOOD-BRAIN BARRIER PROMOTING DEPRESSION AND STRESS RESILIENCE

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Major depressive disorder (MDD) is the leading cause of disability worldwide and will affect 20% of individuals throughout their lifetime. MDD is a recurrent condition and only 30% of patients remit completely. This low efficacy level suggests that conventional treatments do not address causal biological factors. Clinical studies report higher prevalence of MDD in patients suffering from vascular diseases, indicating that increased inflammation and vascular dysfunction may contribute to depression pathogenesis. We showed that chronic stress induces blood-brain barrier (BBB) leakage in the nucleus accumbens (NAc) of mice, promoting depression-like behaviors. Here, we characterized molecular adaptations underlying stress susceptibility (SS) vs resilience (RES) in the NAc endothelial cells of C57Bl6 mice. Mice were subjected to 10-day chronic social defeat stress followed by social interaction test to determine behavioral phenotype. NAc punches were collected and cell-specific magnetic activated cell sorting was performed followed by transcriptome-wide gene-level expression analyses. We observed specific gene expression patterns in endothelial cells of the NAc of SS vs RES. Such changes were also present in RES vs control mice indicating that BBB molecular adaptations are necessary to maintain its integrity under chronic stress. We confirmed changes in BBB-related gene expression in postmortem NAc of MDD patients supporting a role for the vasculature in depression and possibly novel therapeutic strategies. Funding: NARSAD, Canada First Research Excellence Fund, FRQS, CERVO, Fonds Hélène-Hallé U.Laval

COLOUR, MATERIALITIES AND LIGHTING: PHOTOBIOLOGICAL AND BIOPHILIC INTERIOR DESIGN IN NORTHERN ARCHITECTURE

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Daylight consists in the first contact from interior to exterior environment, which regulates our internal circadian clock and biological processes maintaining the well-being and performance of the human body, promoting a better mood in people and mental balance. Nowadays, people spend most of their time in indoor environments, a condition which alters physiological and psychological aspects of living. In order to improve the quality in indoor environments and to overcome the gap between architecture and nature, the concept of biophilic design has been developed in the last decades, to integrate living and natural elements in the space which have the particularity to produce higher levels of happiness and well-being in people. The present research discuses that combinations of colour, materialities, and lighting design strategies could potentially improve the indoor environment in northern

climates. Some authors have related colour effects with emotions. The effect of colour and materials exposed under natural and artificial light produce different reactions in our visual and non-visual response in photobiological and biophilic architecture. Nonetheless, seasonal changes in northern countries, destabilize daylight availability, producing desynchronization in circadian rhythm, reflected in physical and mental health. According to the literature, the properties control and the use of smart lighting has the ability to generate different types of atmospheres which is considered as an affective evaluation of the environment. Moreover, the integration of smart lighting design strategies affects the interior colour combination of materials and finishes, which could improve well-being by producing varying spectral responses in the brain. In matters of materialities is possible to find changes in the optical radiation according to surface properties, such as colour, reflectance, reflectivity, combined with varying luminous distribution of natural and artificial patterns in interior spaces. The use of noble materials such as wood evokes emotions related with naturalism, which could improve the well-being associated with biophilia combined with its photobiological benefits. The presentation illustrates the photobiological potential applied to northern architecture through research results from experimental design explorations of a selection of lighting scenarios. Variables of colour, material and light types will be assessed at 1:50 scale models. To know the strategy effectiveness, High Dynamic Range images (HDRi) and the use of visual lighting sensors (based on Raspberry Pi microcomputers) will be employed, due to the demonstrated accuracy in lighting research. Photopic light, melanopic lux, luminance distribution and colorimetry will deliver image-forming and non-image-forming results in which the modification in parament properties and type of light source demonstrates the advantage and limitation options to enhance the environmental comfort of the human being. Results will be aimed at developing adaptive scenarios in which colour and material properties under different types of lighting, with the main objective to optimize daylight comfort and photobiology in northern cities.

THE EPIGENETIC REGULATION OF GENE CO-EXPRESSION NETWORKS IN MALES AND FEMALES WITH MAJOR DEPRESSIVE DISORDER (MDD)

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Gene signatures of males and females differ dramatically in the brain. Any alteration to the essential organization of these sex-specific gene networks can dramatically increase the susceptibility of developing MDD. Epigenetics, an important regulator of transcriptional networks, potentially contributes to sex differences in depression. Yet little is known of the epigenetic mechanisms regulating these important sex differences. BA25 is extensively reported to be hyperactivated in MDD. We aim to characterize the complex sex-specific epigenetic mechanisms regulating the gene expression network in neurons of BA25 in human MDD. We performed ChIP-seq on FACS sorted neuronal nuclei from BA25 of human MDD patients and control post-mortem tissues. We identified genome-wide differential enrichment sites in males and females with MDD compared to healthy controls. We concluded that males and females exhibit differential epigenetic regulation in BA25 of MDD patients.

FROM INDIVIDUAL POSITION TO ECOSYSTEM QUALITY, HARNESSING THE NEW OPPORTUNITIES OF OPTIC-BASED HABITAT MAPPING IN COASTAL AREAS

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While ecologists greatly benefit from the direct observation of the environment, SCUBA diving sampling methods often entail operational tradeoffs to maximize the amount of data gathered while minimizing the workload and permanence underwater. For example, habitat mapping, the description of the biological communities and the bottom morphology at one location is often estimated from non-contiguous sampling data limiting the study of spatial relationship to very small scales (few meters squared). Luckily, computer vision developed algorithms to obtain orthogonal photomosaics and Structure-from-Motion (SfM) enabled the reconstruction of 3D models from partially overlapping 2D images. When applied to underwater imagery, these methods give ecologists the ability to obtain the underwater equivalent of aerial photographs. Such photomosaics and 3D models can be used to map biological and geomorphological features over continuous and wide areas compared to what was possible with traditional scientific diving techniques. We now have the unprecedented possibility to explore spatial relationships between species, and species and their environment at the scale of a site (i.e., several 100s of meters squared). Here we show how photomosaics and 3D models obtained from SfM represent a new type of data-rich underwater imagery that can generate different datasets to address a variety of topics. First, we present the case study of the development of an Ecosystem-based Quality Index (EBQI) for the Bay of Sept-Iles in the context of the Canadian Healthy Ocean Network (www.chone2.org), where photomosaics allowed for capturing the heterogeneity of the shallow subtidal system and targeting multiple invertebrates and macroalgal species at the same time. Finally, by applying spatial analyses techniques to photomosaic in a GIS framework, we explore how factors such as the substrate morphology or the presence of predators affect the distribution of benthic macro-invertebrate species in subpolar coastal areas. The two case studies presented demonstrate the powerful combination of computer vision, geomatics and spatial ecology in an interdisciplinary approach to both understand ecological dynamics and support environmental management at a local scale necessary to maintain ecosystem functioning, resilience and the provision of ecosystem services.

OPTIMIZATION OF A SURFACE-ENHANCED RAMAN SPECTROSCOPY (SERS) SENSOR TO STUDY THE INTERACTIONS BETWEEN BILE ACIDS AND GUT MICROBIOTA

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Tout porte à croire que plusieurs maladies cardiométaboliques et mentales, nommons par exemple les maladies inflammatoires de l'intestin, seraient provoquées par des perturbations du microbiote intestinal. Entre autres, chez les populations nordiques du Canada, où l'on trouve une prévalence importante pour ces maladies, une diète non équilibrée pourrait avoir perturbé le microbiote intestinal au point d'être responsable de ces problèmes de santé. Cela dit, bien que le microbiote intestinal soit reconnu comme un élément essentiel au maintien de l'homéostasie et du métabolisme, l'analyse de son activité est actuellement limitée à des mesures génomiques et métabolomiques fécales a postériori, ce qui limite considérablement la compréhension des interactions hôte-microbiote. Or, les acides biliaires (AB), une famille de biomolécules hydrophobes, sont intimement reliés au microbiote dans la mesure où celui-ci est l'un des acteurs principaux dans leur bioconversion. L'étude des interactions entre le métabolisme du microbiome intestinal, les acides biliaires et leurs dérivés est donc d'une grande importance. Le présent projet vise l'amélioration et l'application d'un capteur moléculaire capable de mesurer le signal Raman des différentes formes d'acides biliaires et d'en amplifier le signal via l'effet SERS (Surface Enhanced Raman Scattering). Plus précisément, ce projet se concentre sur l'optimisation de l'interaction chimique avec les AB en plus de chercher à obtenir un senseur robuste, reproductible et uniforme. Le capteur moléculaire SERS utilisé dans ce projet consiste en une couche de nano-étoiles d'or fixée sur une lame de verre de microscopie via des procédés de salinisation. Le projet s'est d'abord concentré sur la fonctionnalisation chimique du capteur afin d'assurer une sélectivité optimale envers les AB tout en réduisant l'encrassement biologique.

Pour ce faire, plusieurs ligans ou mixte de ligands ont été testés et analysés, ce qui a permis de générer plusieurs études de caractérisation paramétrique. Entre autres, la concentration, le pH, l'effet du solvant ainsi que la température sont des avenues sur lesquelles nous nous sommes arrêtés. La forme des nanoparticules a également été prise en compte pour améliorer les performances du capteur. Les résultats obtenus aux termes de ce projet vont permettre d'améliorer grandement l'efficacité du capteur SERS en plus d'offrir une meilleure compréhension des mécanismes pathologiques des maladies cardiométaboliques et mentales.

IMPACT OF ENVIRONMENTAL CONDITIONS ON AIRWAY MICROBIOTA AND RESPIRATORY HEALTH IN THE NORTH

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The communities of the North are coping with environmental conditions and lifestyle that favor respiratory diseases. While an association exists between environmental conditions and the development of respiratory diseases in the North, little is known about the mechanisms involved and effective preventive and therapeutic solutions are lacking. Airways are populated with bacteria, fungi, protist and a large community of viruses. Microbiome studies have surged with the new sequencing technologies but most of them concern the gut, for which associations between microbiome content and diseases have indeed been revealed. Our objective is to generate crucial information about the impact and development of respiratory diseases in the North that will lead to effective preventive and therapeutic strategies. More specifically, our aim is to sample microorganisms from the oropharynx and to find associations between patterns in microbial abundance and/or taxonomy and respiratory health in the North. Oropharyngeal samples were collected during the Nunavik Inuit Health Survey of 2017. Subjects were divided into a diseased group (n = 100) and a healthy control group (n = 100) based on their lung function and clinical history. We first focused on the optimization of nucleic acid extraction from the swabs. To maximize microbial coverage it is critical to remove host cell contamination from the swabs prior to metagenomics sequencing, given that the human genome is several orders of magnitude larger than microbial genomes. For bacterial metagenomics, our protocol involves the differential lysis of host cells and subsequent enzymatic digestion of released host DNA, followed by microbial cell lysis and purification of bacterial DNA. Using samples spiked with human-derived macrophages and a custom mixture of bacteria, we showed that our protocol is able to efficiently deplete host DNA contamination with minimal bias to bacterial community composition. Regarding viral metagenomics, the even smaller size of virus genomes makes it essential to directly enrich viruses or their nucleic acids from the samples. Our protocol, is being optimized and involves the capture of viral genomes using a library of several thousands of virus-specific oligonucleotide probes. Through next-generation sequencing and bioinformatics, our project will survey microbial communities of the upper respiratory tract in relation to respiratory capacities. Cross-referencing this data with the household air quality that was also monitored as part of this Sentinel North subproject should further our understanding of the interplay between environmental conditions, the respiratory tract microbiome and respiratory health. ** We are grateful to the 2017 Nunavik Inuit Health Survey -Qanuilirpitaa? (Q2017) participants, as well as to all our Nunavik partners (including the Q2017 Data management committee, Q2017 Steering committee, and the Nunavik Regional Board of Health and Social Services), the Institut National de Santé Publique du Québec, as well as all Inuit and non-Inuit investigators who have collaborated in the in the various steps of the project and provided their intellectual input.

A WEARABLE SPECTRAL SENSOR FOR MONITORING VISIBLE LIGHT EXPOSURE IN NORTHERN REGIONS

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In the context of Sentinel North project 2.8 (development, implementation and use of miniature portable) there was a need to monitor the level of exposure to visible light of individuals, knowing that this can have an important effect on their physical and mental health. Indeed, studies have shown the effect of light exposure on the circadian rhythm and the suppression of melatonin, which is associated with risk of cancer and type II diabetes [1,2]. This is compounded in northern latitude where annual variation in daily light exposure is due to large seasonal differences in photoperiod length [3]. Several studies focused on sleep [4] and nighttime light exposure [5] in northern regions and showed a worse sleep hygiene when exposed to these northern light conditions. To monitor visible light, we developed a wearable smart cap. This wearable is built around the AS7262 6-Channel Visible Spectral sensor from AMS. This sensor is a compact 6-channel spectrometry solution that works on 6 visible channels of light (450 nm, 500 nm, 550 nm, 570 nm, 600 nm and 650 nm, each with 40 nm full width at half maximum). It has a functional temperature range of -40°C to 85°C, which permits deployment in the northern regions. The field of view is aperture-limited to ±20°. The sensor has an internal thermometer for temperature compensation allowing for a typical accuracy of the channel counts/μW/cm2 of ±12%. This sensor is supported by a data logger responsible for keeping an accurate time and storing the data. This data logger consists of an Adafruit Feather 32u4 Adalogger, which is a small development board combining a low power micro-controller, an integrated charging circuit for a lithium-polymer battery and an SD card interface for data storage. It is accompanied by a DS3231 Precision real time clock to keep accurate timestamp under most conditions. By using different battery capacity, an autonomy varying between one day and one week is achievable for a wearable, set-and-forget operation. All the code, a hardware breakdown and software (for tethered monitoring) are open-source and available at https://github.com/alexisfcote/SNLightSensor.
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STUDYING NEURODEVELOPMENTAL DISORDERS USING INDUCED PLURIPOTENT STEM CELLS

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A great prevalence of mental health difficulties has been detected in the Inuit population, which could be caused by genetic and/or environmental factors affecting brain development during embryonic and early postnatal life. We aim to establish an in vitro model to identify abnormal neurodevelopmental processes associated with the emergence of mental health difficulties, which could not only help us to have a better understanding of the underlying physiopathology, but also identify biomarkers or risk factors for diagnosis or disease prevention. Pluripotent stem cells, capable of expansion and differentiation into any cell type in the body, can be induced from isolated patients' cells through cellular reprogramming. The neural differentiation of induced pluripotent stem cells (iPSCs) recapitulates at some extent brain developmental processes in vitro. In a first stage of the neural differentiation, iPSCs-derived neural stem cells (NSCs) form radial organized columnar structures termed neural rosettes, which represent the embryonic neural tube formation. Neural rosettes are characterized by apical-basal polarity, where NSCs migrate from the apical to the basal region during maturation. In the apical region, NSCs connect each other by adherens and tight junctions, forming a ring-like structure around an empty lumen. In our study, we have observed that the lumen's area, identified by the presence of N-cadherin and PKCλ (in the

adherens and tight junctions, respectively) are smaller in the schizophrenic iPSC-derived neural rosettes, compared with healthy controls. We found that the smaller lumen area correlates with a higher expression of cytoskeleton remodeling proteins (Cofilin and Profilin), as well as with a different expression of adhesion genes (higher for NCAM1 and NRXN1 and lower for NLGN1). Moreover, we have not found differences in the ability of schizophrenic iPSCs to differentiate into NSCs (PAX6-positive), neither in the schizophrenic iPSC-derived NSCs to proliferate (expression of the proliferation marker PCNA). Although further studies are needed to better elucidate the observed differences, we speculate that it is due to altered expression of cytoskeleton and cell adhesion-related proteins that schizophrenic NSCs organize differently compared to healthy controls. We also speculate that these neurodevelopmental differences identified in vitro may help us understand the brain structural abnormalities and pathophysiological processes relevantly involved in the schizophrenic patients. Furthermore, we think that iPSCs-derived neural rosettes are a good model to study neurodevelopmental vulnerabilities, including those affecting the Inuit population, since they are both readily obtained in culture (about 10 days of in vitro differentiation) and easily explored with different multimodal high-resolution microscopy techniques.

SUMMER VARIABILITIES IN ARCTIC MICROBIAL EUKARYOTIC COMMUNITIES IN NORTHERN BAFFIN BAY

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Multiple studies indicate that climate warming threatens ice-dependent ecosystems but less is known about its effect on marine phytoplankton and associated heterotrophic protist communities. As the Arctic Ocean freshens due to multiyear ice and Greenland Ice Sheet melt, the microbial communities are being exposed to greater salinity fluctuations over the growth season and across wide geographic areas, which could select for a species regime change. These recent changes in freshwater inflow and stratification mean historical patterns are not reliable indicators of present day seasonal and spatial patterns of the phytoplankton species that support Arctic marine productivity. Remote sensing and in situ data has shown that the highly productive Northern Baffin Bay (NBB) including the Pikialasorsuaq region, has undergone marked changes in chlorophyll and productivity patterns over the last 15 years, but species information is lacking. We applied high throughput amplicon sequencing to investigate summer Arctic microbial eukaryotic communities from two sides of NBB that are subjected to very different stratification and major current regimes. From 2005 to 2018, we found that seasonality was a major factor determining community species composition. In summer, the species complex Chaetoceros socialis-gelidus and Micromonas polaris dominated phytoplankton reads. The proportion of M. polaris reads increased over time in surface waters and at the subsurface chlorophyll maxima (SCM) on eastern (Greenland) side of NBB, where salinity and temperatures are higher than on the Canadian side. The heterotrophic community was more responsive to environmental drivers irrespective of season suggesting high sensitivity to other environmental conditions by the heterotrophic communities.

REMOTE SENSING OF GASES USING BROADBAND LIGHT

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Remote gas sensing is expected to be one of the hot topics of the next decade, due to the increasing environmental regulations around the world and its high application potential in industry and applied research. Remote detection of target gases is also of prime importance for northern scientists to monitor thermokarst emissions resulting from the thawing permafrost. At the moment, there is a large number of techniques able to detect the presence and concentration of a target gas from a certain distance, most of which is based on light absorption at specific wavelengths. Since each molecule is known to possess a unique pattern of absorption wavelengths, it is possible to identify a gas either by probing a single absorption line known to belong to the target gas using a narrowband light source (i.e. tunable laser), or by

measuring a whole section of the absorption spectrum using a broadband light source. While the former approach generally provides more precise measurements, the latter approach is more polyvalent by allowing the detection of multiple gas types with a single system. In the context of northern research where the deployment of an instrument can be very expensive, polyvalent systems able to gather useful data for multiple experiments can be appealing. In this presentation, a short overview of the existing optical techniques allowing for the measurement of multiple gas types from a single system will be presented, along with a novel technique developed by our group based on mid-infrared (MIR) supercontinuum. Compared to most other techniques using near-infrared light (1-3 μm), MIR supercontinuum sources can produce a very broadband laser light (between 3-5 μm) where fundamental ro-vibrational absorption lines of molecules can be up to 100x stronger than their near-infrared counterparts. Its simple design and low electrical consumption make it an interesting candidate for off-the-grid 24/7 measurements of gases such as methane or CO2 in remote areas.

CLIMATE AND PERMAFROST DATA INTEGRATION IN SUPPORT OF THE DEVELOPMENT OF THE COMMUNITY OF SALLUIT, NUNAVIK

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The fast-growing population in the village of Salluit creates important housing and infrastructure needs that must be fulfilled in a secure manner. Many concerns arise from difficult topographical constraints and the ice-rich permafrost of the Salluit valley, and the limited space for construction. These challenges require regularly updated information on permafrost temperatures, rates of summer thawing of the active layer, and georisks. Given the abundance and spatial distribution of monitoring instruments (i.e., thermistor strings, DTS-fiber optic cables, SILA automatic weather station), integration of data and day-to-day observations of ground temperatures allow for monitoring of permafrost behaviour and assessment of georisks in the community. These monitoring instruments offer a constant window on numerous climate factors (air temperature, precipitation, wind speed) and on the ground thermal regime under different soil types. This project is about integrating the data from these monitoring instruments, within the existing geospatial information and databases already produced by the Centre d'études nordiques (CEN) in Salluit. The integration of a pre-warning signal of landslide hazards in the active layer of permafrost in late summer, which occurred in Salluit several times in its history, will allow the community to anticipate such events. This signal and the updated versions of the mapping, climate and permafrost data will be available in ArcGIS Online, using the customizable application Story Map Series, Story Map Journal and Web AppBuilder. These ESRI products display data as narrative text, graphs and tables, combined with geospatial information that is integrated and shared in a single main application. As a result, the data is available free of charge for both institutions and stakeholders involved in the development of northern communities, as well as the interested public. The continuation of the project consists of the analysis of GPR (ground penetrating radar) surveys that we will carry out this summer, in the area identified for the new housing development. Estimating the depth of the bedrock will make it possible to propose the use of construction techniques in housing design that are better adapted to the terrain, such as pile to bedrock. If the context is favorable to this type of foundation, this knowledge allows us to produce a cost analysis, using these construction techniques. The goal is to compare the cost of current practice to an approach better adapted to the geomorphological context of Salluit, but also regarding the depleted gravel resources. The overall purpose of this project is to facilitate decision-making towards sustainable development, offering a support to land-use planning, construction, and security assessments.

SLOWING DOWN THE LIGHT TO IMPROVE THE NEXT GENERATION OF MINIATURIZED METHANE SENSOR

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Positive feedback to climate warming due to the release of methane, a greenhouse gas having a high global warming potential, from thawing permafrost and Arctic lakes is expected to accelerate climate warming. A new generation of cheap, selective and precise methane

sensor is thus needed for remote and real-time monitoring of methane emissions in northern environments for climate change monitoring and data collection. Here, the application of subwavelength grating (SWG) waveguide integrated on a silicon photonic chip is proposed for methane sensing by near-infrared tunable diode laser spectroscopy. The periodic segmentation of the SWG waveguide results in a large fraction of the light travelling in the air, the media of interest to probe. Moreover, we demonstrated that the periodicity in the structure, close, but smaller than the wavelength of the light, results in a slow-light effect; the speed of light highly decreases in such waveguide. We propose to harvest this slow-light effect to increase the light-methane interaction, therefore improving the performance of the sensor. The light speed experimentally measured in SWG waveguide is up to 30 times slower than in air. This slow-light effect increases the interaction between the light and the methane by the same factor, and so the detectable absorption signal. We propose to exploit these two effects taking place in the SWG waveguide to enhance the sensitivity and the limit of detection of on-chip trace-gas sensors.

NOVEL BIOMARKERS FOR EARLY DIAGNOSIS OF PARKINSON'S DISEASE

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Parkinson's Disease (PD) is one of the most common neurodegenerative diseases. Epidemiological surveys of Parkinson's disease (PD) have shown substantial geographical variation in prevalence. In northern populations such as the Greenland Inuit and people living in the Faroe Islands, a much higher prevalence of PD was recorded. The cause of higher incidence of PD seen in these regions is still not fully understood but the exposure to environmental contaminants was proposed to be a possible risk factor for PD in Arctic populations since PCBs and pesticides were found markedly increased in their blood samples. The pathological characteristic of PD is the deterioration of dopaminergic neurons present in the substantia nigra in the brain and the appearance of cytoplasmic inclusions known as Lewy's bodies. Dopamine neurons are already severely affected in patients consulting in clinics for PD symptoms for the first time, stressing the urgent need to develop biomarkers to initiate neuroprotective therapies early, before the onset of symptoms. The aim of this project is to find peripheral biomarkers which may confirm the pathology onset, and possibly to identify the disease in early stages. In this project, we focused on saliva since salivary glands innervation represents an excellent transport system of small molecules from the central nervous system to the periphery. Furthermore, the alteration produced in the disease condition and the presence of these molecules modify the oral environment and may alter the normal bacteria flora leading to the formation of new and unknown biomarkers. As an additional way to predict early loss of dopamine neurons, we are analyzing electroretinography (ERG). This method has been recently found to be efficient in measuring fluctuation of central dopamine in animal models and in patients with psychosis in which dopamine is also hypothesized to be part of the underlying mechanism of changes observed at the level of the retina. Our preliminary analysis using mouse and non-human primate models of PD indicate that ERG could be a valuable tool to detect central dopamine changes. Patients suffering from PD are actually recruited to support the validity of our data using animal models of PD. We also expect that the combination of multiple biomarkers, such as the microbiome composition found in the saliva will increase the accuracy to detect PD in its early non-symptomatic phase.

ÉVALUATION DE LA RECHERCHE PARTENARIALE EN CONTEXTE AUTOCHTONE : FONDEMENTS THÉORIQUES ET MÉTHODOLOGIQUES

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Cette présentation aborde la recherche partenariale en contexte autochtone sous l'angle des principaux défis et concepts qui la définissent et l'orientent. La recherche partenariale est en phase avec la perspective de Sentinelle Nord souhaitant donner aux Autochtones une place centrale dans la production de la recherche et des activités. Elle répond a priori aux intérêts des communautés autochtones qui réclament plus de leadership et une participation accrue dans la recherche. En architecture et en aménagement, la recherche partenariale avec les

milieux autochtones est privilégiée, voire obligée par les organismes subventionnaires. Or, il est pourtant admis que la participation est rarement évaluée adéquatement et qu'elle a peu d'impacts réels sur l'issue des projets d'aménagement. De nombreux auteurs soulignent les difficultés de l'évaluation de la recherche partenariale, notamment quant au caractère intangible des interrelations entre les acteurs. Ce doctorat s'appuie sur l'étude de cas, appropriée au paradigme de la recherche autochtone. La recherche traite plus particulièrement du partenariat établi depuis 20 ans entre la communauté Uashat mak Mani-Utenam et l'École d'architecture de l'Université Laval. La longévité du partenariat en fait un objet de recherche particulièrement intéressant. La présentation rend compte d'une revue de la littérature sur les cadres évaluatifs de la recherche partenariale. Elle définit les concepts et les méthodologies clefs qui servent à jeter un regard sur les rouages et sur les façons de décoder les interrelations entre les acteurs (universitaires et communautaires). Les constats mettent en exergue la quasi-absence de littérature sur l'évaluation de la recherche partenariale en aménagement et en contextes autochtones, alors qu'elle foisonne dans les domaines de la santé. Des différents cadres théoriques répertoriés émergent les facteurs d'une évaluation appropriée : les interactions sociales (confiance), le contexte, la temporalité, les buts communs (missions), la traduction/médiation, les retombées, de même que l'interaction de tous ces facteurs entre eux. Ces thématiques apparaissent souvent comme les fondements des questionnaires et des différents outils d'évaluation développés par les auteurs. Aussi, les approches et outils méthodologiques qualitatifs apparaissent les plus porteurs pour récolter des données détaillées. Ces constats multiples orientent la méthodologie en élaboration du présent projet doctoral, pour, à terme, développer un cadre évaluatif adapté aux contextes autochtones nordiques.

IMPACTS OF THE INTRODUCTION OF MUSKOX ON PLANT COMMUNITIES IN NUNAVIK AND DEVELOPMENT OF A MONITORING PROTOCOL

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The introduction of a new species can modify interspecific relationships and terrestrial ecosystem dynamics. Muskox (Ovibos moschatus) was first introduced in Kuujjuaq, Nunavik, in the 1960s where 54 animals were gradually released into the wild until the 1980s. Recent observations suggest that the population has now increased to several thousand individuals. Inuit communities have expressed concerns about the possible impacts of this new established ungulate species on Nunavik ecosystems, more particularly on caribou. Large herbivores can change plant communities through consumption, trampling and the addition of nitrogen to the soil by faeces and urine in the habitats they use. Our main objective is to evaluate if the introduction of muskox altered the composition and the structure of plant communities in habitat types they most frequently use. During summer 2019, we will conduct vegetation sampling of the Arctic tundra in two areas with contrasting occupancy histories. The sites with a long history of occupation are located on the Ungava Coast. Contemporary occupation sites will be located near the Inuit village of Umiujaq and Inukjuaq on the Hudson Coast. Sites were selected using GPS positions from muskox with GPS collars and local knowledge from the Inuit communities. In each area, we will compare sampling sites disturbed by muskoxen with sampling sites that are poorly or not accessible to them. This study will help with the development of a long-term monitoring protocol for muskox habitat in Nunavik and will contribute to answering Nunavimiut concerns about the effects of muskox presence on the land.

SEDIMENTARY ANCIENT DNA REVEALS POLARELLA GLACIALIS AS A NOVEL CIRCUM-POLAR SEA ICE PROXY

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One of the most striking consequences of current climate change is the abrupt decrease in Arctic sea ice extent. Current projections indicate a blue Arctic Ocean during summers already within the next few decades. Despite its importance, sea ice is one of the most poorly understood components of the Earth System, stressing the urgency to develop new proxies for reliable past reconstructions. Here we demonstrate the potential of the sea ice dinoflagellate Polarella glacialis as a seasonal sea ice indicator. The species is known to inhabit sea ice in the Antarctic but only a few sightings have been reported from the Arctic. Based on microscopic observations in surface sediment, sediment traps, and sea ice we confirm that this species has a pan-Arctic distribution closely tracking first year sea ice. It forms characteristic resting cysts during its life cycle that are present in large numbers in both sea ice and sediment trap samples. Within seasonal sea ice, it can represent up to 82% of the microalgae communities while it is absent from multi-year sea ice. Although the cysts are exported from the sea ice/sea surface to bottom sediments, there are few reports of this species in sediment records. This is likely due to problematic identification, its size smaller than 20 μm, and its sensitivity to harsh palynological treatment (e.g. using warm HF) and/or cyst degradation in the sediments. Therefore, we chose to explore a paleo-DNA approach for tracing this species in sediment core records. We designed species-specific primers of the ITS1 gene-region to detect and quantify sedimentary ancient DNA (sedaDNA) from P. glacialis in two dated marine sediment cores collected off West Greenland spanning the past ca. 12.000 years. Our results demonstrate that DNA of the ITS1 gene-region in P. glacialis can be amplified and quantified using either a standard qPCR or droplet digital PCR approach. We also quantified P. glacialis DNA in 53 surface sediment samples from marine and fjord settings around Greenland. The P. glacialis DNA results were compared against "classical" proxies such as microfossils and the isoprenoid biomarker IP25 in both sediment cores and the surface sediments. Our findings are particularly relevant to fjord systems, where P. glacialis appears to reflect sea ice conditions more reliably than IP25. We suggest sedaDNA from P. glacialis as a novel and reliable sea ice proxy that can improve sea ice reconstruction both in marine and near-shore environments of the Arctic and Antarctic regions.

A FLUORESCENT MOLECULARLY IMPRINTED POLYMER FOR THE DETECTION OF BILE ACIDS IN THE GUT MICROBIOTA

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Nutrition changes from traditional food to a "western" type diet are suspected to have significant negative effects on the health of indigenous populations in the Canadian North. They can cause a dysregulation of the gut microbiota (the system of microorganisms present in the gastro-intestinal tract (GIT)), leading to various health problems including diabetes, cardiometabolic pathologies and mental illness. Therefore, there is a great interest in quantifying certain metabolites of interest in the GIT, such as bile acid metabolites that have been associated with the development of certain pathologies. Even though analytical methods for the characterization of these metabolites already exist, they are expensive, time-consuming and cause the lost of critical spatial and temporal information. The overarching objective of the project is to develop a fluorescent sensor deposited on an optical fiber probe to achieve real-time bile acid level determination in vivo. The molecular sensor is composed of a molecularly imprinted polymer (MIP) that will selectively capture bile acids present in the GIT. A MIP is a polymer network formed in the presence of the labile analyte, thus bestowing it pores having high affinity for the targeted molecule. The synthesis of the MIP is achieved via radical polymerization by precipitation. By carefully choosing the monomeric transducer, the non-covalent interaction between the analyte and the polymer can be made to generate a fluorescent signal. The molecular sensor will then be integrated into a core-shell architecture to improve the luminescence properties of the probe, enhancing its brightness and photostability, and improving detection sensitivity. The principle of plasmon-enhanced fluorescence is based on the interaction of the conduction electrons of a metal with a nearby fluorophore upon light irradiation, resulting in a significant increase in the fluorophore's brightness and photostability. During this presentation, various aspects of the project will be discussed, including optimization of the MIP's morphology and analytical performances

(e.g., detection sensitivity and selectivity) as well as the synthesis and characterization of the core-shell plasmonic nanostructures.

LA PRÉSENCE DU BIOMIMÉTISME ARCHITECTURAL DANS LES RELATIONS À LA NATURE DES INUIT AU NUNAVIK

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Écologiquement remises en cause dans leur contexte d'origine, les solutions architecturales exportées du Sud au Nord ont souvent créé plus de problèmes qu'elles en ont résolus, augmentant la dépendance du Nord aux modèles du Sud et en énergie fossile. On se retrouve ainsi avec une problématique exacerbée soulevant des questions sociales et culturelles, sanitaires, techniques, économiques et écologiques. Quelle est l'architecture culturellement adaptée aux communautés inuit du Nunavik qui répond à la fois à leurs besoins et à la complexité du contexte nordique actuel? Pour tenir compte du caractère indissociable, interrelié et complexe de la problématique, le choix de l'appréhender dans son ensemble est primordial. En effet, une approche traditionnelle par interventions isolées ne parvient pas à offrir une réponse d'ensemble qui soit suffisfaisante (« suffisamment bonne », « Satisficing »; Simon, 1969) et soutenable, car elle échoue à concilier les multiples contraintes qui jalonnent le système de production de l'architecture nordique et à répondre à la complexité de la situation actuelle. Parmi les approches qui saisissent la complexité, le biomimétisme qui cherche des solutions innovantes et soutenables en imitant les schémas et stratégies de la nature nous apparaît répondre adéquatement à la problématique pour plusieurs raisons. D'une part, il résulte de la prise de conscience, par les milieux occidentaux, du caractère anthropocène de leurs activités depuis l'industrialisation. De plus, en architecture soutenable, il aborde les dimensions éthiques en plus des défis méthodologiques et techniques. Par ailleurs, la culture inuit est riche en interactions avec la nature. La cohabitation réussie entre les Inuit et une nature des plus rudes est basée sur une observation fine et une interaction respectueuse qui transparaît dans leur relation à l'environnement (Rundstrom, 1990), ancrée dans leurs comportements et nécessaire à leur survie. L'approche biomimétique architecturale se base sur le transfert de savoirs entre la biologie, qui étudie les êtres vivants et l'architecture. Dans notre cas, nous cherchons à identifier et à comprendre les savoirs inuit de la nature nordique (Freeman, 1992) en relation forte avec leur architecture et leur potentiel d'applicabilité au processus de conception biomimétique. À l'aide d'entrevues, de rencontres et d'échanges, nous visons une collaboration active avec des membres de communautés inuit, la valorisation de leurs savoirs ancestraux et contemporains, et, à terme, leur implication dans la conception de solutions architecturales inuit (Dawson, 2006). La présentation aborde la recherche depuis la construction de sa problématique à la méthode qu'elle prévoit utiliser. Elle expose ses questions de recherche ainsi que les éléments émergeant de la revue de littérature qui permet d'en préciser le sujet, les actions ainsi que les résultats à atteindre.

DESIGN AND IMPLEMENTATION OF WIRELESS MICROELECTRONIC SENSORS TO MEASURE MICROORGANISMS' GROWTH IN DIVERSE ENVIRONMENTS

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Understanding the impact of global warming and human activities on northern habitats and ecosystems and their influences on wildlife, human beings, and health is one of the most important challenges of our time. To this end, characterization, identification, and monitoring of sentinel microorganisms' growth and metabolic activity can provide invaluable insight into the environmental changes in northern areas. In fact, at low temperature, the activity of microorganisms like bacteria and microbes decreases dramatically. Hence, we will design a customized high-precision bioimpedance measurement system that can address a precision to measure bacteria diluted down to several millions of CFU/ml. This project aims to build a multi-technology microsystem to measure bacterial growth and environmental parameters in diverse environments, such as northern climates. We intend to design and fabricate a microelectronic chip to perform local bioimpedance measurement. Our approach will leverage the design of a new fully integrated bioimpedance measurement circuit that will enable high-precision and placement in hard to reach areas of the northern regions. Additionally, an integrated system to precisely monitor and measure the microorganisms will increase autonomy, decrease manufacturing and transport costs, and be capable of working under a temperature below -40 °C. In this research, the bacteria-sized, gold microelectrodes array (MEA), proposed to be fabricated on a 0.18 μm

CMOS process with electroless gold plating technique. A high-sensitivity dual-phase lock-in amplifier (LIA) being capable of extracting the real and imaginary portions of electrochemical impedance with sensitivity to read small AC currents down to 1 pA will be designed to follow low bacteria growth rate and concentration in cold climate. This research project funded by the SMAART CREATE Program and the Sentinel North Strategy at Université Laval will enable the precise monitoring of the unique microbial ecosystems of the Arctic regions and northern environments.

DIVERSITY AND DISTRIBUTION OF MICROBIAL EUKARYOTES IN THE CHURCHILL — NELSON RIVER BASIN.

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Freshwater within the Greater Hudson Bay Marine region originates from rivers with large drainage basins and is modified by sea ice formation and melting. Within the BaySys project, which aims to provide a scientific basis to separate climate change and water regulation impacts, our subproject aims to provide baseline data on microbial biodiversity and associated environmental drivers. Being at the interface of freshwater and marine systems, estuaries are of great interest to understand freshwater influence on microbial coastal communities. Within estuaries, gradients in light, nutrients, heat and salinity through freshwater and seawater mixing, are predicted to influence microbial community structure. We sampled microbial eukaryote assemblages using rRNA 18S marker genes along the salinity gradient of two major inflows into the Hudson Bay: The Nelson and the Churchill Rivers. These rivers are both highly stratified but exhibit strong hydrodynamic differences under the contrasting influence of river damming and estuarine geomorphology. Data on the distribution and composition of microbial communities was compared with environmental parameters along the salinity gradient to identify spatial patterns and factors potentially controlling the distribution of the microbes. Flowing cytometry were used to estimate phytoplankton and bacterial cell concentration along the transects. Samples were also used to identify a coastal core community and combined with earlier Western Hudson Bay results. We then screened for potential unique and invasive species in all samples. Preliminary results show that coastal communities clustered by location under the influence of salinity, temperature and silicate. A more detailed investigation allow us to identify a bloom of the diatom Rhizosolenia in the Nelson estuary, a specie which is able to process diazotrophy through association with cyanobacterial symbionts. The presence of this species could have implication on the nitrate, nitrite and ammonium availability within the estuary. These results will provide a baseline to compare western and eastern Hudson Bay coastal communities and will be of use to managers by inferring whether new invading organisms will more likely replace current species.

DESIGN OF RARE-EARTH DOPED FUNCTIONALIZED SILICON SUBWAVELENGTH GRATING WAVEGUIDE FOR INTEGRATED SENSORS

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The current fast-paced warming of the Arctic climate is bound to release exponentially large amounts of greenhouse gases (GHG) in the atmosphere through the positive feedback mechanism caused by the permafrost thawing. Ultra-compact, low-cost gas sensors are required to deploy a large-scale monitoring network of the atmosphere, water quality and increasing concentration of GHG in the Arctic. In this project, we propose the development of sensing solutions operating in the near- and mid-infrared region based on the CMOS-compatible silicon photonics platform (SOI), thus making them suitable for affordable high-volume manufacturing. The development of such sensors requires efficient on-chip laser source, which is challenging on SOI due to the lack of intrinsic light-emission process in silicon. To circumvent this limitation, we suggest using metamaterial structures functionalized with efficient light-emitting materials like erbium-doped amorphous Al2O3 in order to develop novel monolithic lasers. Here we present the complete design of a silicon-based laser prototype that is easily integrable with the exhaustive library of silicon photonics components, making it suitable for the development of more complex on-chip devices like sensors. In addition, our design can be easily scaled to other wavelengths by combining the silicon light-guiding structures with other combinations of rare-earth dopants and host materials, thus making it a highly modulable solution. Our design uses subwavelength grating waveguides in order to enhance the

light-matter interaction between the silicon and the active light-emitting material deposited on top and increases the conversion efficiency in mm-scale devices.

CONVERGENT VALIDITY OF A SMART SHIRT FOR LUMBAR ELECTROMYOGRAPHIC AND KINEMATIC MONITORING IN REAL-WORLD ENVIRONMENTS: A STUDY PROTOCOL

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The objectives are [1] to develop and optimize a novel Smart Shirt that could be used to measure lumbar movements (kinematics) and muscle activity (EMG) and [2] to evaluate the convergent validity of EMG and kinematic data recorded during simple daily living activities using our Smart Shirt. As a study design, we used a validation cross-sectional study. Lower back pain (LBP) constitutes an important socioeconomical burden and generates the highest number of claims due to work-related injuries. Spine biomechanics and motor control have been mostly studied in laboratory and controlled environments, but the emergence of novel fabrics, miniaturization and wireless technologies allow for research in real-life environments. Our research group is in the process of developing a Smart Shirt with embedded sensors to measure spine biomechanics and motor patterns. However, considering the novelty of this technology, it is first required to confirm its convergent validity. An iterative process will be used: researchers, engineers and a patient representative will collaborate to develop and optimize the Smart Shirt. The convergent validity of the optimized prototype will be assessed in 20 healthy participants. Participants will take part in one session during which they will perform five tasks. Although the Smart Shirt has the potential to be used in complex situations (real work environments), the first step is to validate it during simple tasks. During Task 1, participants will perform, while standing, a full flexion of the trunk followed by a return to the initial position. During Task 2, participants will stand up from a seated position on a chair without armrests. During Tasks 3 to 5, participants will lift a load (20% of participant's weight) from the ground with both hands and will place it on a shelf in front of them at their knees (Task 3), waist (Task 4) or shoulders (Task 5) level. Lumbar spine kinematics as well as thoracic (TES) and lumbar (LES) erector spinae EMG will be recorded. For each task, data will be collected 3 times with the smart shirt and the kinematics gold standard system (Vicon Motion Capture) and 3 times with the EMG gold standard system (Delsys-Trigno). Variables of interest will then be computed: lumbar range of motion (degrees), angular velocity (degree per second) and acceleration (degree per second squared) in the sagittal plane as well as peak value and root mean squared of TES and LES EMG. Cross-correlation coefficients (r) will be computed to establish the convergent validity of the kinematic data, while intraclass correlation coefficients (ICC) will be calculated for the normalized EMG variables. Modifications to the initial prototype are expected. Its optimized version will show a good convergent validity (r and ICC>0.75) with gold standard systems for kinematic and electromyographic variables. These results will lay the foundations of a larger study aimed at the characterization of lower-back muscle activity and movements in workers in their real-life environment to identify potential risk factors related to specific working environments and to develop predictive models of LBP prevention.

A VISION-BASED EQUIPMENT FOR OBSERVATION OF LEMMINGS UNDER SNOW IN THE ARCTIC

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Lemmings are small rodents that inhabit the vast areas of northern Canada and live under the snow for much of the year. These small mammals are of crucial importance to the web of life in Arctic regions due to their role in the food chain. However, extremely large population fluctuation and many other of their behaviors have remained unknown. This paper presents a vision-based equipment to observe the behavior of lemmings under harsh conditions of the Arctic in winter. Design and implementation of this equipment involves different aspects of electronics from data acquisition to power

management. The ability of the system to cope with very low ambient temperatures and high humidity for an extended period of time, frost formation, and lack of electricity are of critical importance for success. Once the equipment is installed, no intervention will be possible for a whole recording season (around nine months). Consequently, autonomy and robustness are two crucial desired features for the system. The proposed equipment is made of four units: environment, data acquisition, power management and low-level control system, and power unit. The environment is an aluminum box designed to be hopefully chosen as the nest by lemmings. Having a nest in winter is vital to maintain thermoregulation for newly born and young lemmings. During winter, the nests are under snow and considering lack of light, especially within winter, the equipment must work under nearly complete darkness for almost the entire recording season. This issue is addressed by using a near infrared (NIR) camera. Full time monitoring is desirable but inaccessible due to shortage of power sources. Therefore, a sample based approach directed by infrared motion detection sensors is employed such that photo/videos will be recorded for limited periods only during the presence of lemmings inside the box. The heart of the image acquisition and data storage units is a single based computer (SBC). For this purpose, we use Raspberry Pi 0. Interaction with other parts of the system, including the camera and real time clock is done through low-level programming rather than the operating system (e.g., Windows or Linux). A low-level processing unit controls the operation of SBC mainly via monitoring signals from the motion detection sensors. Upon development of the first prototype, three units were installed at Bylot Island in August 2018. Just a few days before submitting this paper, the first ever images from lemmings under snow in the wild were retrieved from deployed units. The rate of success was beyond our expectation; not only did lemmings opt for three (out of three) installed boxes, the image acquisition was also successful in all units. The results from the first version of the system are very promising and we believe this tool will significantly assist animal ecologists and biologists in the study of lemmings in the wild under snow, a condition under which, to the best of our knowledge, lemmings have not been studied before. We hope this eventually leads to new insights into these interesting mammals, particularly their unknown behaviors, including their reproduction in winter.

FULLY INTEGRATED SPECTROPHOTOMETER IN THE VISIBLE AND NEAR-IR RANGE

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This project aims to develop a wireless microsystem for diffuse multi-wavelength spectroscopy in real time monitoring of extracellular neurotransmitter concentration or protein interactions based on fluorescent sensing principles. As an example, fluorescence resonance energy transfer (FRET) is a technique, for observing the molecular scale interactions, that depends on the distance between a donor and acceptor. In this dual readout method, the source light excites the donor to emit light in a higher wavelength. Light of the donor excites the acceptor if it gets close to the donor. Therefore, the acceptor also emits light in a higher wavelength. Such assay, which sends one excitation wavelength and receives more than one emitting wavelength, has allowed the visualization of numerous protein interactions in many different cell types and organisms and has contributed to applications like detection and quantification of DNA methylation. The direct application of this method on clinical samples offers great promise for its translational use in early cancer diagnosis, prognostic assessment of tumor behavior, as well as monitoring response to therapeutic agents. The first step of this project consists of designing, fabricating, and testing a discrete-component prototype, including a commercial micro-spectrometer integrated with a microcontroller and a wireless transceiver. This miniaturized cell spectrophotometer for the real-time determination of VERO E6 cells hybridized with anti-tubulin antibody and tagged by Alexa Flour 488 and DAPI is tested and successfully applied for trace determination of tubulin protein. The performed experiments prove the designed cell spectrophotometer capability of qualitative and quantitative detections. The device consists of a new interface platform to perform the analysis of the detected light and determine the concentration of an unknown sample. Experiments and in vitro measurements are accomplished by a 7.4 V power supply voltage at the spectral detection range of 340-850 nm. Based on

measurements, the device consumes low power (88 mW) and has a minimum detection of 89 μM/L. Along with the use of a wireless system, it also has a small size and total weight of 17 g. Such a prototype and results validate prospective models and approaches to design a fully integrated cell spectrophotometer. Then, a specialized chip solution is designed and fabricated within CMOS technology to decrease power and size. This chip includes photosensor elements and mixed-signal circuits integrated within a single chip. The photo-sensing elements consist of PIN photodiodes to convert the light into electrical current and a bank of metal patterns acting as nanoplasmonic filters. New circuit techniques such as switched bias transistors are used in this design to decrease the input referred noise without increasing its size and power consumption. Having all the photo-sensing and the mixed-signal circuits implementing a complete spectrometer integrated on a single chip will lead to an unprecedented level of miniaturization for these types of instruments, making the proposed system flexible and expandable to several applications. The envisioned microsystem on a chip will be the core of an adaptive, autonomous, and smart microsystem for spectroscopy of complex structures and diverse materials like human tissues.

STUCKBERRY LAKES PROJECT UPDATE: INSTRUMENT DEPLOYMENT AND PALEOLIMNOLOGY AT CANADA'S FAR NORTHERN COAST AS A SENTINEL NORTH CONTRIBUTION TO T-MOSAIC.

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The northern coast of Ellesmere Island is a fast changing region at the interface of the Canadian Arctic Archipelago and the Arctic Ocean ice pack. In 2017, we launched the Stuckberry Lakes Project to study a series of four lakes in Stuckberry Valley (82° 54' N, 66° 56' W), which is among the northernmost terrestrial ecosystems on the planet. The lakes lie in Quttinirpaaq National Park, Nunavut, and were totally unexplored before our first sampling. Our studies revealed a diversity of limnological conditions, including lakes with hypoxic water columns that are atypical of high Arctic lakes. To date, we have collected water and sediment samples for analysis of photosynthetic pigments and microbial diversity (including viruses), as well as made physical and chemical limnological measurements, to understand the lake microbiomes and their relationship to environmental conditions. After three field seasons our data show that the two shallower lakes are oxygen deficient each spring while the two deeper lakes have mostly oxygenated water columns, although there are interannual variations in the profiles of both lake types. Limnological conditions during the brief summer ice-free season remain completely unknown. In order to better understand annual cycles in the lake water columns, we installed moorings with oxygen, temperature and conductivity probes in one of each type of lakes. Complementary paleolimnological work is ongoing in order to provide the long-term context for interpreting recent changes. We were able to collect a set of surprisingly long sediment cores during the 2019 field campaign, and these may provide an opportunity to reconstruct past environmental changes at high temporal resolution. We were also able to sample marine sediments from the adjacent Arctic Ocean for the first time. These samples will provide further important information about linkages between the coastal terrestrial environment and the Arctic Ocean, the theme of the international project 'Terrestrial Multidisciplinary distributed Observatories for the Study of Arctic Connections' (T-MOSAiC). The results will also be relevant to the proposed new conservation area in this region called Tuvaijuittuq (the Lasting Ice Area). The suite of monitoring activities of the Stuckberry lakes project represents one of the terrestrial sites closest to the central Arctic Ocean where the MOSAiC oceanographic project is taking place in 2019-2020. The Stuckberry Lakes Project is thus drawing an important link between the marine MOSAiC project and its terrestrial counterpart.

PHYSICAL VARIABILITY AND TRENDS IN THE CANADIAN BEAUFORT SEA FROM 2009-2018: IMPLICATIONS FOR THE NEXT DECADE OF GLOBAL OBSERVATION SYSTEMS

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The integrated Beaufort Observatory (iBO) program aims to obtain science knowledge and support the development of predictive capability regarding physical conditions (e.g. interactions between sea-ice, currents, waves and storms) in the Canadian southern Beaufort Sea. Under the collaborative leadership of academic research, government, and the private-sector (i.e. ArcticNet, Fisheries and Oceans Canada, and Golder Associates), intensive mooring data were collected at five key eulerian stations from 2009 to 2018 as well as some other stations for shorter periods. The moorings were instrumented to measure ice draft, surface waves and currents throughout the water column (approximately 700m water depth at maximum) with Ice Profiling Sonar (IPS) and Acoustic Doppler Current Profilers (ADCPs), as well as chemical/biological data with Sediment Traps. We synthesize the iBO data to assess the inter-annual variability and trends in the environment, which will further support the development and validation of model predictions regarding the future Beaufort Sea. Preliminary results from our synthesis work illustrate that over the ten years of the project, sea ice breakup has been advanced by 2-5 days throughout the McKenzie Shelf and in the Canada Basin. The work also helps to explore a strong sub-surface jet, “the Shelfbreak Jet”, flowing eastward along the McKenzie Shelf. We clarified the characteristics of its fluctuation and signal propagation from the western side of the McKenzie Shelf to the east and its interplay with water-mass transportation. Our results demonstrate that direct observations with moorings are essential to explore and clarify physical phenomena at sea, especially in ice-covered areas. Mooring observations have spatial limitation due to their point-to-point nature and future observations should include additional strategies. This could include new observation systems such as autonomous underwater platforms. New observational strategies for the Arctic Ocean should be further aligned with the global ocean observation community, such as with the multinational-entity OceanObs’19 that will develop goals for future observation systems for the next decade. In our presentation, we will show key results from the iBO mooring data, but we will also address the implications of our synthesis analysis for the planning of the next decade of observations and on how observations in the Canadian Beaufort Sea could contribute to global observational goals.

SPRUCE BUDWORM OUTBREAKS IMPACT THE SURVIVAL AND SPACE USE OF BOREAL CARIBOU

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The boreal populations of woodland caribou (Rangifer tarandus caribou, hereafter boreal caribou) are considered as threatened in Canada. Most plans for population recovery focus on the protection or restoration of their critical habitat. While the impact of wildfires and human activities on boreal caribou populations have been largely characterized, little information exists on how forest insect pests influence the distribution of boreal caribou. Yet, insect outbreaks affect areas larger than those impacted by wildfires and logging activities combined. Understanding the response of boreal caribou to insect outbreaks can provide critical information for their conservation, especially given that outbreaks are expected to become more severe and to occur at increasingly higher latitude following climate change. In Canada, spruce budworm (Choristoneura fumiferana) outbreaks modify forest composition by attacking particularly balsam fir (Abies balsamea), and forest structure by creating patches with different levels of tree mortality. The canopy gaps created by tree mortality can be colonized by deciduous vegetation that provides high-quality food for moose (Alces alces), which can change wolf (Canis lupus) distribution, and impact predation risk for boreal caribou. Spruce budworm outbreaks can thus have a complex influence on food webs, and empirical research is needed to clarify the role of this insect on trophic interactions involving boreal caribou. We investigated the combined impact of spruce budworm outbreaks, wildfires and forest harvesting on the survival and space use of boreal caribou and its main predator, the gray wolf, in the Côte-Nord region of Quebec. Seventy-three boreal caribou and sixteen wolves were monitored with Global Positioning System (GPS) collars. Habitat was characterized from

the Canadian National Forest Inventory (CNFI) forest cover maps that have been taken in 2001 and 2011 with 250 m resolution. The satellite image was updated every year with information on forest harvesting and wildfires. Local severity of spruce budworm infestation was estimated by the rate of defoliation of forest stands, each year since the beginning of the outbreak. Preliminary analysis revealed that boreal caribou responded to the spruce budworm infestation by decreasing the size of their home range as the area became increasingly impacted by spruce budworms. In addition, we found that caribou which died during the study were the ones selecting more strongly areas impacted by the insect. Spruce budworm outbreak also influenced wolves in their habitat selection, with individuals selecting areas impacted by the insect during most of the year. Similarities in habitat selection between caribou and wolves can explain the relatively high mortality risk that the prey experienced in forests impacted by spruce budworms. The next steps of this study will be to evaluate how the insect outbreak impacts vegetation over time. Finally, we will evaluate the proposed boreal caribou recovery strategy in the context of environmental changes by assessing the cumulative and specific impact of forest harvesting and climate-induced changes on wildfires and spruce budworm outbreaks.

ARCHITECTURAL SPACE AND LIGHT SPECTRUM: PATTERNS AS INDICATORS OF TERRITORIALITY

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Architectural daylighting design strategies can improve the quality and inhabitability of interior spaces through a better relationship between architecture and the exterior environment, as architectural form and configuration directly affect light distribution and patterns. Photobiology also favours daylight as a light source in interior spaces for its ability to consolidate the human biological clock and circadian rhythms. Moreover, daylit spaces can reflect the exterior environment and atmospheric conditions, in terms of light patterns, intensity, and chromaticity, thus increasing the relation to the outside and, in the case of Nunavik, the land. Yet, architectural daylighting remains a challenge in northern regions due to their particular climate, photoperiod and solar geometry. The main objectives of this research are thus to develop new modes of representation that will allow the spatialization of natural and artificial light, so as to link architectural form and components to visual (photopic) and biological clock (melanopic) lighting ambiences, and to characterize its quality and availability to optimize its integration into future architectural projects. This research addresses spatial representations of quantitative information and patterns related to daylight properties as an appropriate tool for assessing light ambiences. Moreover, it integrates various melanopic metrics of light in architectural representations. Spatial mapping would allow for better translation and communication of the qualities of various architectural environments, which could lead to improved dialogue between architects and other stakeholders in the building industry. In the context of Nunavik, a digital tool based on Raspberry Pi microcomputers is developed for automated and low-cost surveys. The associated Camera Module (RPiCM) allows for the capture of High Dynamic Range (HDR) images, which accurately measure luminance to render human perception in relation to light chromaticity and intensity. Light is represented as luminance (cd/m2) and illuminance (lux and EML) values for the photopic and melanopic portions of the electromagnetic spectrum. The combination of photographic and photometric data authenticates the needs and challenges related to architectural daylighting in Nunavik: the biological clock assessment is achieved with photopic and melanopic illuminance, and spectral dominance maps identify the surfaces and architectural components that contribute to those respective spectra. Different lighting scenarios are experimented, consisting of various interior and exterior spaces, times of day, and position of the observer regarding the built environment. The comparison of visual patterns of exterior and interior spaces suggests how the latter reflect the exterior environment, in terms of orientation, spectral dominance and visual complexity. Ultimately, spatial representations of light intensity and spectrum provide insights regarding architects' design initiatives, and act as a communication tool with other building stakeholders.

DEVELOPMENT OF A GLYCAN-BASED PLASMONIC BIOSENSING TOOL FOR MONITORING MICROBIOTE METABOLISM

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Changes from a traditional to a "western" diet are believed to contribute to the greater prevalence of cardiometabolic diseases (CMD) and mental illnesses among indigenous populations in the Canadian North. Dysregulation of the gut microbiota's host-bacteria interactions — the microbiota being the community of micro-organisms involved in several functions including immune system regulation and nutrient metabolism — caused by these dietary changes is suspected to be involved in these pathologies. However, investigating the link between the host's diet and his health is impeded by the inability of current analytical methods to characterize the metabolism of the gastro-intestinal tract (GIT) microbiota in real-time, which causes the loss of critical information that cannot be obtained from classical a posteriori molecular analysis of fecal samples. The overarching aim of this project, by combining the expertise of chemists, physicists and health scientists, is to develop a fiber-optic sensor to probe microbial processes in the GIT of animal models subjected to various nutritional regimens. Various molecular species qualify as target metabolites of interest in the GIT, including small molecules, lipids and proteins. Current methods for the sensitive detection of proteins usually involve antibodies in what are broadly designated as ELISA assays. However, this technology's reliance on antibodies, which are fragile and costly reagents to begin with, means that they are very difficult to adapt to our fiber-optic sensor strategy. Instead, we propose to use glycans; the latter, being the natural antigens to a large number of proteins including—but not limited to—antibodies, represent much more stable capture probes, and could lead to a more robust assay strategy than ELISA-based detection methods. With the goal of establishing a proof-of-concept, we are developing a detection platform combining the high sensitivity of surface plasmon resonance (SPR) and the specificity of the glycan-protein interaction. The platform is based on simple optical and fluidic components and an easy-to-use user interface. To validate our detection strategy, a substrate selective to a lectin (Riccinus communis agglutinin) was chosen as proof of concept. A plasmonic gold film supported on a Dove prism was grafted with sensing and antifouling molecular components, namely, a derivative of lactose and polyethylene glycol (PEG). The lactose is well known to bind this lectin, while PEG prevents non-specific adsorption to the gold surface. In preliminary studies, this sensor design allowed for quantitative detection of lectin with a sensitivity in the nanomolar range both in a simple matrix (phosphate buffer) and in human blood serum. The latter was chosen as a surrogate matrix to optimize the sensor surface composition to maximise selectivity to the targeted protein in the presence of potential interfering species.

SCIENCE AND TECHNOLOGY OPPORTUNITIES AT THE CANADIAN HIGH ARCTIC RESEARCH STATION (CHARS)

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Polar Knowledge Canada (POLAR) is a federal agency established in 2015 to advance knowledge of the Canadian Arctic in order to improve economic opportunities, environmental stewardship and the quality of life of people living in the North and all other Canadians. POLAR operates the Canadian High Arctic Research Station (CHARS) campus established in Cambridge Bay, Nunavut, in the central Canadian Arctic and is providing support to Arctic researchers notably with field operation support, laboratories and office facilities. This is anchoring even more the Canadian presence in the Arctic to serve Canada and the world, year-round. Based on recent pan-Canadian engagement, draft goals and approaches for implementing research activities and mobilizing knowledge were developed to guide POLAR's science and technology plan from 2020 to 2025. POLAR, following full approval of its draft plan, will seek to: 1 - Improve understanding of dynamic northern ecosystems in the context of rapid change, 2 - Advance sensible energy, technology and infrastructure solutions for the North, and 3 - Increase understanding of

the connections between northern community wellness and environmental health. Intensive ecosystem research will take place in the CHARS Environmental Research Area (ERA), a zone centred around the CHARS campus that includes six communities — Ulukhaktok, Kugluktuk, Cambridge Bay, Gjoa Haven, Taloyoak, and Kugaaruk. From a regional biodiversity perspective, the ERA is encompassing four bioclimatic zones and provides access to a range of freshwater, terrestrial and marine habitats. Focus on the ERA will allow for the development of a comprehensive assessment of its ecosystems and lead to an advanced understanding of current changes taking place to project future fluctuations and facilitate adaptation. Additionally, availability and use of clean energy, waste and waste water, and housing technologies and techniques will be increased to meet the unique environmental, social, and cultural conditions that prevail in remote northern communities. Finally, improved knowledge of wildlife health will lead to a better understanding of country food quality and supply, and greater clarity on the connection between human activities and the environment. POLAR is strongly committed to developing productive research partnerships with local, national and international scientists and opportunities exist for researchers to use the facilities. Science and technology activities will involve communities and work with collaborators while supporting capacity building, knowledge mobilization and data management. Through this Science and Technology plan, POLAR will bring significant and new understanding of climate change effects in the North and will provide information deeply needed to decision makers to plan the way forward in a time of unfamiliar and rapid change.

DE NOUVELLES PERSPECTIVES SUR LES ENVIRONNEMENTS NORDIQUES : LES VIRUS DANS UN PERGÉLISOL EN CHANGEMENT

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Les conditions actuelles de réchauffement climatique provoquent d'importants changements dans les paysages subarctiques, notamment le dégel du pergélisol et la croissance des mares de thermokarst. Ces mares sont connues pour leur libération importante de gaz à effet de serre (GES), un processus conduit par l'activité microbienne. Ce projet de métagénomique utilise comme modèle les mares de la région de Whapmagoostui-Kuujjuarapik au Nunavik pour tracer un portrait des populations virales de ces milieux dans l'optique de permettre une meilleure compréhension des changements liés au dégel du pergélisol. Les mares de thermokarst sont peu profondes (<3 m) et riches en matière organique. Durant la saison estivale, leur colonne d'eau est stratifiée, présentant une eau chaude et bien oxygénée en surface, et plus fraîche et entièrement anoxique en profondeur. Durant la saison hivernale, la colonne d'eau se retrouve isolée, empêchant les échanges avec l'atmosphère, et devient entièrement anoxique. Ces conditions anoxiques favorisent l'activité de micro-organismes méthanogènes et la formation de GES. Les virus, de petits parasites intracellulaires, sont connus pour avoir un impact considérable sur leur hôte et environnement. Ils peuvent affecter la chaîne alimentaire, l'équilibre des populations microbiennes et les cycles biogéochimiques. Puisque la grande majorité des virus sont encore inconnus et leur impact sur l'écosystème arctique est encore largement sous documenté, ce projet représente une occasion de combler une grande lacune dans les connaissances actuelles. Dans ce projet, nous analysons la communauté virale des mares de thermokarst du nord du Québec. Trois échantillonnages ont été effectués entre 2015 et 2017 dans la vallée de la rivière Sasapimakwananistikw (SAS). Les métagénomes enrichis en séquences virales ont été ensuite analysés par diverses méthodes bio-informatiques. Au terme de ces analyses, nous avons identifié diverses souches virales jusqu'ici non répertoriées et établi la présence d'au moins deux communautés virales distinctes; une communauté annuelle plus variable retrouvée en surface durant la saison estivale et une communauté pérenne présente autant dans la couche d'eau anoxique en saison estivale que sous la glace en saison hivernale. Ces communautés virales sont constituées en grande partie de séquences provenant de virus jusqu'ici non répertoriés, démontrant l'importance des virus environnementaux. Nous avons également établi un réseau d'infection en combinant nos données à des données cellulaires. Nous avons pu ainsi prédire spécifiquement quels genres cellulaires peuvent être infectés par les virus identifiés. La suite des analyses permettra d'identifier des gènes viraux pouvant avoir un impact direct sur les cycles biogéochimiques. Nous prévoyons également étudier la connectivité entre les communautés virales des mares thermokarst, de la rivière SAS et de la baie d'Hudson située en aval du système.

MEASUREMENT OF IN-ICE ANGULAR RADIANCE DISTRIBUTIONS

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To better understand sea ice thermodynamics and the growth of ice algae, the propagation of solar radiation within the medium needs to be studied in more detail than usually achieved. Previously, most sea ice light measurements were made at the upper and lower boundaries in order to derive spectral albedo and transmittance for different ice conditions. These bulk apparent optical properties do not allow for inferring vertical partitioning of light at a small scale within sea ice. A few studies have tried to measure in-ice irradiance vertical profiles using rather bulky instruments that induced shadow, destroyed the medium and were limited in vertical and angular resolutions. The aim of this project is to design, build, characterize and field test a miniaturized probe for measuring radiance angular distributions within sea ice. This instrument is to be included on a sea ice endoscopic platform which will gather other probes for documenting sea ice structural, optical and biogeochemical properties. In addition to the prototype, we investigate the possibility of using commercial miniature 360 degree cameras as an affordable and easy solution to obtain radiance angular distributions within sea ice. The goal is to be able to use these measurements to develop strong structural-optical relationships that would help to develop better light transport models.

MACHINE LEARNING APPROACHES APPLIED TO QUANTITATIVE VOLUMETRIC IMAGE ANALYSIS OF THE ZEBRAFISH BRAIN

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Model organisms such as the zebrafish, are powerful tools to investigate the mechanisms underlying the gut-brain communication and hows it affects brain development, mental health and neurological disorders. Using fluorescence two-photon microscopy and optogenetics methods, it is possible to study how brain cells communicate and respond to various types of stimuli in living zebrafish larvae (5-6 days old). Using fish lines that express fluorescent sensors reporting neuronal activity in brain cells, we can monitor the activity and morphology of a large population of neurons (> 1000) with a very high spatial (< 5 μm) and temporal (> 5 Hz) resolution. This gives rise to very complex datasets necessitating the development of high throughput quantitative analysis methods. We developed machine learning approaches to assess different tasks of volumetric image analysis of the zebrafish brain. We compared how convolutional deep neural network (CNN) and Random Forests perform for class specific segmentation in fluorescence microscopy images. To generate reliable training datasets, we developed a user-friendly image annotation application adapted to volumetric imaging of the zebrafish brain. We then applied our methods to high throughput quantification of different features such as cell types, cellular morphology, subcellular structures, calcium activity. Another important step is to identify the cell types, according to their location in the brain, where the neuronal activity has been recorded. For this purpose, zebrafish brain atlases from 6 day old zebrafish have been developed by a few laboratories. We characterized how the generated segmentation maps can be used for image registration with those zebrafish brain atlases, in order to identify the specific circuits in which neuronal activity was recorded. These technical developments will help accelerate the investigation of the impact of manipulation on gut microbiota on neural circuit development and function.

MICROBIAL DIVERSITY IN ARCTIC SIBERIAN PONDS AND IMPLICATIONS FOR CARBON TURNOVER

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Shallow ponds are numerous in the Arctic Siberian tundra and can display a high variability in their features such as colour or origin. This variability is likely to influence the microbial community assembly processes and possibly the functional properties of these communities. As the Siberian Arctic is rich in carbon and its remineralisation is mainly carried out by heterotrophic bacteria, variability at the small scale might have important implication for Carbon budget at the landscape scale. The limnological characteristics of 20 ponds located in Kytalyk, between the Lena and the Kolyma rivers were investigated in July 2018. The ponds were categorized into 2 groups according to their supposed origin (polygonial vs. thermokarst) and their Dissolved Organic Carbon (DOC) content. The microbial communities of these ponds were assessed by pro- and eukaryotic SSU rRNA gene sequencing. While taxonomic richness of the pro- and eukaryotic microbial assemblages (between 48 and 432 OTUs for the prokaryotes) was as variable within as between the two pond types, they were nevertheless clearly separated with respect to their community composition. Interestingly, the bacterial communities also showed high dissimilarity within each pond type (65% and 64% for the polygonial and thermokarst ponds, respectively). Pronounced functional variability of the ponds was suggested by the large range of concentrations of dissolved CO2 and CH4. The next field campaign in 2020 aims to further elucidate the functional properties of these ponds and their relationship to microbial community structure in order to help predict the behaviour of these Arctic habitat types in the context of climate change.

SURFACE-ENHANCED RAMAN SPECTROSCOPY (SERS) SENSOR FOR REAL-TIME IDENTIFICATION OF BILE ACID MARKERS OF THE MICROBIOTA ACTIVITY

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In Canada's northern populations, nutrition is targeted as an important cause of many cardiometabolic and mental diseases. Scientific evidence increasingly supports the conclusion that environmental factors, such as changes in diet, are at the origin of important disturbances in the intestinal microbiome which could potentially drive pathogenic mechanisms of cardiometabolic and mental diseases. Bile acids (BA) are generated from cholesterol in the liver, stored in the gallbladder and secreted in the intestine during meals. Since BA bioconversion is crucially dependent on the microbiota makeup, they are currently viewed as potential markers of microbiome disturbances. Furthermore, given that current analytical methods used to measure gut microbiota metabolites are costly and time-consuming procedures, alternate methods that rely on simpler and faster instrumentation are sought. The present project aims to develop a BA-selective sensing approach based on Surface-enhanced Raman spectroscopy (SERS). Raman spectroscopy is a non-destructive and label-free molecular identification technique that produces a highly specific spectrum with various bands correlated to the molecular structure of the chemical being measured. Moreover, the rich spectral information and the enhanced detection sensitivity offered by Surface-enhanced Enhanced Raman spectroscopy (SERS) allows for analyzing mixtures of related chemical species in a relatively short measurement time. Combining SERS with machine learning allows, in some cases, to increase the detection and classification capabilities even further. In the present work, an optimized SERS substrate was

fabricated where gold nanostars were immobilized on glass slides using an optimized meniscus-assisted deposition technique. This method produces robust, densely-packed and uniform plasmonic surfaces capable of capturing and enhancing the Raman signal from adsorbed BA. Various anti-fouling surface coating strategies were also evaluated to minimize non-specific adsorption of matrix species. Thousands of Raman spectra from individual BA and BA mixtures in various matrices were recorded to build a spectral database for spectral analysis using machine learning and deep learning algorithms. The resulting trained algorithms were successfully applied to single-component and multi-analyte mixtures in simple aqueous solutions. We believe that the results from this project will in time contribute to the improvement of the health of Canada's northern population. Indeed, the identification of key biomarkers related to the prevalence of cardiometabolic and mental diseases will be useful for predictive diagnosis of these prevalent diseases. Furthermore, by providing a better understanding of the host-bacteria interactions in the gut microbiota and their impact on one's health, the knowledge and tools developed in this project will lead to the development of faster, more specific intervention techniques in the medical field.

MOBILITY OF ARSENIC IN LAKE SEDIMENTS INFLUENCED BY GIANT MINE EMISSIONS, NORTHWEST TERRITORIES

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In the 1940s, mining activity was the principal economic driver of the Northwest Territories. One of the largest abandoned mines is the gold mine Giant, in the Yellowknife area. The extraction of gold from arsenopyrite generated arsenic trioxide dusts between 1940 and 2004. This contamination went beyond the immediate mining sites via emissions to the atmosphere and subsequent deposition on soils and lakes. At present, the extent of this legacy is poorly known. Yellowknife is in the subarctic area, one of the most rapidly warming areas in the world. As it warms, subarctic permafrost thaws and the decomposition rates of organic matter accelerates. This increases the load of dissolved organic matter and, subsequently, may increases the mobility of contaminants previously sequestered along with it, such as arsenic. In this context, the Sub-Arctic Metals Mobility Study (SAMMS) study aims to characterize the transport and behaviour of dissolved organic matter and the associated metals/metalloids in soils and aquatic systems. The objectives of my projects are to determine the extent and history of arsenic contamination in eight lakes located in an 80 km transect northwest from the mine. To this end, I interpret concentration profiles of arsenic in sediment porewater. Four sediment cores were collected in each lake for i) dating, ii) paleolimnology, iii) carbon and sulfur speciation, iv) porewater analysis. Porewater samples were directly analyzed by inductively coupled plasma mass spectrometry (ICP-QQQ-MS) for metals and metalloids concentrations. Diagenetic modelling of these profiles revealed that arsenic flux ranged from 39,5 μmol/m2•yr close to the mine to -27 μmol/m2•yr at 80 km, decreasing with distance. At the 40 km mark, the sediment switches from a source to a sink of arsenic to the water column. Using information on arsenic mobility in the sediment acquired from modelling, I will correct solid-phase profiles for the effect of diagenesis and discriminate between natural and anthropogenic arsenic sources to the lakes.

OPTOGENETICS STUDY OF THE IMPACT OF THE MICROBIOTA ON BRAIN DEVELOPMENT AND FUNCTION IN ZEBRAFISH LARVAE

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It is becoming widely accepted that intestinal microorganisms play a central role in the health and disease of vertebrates. When the host encounters a physiological or environmental stress, such as exposure to pollutants, the microbiota ecosystem equilibrium is altered. Since neuro-active molecules are produced by the gut microbiota, this dysbiosis may induce reversible or irreversible consequences on brain development and neural function, affecting mental health. Climate changes in the northern environment are thought to have significant consequences on the equilibrium of the microbiome. To understand the rules governing how disturbances in this equilibrium may impact human health and brain disorders, we need to develop experimental models. Thus, to investigate the mechanisms of gut-brain communication, we are using zebrafish (ZF) larvae and optogenetic methods to probe brain development through the transparent larvae and manipulate the gut microbiota. Our first goal is to develop tools to compare the developmental profile of brain cells in ZF that are either germ-free (GF), obtained by sterilization of the eggs, conventionally raised (CR) or reconventionalized (sterilized eggs grown in the same egg water as the CR). This will then allow us to investigate the potential role of microbiota in regulating brain development in different contexts (physical stress, pollutants, etc). We aim also to relate changes in brain development with behavior. We are thus evaluating changes in ZF behavior (locomotion, stress) by video tracking. Since dopaminergic neurons are known to be sensitive to environmental pollutants and are involved in various functions, such as movement, rewards and response to stress, among others, we are analyzing the development of the dopaminergic system using transgenic lines expressing fluorescent proteins only in dopaminergic cells. To assess the impact of the microbiota on dopaminergic neuronal activity, we are also using ZF expressing a pan-neuronal calcium indicator. Meanwhile, we are also investigating the impact of microbiota on the immune system by monitoring fluorescent microglia, the brain resident immune cells. Learning more about the impact of the microbiota on circuit development and function may provide useful insights to better understand the gut-brain relationship, which might then be translatable to human health.

GEOPHYSICAL INVESTIGATION AND MONITORING OF THERMO-HYDRAULIC CONDITIONS OF TALIK AND ICING OF THE KUUGULUK RIVER AT SALLUIT, NORTHERN QUEBEC, CANADA

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The Inuit community of Salluit in northern Quebec, Canada, is located in the continuous permafrost zone characterized by a mean annual air temperature (MAAT) of -8.0°C over the period from 1981 to 2010. In such a cold environment, it is challenging to find a sustainable supply of water. A well drilled in fractured bedrock and located in a talik underneath the Kuuguluk River is used as a source of drinking water by the municipality of Salluit. To verify the spatial distribution of the talik beneath the floodplain of Kuuguluk River, geophysical investigations including ground penetrating radar (GPR) profiling and electrical resistivity tomography (ERT) were undertaken in spring 2011 and summer 2018. Moreover, a mooring with water level and temperature dataloggers in the river was installed over the 2015-2018 period to assess the thermo-hydraulic conditions of the riverbed. According to the mooring results, the mean annual temperature of the riverbed (MATRB) was 1.4°C in 2015-2016 while the mean annual air temperature (MAAT) was -7.1°C. This MATRB above 0°C is due to the heat storage of running surface water in the riverbed and the suprapermafrost water flow in the talik. Riverbed temperature below 0°C and as low as -3°C from October 10, 2015 to November 20, 2015 and from January 23, to April 17, 2016 were recorded. The spring freshet occurred on June 24, 2016. Outside these periods, the riverbed temperature stayed remarkably stable at 0.05°C in winter time. While the water level in the Kuuguluk River varies from 0.4 to 1.0 m in summer time following the precipitation events, the water pressure can be as high as 2.8 m in winter under the icing. Sharp water level decrease events of a few decimeters due to water pressure release through icing fracturing were also recorded. It was assumed that the

ice sheet on the floodplain of Kuuguluk River is a thin circular plate with the embedded edge having an elastic behavior, and this sheet is uniformly loaded. The radial and tangential stresses in the ice sheet can be assessed according to the theory of plate mechanics. The radius and the thickness of the circular ice sheet are estimated at 25 and 1.5 m respectively. For a hydraulic head in excess of 2.4 m monitored in the riverbed (2.9 m in mid-April 2016 – 0.5 m in summer), the water pressure underneath the ice sheet is 23.52 kPa. The radial and tangential stresses are equal to 3.26 MPa. According to Petrovic (2003), the tensile strength of ice varies between 0.7 to 3.1 MPa with an average of 1.43 MPa in the temperature range of -10 to -20°C. This mechanical property along with the compressive strength of ice depends on temperature, strain rate, volume, and ice grain. Therefore, the estimated radial and tangential stresses in the icing of the Kuuguluk River in winter due to water pressure building up underneath the icing in winter are high enough to break up the ice cover and form icing blisters.

GERM FREE MICE AS A MODEL TO INVESTIGATE NEW MECHANISMS INVOLVED IN CARDIOMETABOLIC DISORDERS IN THE NORTH; HOW THE GUT MICROBIOTA IMPACTS THE ENDOCANNABINOIDOME

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Improvements in communications and transportation to and from southern regions caused rapid social transitions in northern populations that led to a progressive shift from their traditional diet rich in proteins and essential vitamins to a more westernized one. This transition has been associated with an increased prevalence of cardiovascular risk factors such as obesity, high blood pressure, elevated blood lipid levels and diabetes, even if the associated mortality rates are lower compared with southern populations. The development of metabolic disorders is influenced by an interaction of genetic, environmental, behavioral and microbial factors. In northern populations, the exposure to cold and the variation in the daily light cycle results in adaptive responses and management of fuel that profoundly affect human physiology. It has been reported that transplantation of caecal material from mice reared at low temperatures to germ free (GF) recipients improved their metabolic phenotype, reduced obesity and improved insulin sensitivity. Gut microbiota "interact" with adipose tissue development and metabolism through the endocannabinoidome (eCBome)-a complex lipid signaling system with important functions in cardiometabolic health-by modulating the expression of endocannabinoid metabolic enzymes as well as the expression of the cannabinoid receptor type-1 (CB1) in the intestine and adipose tissue of mice. The intestinal microbiome and the eCBome also show differences in sex and age that may affect people's susceptibility to obesity-related complications. Given the interconnection between the microbiome and eCBome, we aimed at gaining evidence for a strong link between these two systems by investigating how the eCBome is altered by the lack of a functional microbiome in the gut of GF mice, and by the subsequent restauration of a functional microbiome in these mice following faecal microbiome transfer (FMT). We measured the basal eCBome gene profiles and lipid levels using qPCR and LC/MS, respectively, within metabolically relevant tissues of germ free and conventionally reared male and female mice at juvenile and adult ages. Our preliminary qPCR and LC/MS results show that the absence of the gut microbiome is accompanied by profound modifications in eCBome gene expression and lipid mediator levels in the small and large intestine. These results are consistent with the phenotype of GF mice and the roles that various eCBome components are known to play in intestinal motility, absorption and inflammation. FMT from healthy donor to age matched GF male mice was able to reverse most of these alterations, reinforcing the concept that the gut microbiome directly impacts the host eCBome, with possible implications for the regulation of metabolism. Our study is providing us with more information on how the microbiome can impact the eCBome, allowing us to better design and perform studies in which we will investigate microbiome changes induced by different dietary regimes, cold and photoperiod and consequent modulation of the eCBome in metabolically relevant tissues and their impacts on cardiometabolic health of northern populations.

STREAM TURBIDITY WITHIN DEGRADING PERMAFROST TERRAIN IN THE TASIAPIK VALLEY, UMIUJAQ REGION, NUNAVIK

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Permafrost degradation caused by rising temperatures has had a significant impact on northern ecosystems. For example, it contributes to greenhouse gas emissions, increased recurrence of landslides, and changes in water resources. Sediment migration to the soil surface has also been observed during soil settlement caused by thawing permafrost. Soil settlement increases the flow of water which is enriched in organic matter and mineral sediments toward streams and lakes, resulting in increased suspended sediment load and increased river turbidity. Furthermore, during flood episodes in spring and high rainfall in autumn, the loose sediment is supported and transported toward the river by surface runoff. This increase in turbidity can have negative effects on the trophic chain, especially on fish as a result of the abrasion of their gills. Variations in river turbidity have been examined in several studies (Lawler et al., 2006; Hamilton and Luffman, 2009). However, in the context of current and future climate change, there is limited knowledge about the effects of variations in river turbidity associated with permafrost degradation. Thus, the objective of this research is to track variations in river turbidity in the periglacial context in relation to environmental field parameters. The Tasiapik Valley is located 5 km east of the village of Umiujaq, Nunavik (Canada). A central stream drains the valley which contains discontinuous and degrading permafrost mounds and surface water ponds. The stream collects water from tributaries originating from the northern slopes of the valley and flows into Lake Tasiujaq, which is part of Tursujuq National Park. The surrounding environment is a unique and important place for fishing and outdoor activities both for the Umiujaq community and for the increasing number of tourists. In addition, the valley is the subject of numerous scientific and environmental research projects being conducted by the Centre d'études nordiques (CEN; Centre for Northern Studies) of Université Laval. Characterization of the local environment has already been completed through geomorphological surveys, while sedimentological analyses of fluvial samples will be carried out. Turbidity data are being collected during the river's frost-free period using submersible turbidity meters. These measurements will be analyzed and correlated with weather data from the CEN VDT-SILA meteorological station in order to examine the relationship between variations in turbidity and environmental parameters such as air temperature and precipitation.

TRANSPORT AND DEPOSITION OF FINE SEDIMENTS IN AN AREA OF DISCONTINUOUS AND DEGRADING PERMAFROST

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Permafrost regions are particularly prone to changes affecting soil stability and water quality. In such cases, changes occurring during permafrost degradation can be difficult to study because they are evolutionary and depend on several coupled processes. To account for this dynamic component, the detachment and the transport of fine sediment associated with permafrost degradation through porous media will be investigated. To date, research on this subject has been very limited, thus this project focuses on the interactions between groundwater flow, heat transfer and sediment transport processes which can affect water quality, soil stability and loading of surface water from groundwater discharge. To investigate these issues, sediment samples were collected from an area of discontinuous permafrost in the Tasiapik Valley located near Umiujaq, Nunavik, Quebec. Sample analyses were carried out in the laboratory using a non-destructive imaging technique (X-ray CT scanning) to predict the spatio-temporal evolution of the hydraulic properties and soil deformation controlling mass transport associated with permafrost thaw. A conceptual cryo-hydrogeological model of groundwater flow, heat transfer, permafrost thaw and suspended particle transport is developed for the Umiujaq site based on field and laboratory data. A simulation strategy is then proposed based on the HEATFLOW finite element model, with preliminary conceptual simulations

highlighting the roles of hydraulic conditions and physical soil characteristics on sediment transport and deposition mechanisms in porous media. Understanding the dynamic process associated with permafrost degradation is essential for including the changes associated with permafrost degradation in current models and for further study of the feedbacks between groundwater flow, heat transfer and sediment transport processes in the context of climate change.

DIVERSITÉ DES POPULATIONS MICROBIENNES DES LACS DE LA VALLÉE DE STUCKBERRY (NUNAVUT) DANS UN CONTEXTE DE CHANGEMENTS CLIMATIQUES

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L'Arctique connaît actuellement un réchauffement disproportionné et en accélération comparativement au reste de la Terre. Une meilleure compréhension de ces régions polaires est donc cruciale afin de détecter et de saisir les conséquences éminentes des changements climatiques. Ce projet se concentre sur l'impact de ces dérèglements sur les populations microbiennes puisqu'elles forment la plus grande biomasse des environnements aquatiques arctiques et jouent des rôles considérables dans les cycles biogéochimiques. La vallée de Stuckberry (île d'Ellesmere, Nunavut) a subi les effets d'une importante variabilité climatique au cours de l'Holocène. Le glacier principal s'est retiré et quatre lacs se sont formés, se séparant graduellement de l'océan Arctique par le phénomène de rebond postglaciaire. L'objectif central du projet est de caractériser la diversité microbienne de ces milieux aquatiques changeants. Cette étude comparera la biodiversité des quatre lacs selon les profondeurs distinctives de la colonne d'eau. Les résultats de cette région inconnue seront également mis en parallèle avec ceux de l'île Ward Hunt, une région davantage étudiée et située près de la vallée. Au printemps 2018, l'eau de chaque lac a été échantillonnée à plusieurs profondeurs selon le profil physico-chimique de la colonne d'eau, puis filtrée pour récupérer les parties microbienne et virale. Le séquençage (Illumina MiSeq) des gènes ribosomaux 16S et 18S et de marqueurs génétiques spécifiques à des familles de virus sera réalisé. Des analyses bio-informatiques et statistiques suivront pour réaliser l'affiliation taxonomique et les comparaisons. Cette étude donnera un premier portrait de cette vallée jamais étudiée auparavant. Cette région agit également comme sentinelle pour comprendre les effets des changements climatiques accélérés sur les lacs du Haut-Arctique.

VERS UNE TECHNOLOGIE COMPACTE ET ROBUSTE POUR DÉTECTER DES VULNÉRABILITÉS AUX MALADIES MENTALES

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Les grandes psychoses affectives et non affectives ont une composante neurodéveloppementale (génétique/environnementale). Des états de vulnérabilité sont présents durant l'enfance et l'adolescence, et favorisent la survenue de troubles invalidants causant souvent une rupture avec la famille et la société, et pour lesquels il n'existe que des traitements palliatifs. L'espoir d'une prévention primaire nécessite l'identification des biomarqueurs de risque de ces états de vulnérabilité, qui semblent partager un socle commun relevant notamment de la difficulté à intégrer les différentes modalités sensorielles. On parle de difficultés d'intégration multisensorielle (IMS) qui peuvent compromettre notamment le développement du soi corporel. En effet, les jeunes présentant des altérations d'IMS décrivent des difficultés à se localiser soi-même et leur corps, de percevoir l'environnement depuis cette localisation, et de se sentir à l'origine de leurs propres actions (« Quand je fais un mouvement, je sens ma jambe avec retard »). Ce projet consiste à développer des tests capables de mesurer, de manière ambulatoire, des altérations de l'IMS et de la prédiction temporelle afin de détecter ces états de vulnérabilité. Nous vérifierons également la sensibilité de nos tests à des facteurs pertinents pour les populations nordiques, tels que le chronotype et l'heure de passation des tests. Méthodologie : Prédiction temporelle : deux tâches de prédiction

temporelle ont été développées (visuelle/tactile). Après un signal de départ, une cible (visuelle/tactile) est présentée. Le délai entre le signal de départ et la cible est variable (court/long). Le sujet doit appuyer sur un bouton-réponse le plus rapidement possible à l'apparition de la cible. Prédiction spatiotemporelle : les sujets doivent suivre un labyrinthe avec les doigts le plus rapidement possible sans toucher les bords. L'exploration est faite seulement dans la modalité tactile, le sujet ne voit pas le labyrinthe. Après un signal de départ, le sujet peut explorer le labyrinthe. Dès qu'il s'approche d'un obstacle, un signal tactile indique qu'il doit s'arrêter, décider de tourner à droite ou à gauche, et attendre le prochain signal de départ avant d'explorer le prochain segment. Transfert intermodal : Pour explorer le transfert entre les modalités visuelle et tactile, nous utilisons des objets à explorer (visuellement/tactilement). À partir de l'information tactile, les sujets doivent trouver l'objet visuel qui correspond, et vice-versa. Résultats attendus et portée des résultats : prédire une information permet d'améliorer sa détection, et le passage du temps augmente la préparation et réduit le temps de réponse. Les patients qui ont des troubles du soi corporel (évalué cliniquement) ne bénéficient pas du passage du temps pour prédire et se préparer à répondre à une cible. Un effet de répétition de tâches est observé chez des sujets sains, étant lié à une composante attentionnelle bien décrite dans la littérature. La prédiction temporelle est par contre stable entre les différentes passations. Le chronotype du sujet en fonction du moment de la passation ne semble pas affecter la prédiction temporelle. In fine, nous aurons des versions simplifiées des tests, qui pourront être utilisées à plus large échelle de manière ambulatoire, en particulier sur les populations nordiques, pour identifier des états de vulnérabilité/résilience.

L'INTERNET DES OBJETS MÉDICAUX POUR PRÉVENIR LES RISQUES LIÉS À LA SANTÉ : RÉSEAUX DE CAPTEURS (SIGNAUX PHYSIOLOGIQUES, VITAUX ET MOUVEMENTS) À TRAITEMENT EN TEMPS RÉEL INTÉGRANT L'IA

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La société a une demande grandissante pour les « environnements intelligents » alimentés par des concepts émergents tels que l'Internet des objets (IoT). Ce dernier prend de l'importance dans la vie quotidienne, en particulier pour les applications médicales telles que les soins de santé à distance. L'IoT médical (IoMT) repose sur des dispositifs portables intégrés basés sur des capteurs et des technologies permettant la transmission d'informations physiologiques à une unité médicale distante. L'IoMT peut aider à surveiller, à informer et à notifier les fournisseurs de soins de santé avec des données réelles pour prévenir de potentiels problèmes. De plus, la surveillance continue des signaux physiologiques d'un patient à l'aide de capteurs directement appliqués sur le corps pour mesurer et communiquer les données pertinentes pourrait constituer un outil de diagnostic alternatif à moindre coût et prévenir les chutes, par exemple. Enfin, l'apprentissage automatique et profond trouve aussi de bonnes applications dans le secteur de la santé : amélioration de l'expérience client, détermination et valorisation des piles de données, analyse efficace des dossiers médicaux et amélioration du traitement des patients. Une première phase du projet comprend la détection et l'analyse du mouvement en temps réel à l'aide de trois centrales inertielles pour la capture et d'un apprentissage machine (Support Vector Machine à noyau Gaussien) pour l'analyse. Huit activités de la vie quotidienne sont prédites à une fréquence de 60 Hz avec une faible latence (450 ms de mise en tampon et 6 ms de classification). Le prédicteur est optimisé grâce à l'ajout d'une normalisation sphérique qui permet un éparpillement optimisé des données collectées. Cette phase sera bonifiée avec l'ajout d'une nouvelle centrale inertielle ICM-20948 qui intègre un processeur de mouvement numérique. La deuxième phase est axée sur l'acquisition des signaux musculaires avec une électrode-fibre novatrice à l'aide d'une plateforme personnalisée offrant une fréquence d'échantillonnage de 2 kHz avec une bande de 930 Hz. Les deux technologies combinées offrent des performances surpassant les technologies commercialement disponibles comme les capteurs Delsys. La plateforme permettra de mesurer précisément le mouvement d'un membre en fusionnant les données de plusieurs capteurs, dont les centrales inertielles et des jauges de contraintes. La suite du projet consiste à conceptionner un textile intelligent intégrant de multiples capteurs interconnectés en étoile réalisant différentes mesures physiologiques (EEG, ECG, sEMG, respiration)

et inertielles (détection de mouvement). L'ensemble des capteurs communiquera par protocole Bluetooth 5 avec cryptage en AES 128 bits pour assurer la confidentialité des données médicales. De plus, un principe innovateur basé sur la blockchain sera intégré. Il s'agit de protéger les données des patients en les partageant de manière cryptée à plusieurs ordinateurs pour éviter toutes falsifications. Ces deux cryptages combinés assureront la viabilité des données collectées et minimiseront le piratage. Enfin, des couches d'apprentissage machine seront ajoutées pour analyser les données et réaliser des modèles prédicteurs. Ces derniers préviendront et anticiperont les risques et enjeux liés à la santé.

SENSITIVITY OF PHYTOPLANKTON PRIMARY PRODUCTION ESTIMATES TO AVAILABLE IRRADIANCE UNDER HETEROGENEOUS SEA-ICE CONDITIONS

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The Arctic icescape is composed of a mosaic of ridges, hummocks, melt ponds, leads and snow. Under such heterogeneous surfaces, drifting phytoplankton communities are experiencing a wide range of irradiance conditions and intensities that cannot be sampled representatively using single-location measurements. Combining experimentally derived photosynthetic parameters with transmittance measurements acquired at spatial scales ranging from hundreds of meters (using a Remotely Operated Vehicle, ROV) to thousands of meters (using a Surface and Under-Ice Trawl, SUIT), we assessed the sensitivity of water-column primary production estimates to multi-scale under-ice light measurements. Daily primary production calculated from transmittance from both the ROV and the SUIT ranged between 0.004 and 939 mgC m-2 d-1. Upscaling these estimates at larger scales using satellite-derived sea-ice concentration reduced the variability by 22% (0.004-731 mgC m-2 d-1). The relative error in primary production estimates was two times lower when combining remote sensing and in situ data compared to ROV-based estimates alone. These results suggest that spatially extensive in situ measurements must be combined with large-footprint sea-ice coverage sampling (e.g., remote sensing, aerial imagery) to accurately estimate primary production in ice-covered waters. Also, the results indicated a decreasing error of primary production estimates with increasing sample size and the spatial scale at which in situ measurements are performed. Existing estimates of spatially integrated phytoplankton primary production in ice-covered waters derived from single-location light measurements may be associated with large statistical errors. Considering these implications is important for modelling scenarios and interpretation of existing measurements in a changing Arctic ecosystem.

L'APPRENTISSAGE PROFOND POUR L'IDENTIFICATION DE COPÉPODES DANS DES IMAGES LOKI

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L'installation de caméra LOKI dans l'Arctique a permis au département de biologie de l'Université Laval de faire de l'analyse de la population marine nordique, plus particulièrement des copépodes. Par ailleurs, les chercheurs peuvent estimer la valeur nutritive d'un copépode en mesurant la poche lipidique de celui-ci. Cette poche est visible sur les images LOKI. Toutefois, le processus est long et ardu. Comme il y a des milliers d'images, il est difficile de toutes les traiter dans des délais raisonnables. De plus, bien que la tâche est longue, elle est aussi ennuyante. Si une intelligence artificielle (IA) pouvait faire cette identification pour le chercheur, il pourrait utiliser ce temps pour approfondir ses recherches. Mais comment enseigner à un ordinateur à faire cette tâche? Via l'apprentissage profond. L'apprentissage profond a présenté beaucoup de potentiel depuis les dernières années. Cette forme d'IA a en effet permis d'accomplir des tâches difficiles, voire impossibles à simplement programmer. Allant du bénin, comme jouer au Go (AlphaGo), au pratique, comme repérer des piétons sur la route. Ce potentiel a toutefois été peu exploré dans

le domaine de l'écologie. L'affiche présente les résultats préliminaires de l'utilisation de l'apprentissage profond dans la première étape de traitement des images : la classification d'images LOKI. Plus particulièrement, la présentation démontre, une fois l'apprentissage fait, le niveau d'efficacité de l'intelligence artificielle à identifier différentes images de copépodes d'une base de données avec une variété d'espèces marines et de déchets marins.

LA CHIRURGIE BARIATRIQUE ET SES EFFETS SUR LE MÉTABOLISME ET LE MICROBIOTE INTESTINAL CHEZ LE RAT OBÈSE

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La chirurgie bariatrique demeure le moyen le plus efficace pour traiter l'obésité sévère, dont la prévalence continue d'augmenter dans plusieurs régions du monde. La compréhension des mécanismes par lesquels ce type de chirurgie exerce ses effets bénéfiques sur la santé s'avère indispensable. L'un des mécanismes probables impliquerait des modifications du microbiote intestinal en période postopératoire. L'objectif de cette étude était d'analyser les liens existants entre les effets des chirurgies restrictives et malabsorptives sur le microbiote intestinal et les effets bénéfiques des chirurgies sur le poids et la masse grasse, le bilan d'énergie et le métabolisme du glucose chez des rats obèses. Les chirurgies gastrectomie verticale (SG), dérivation gastrique (RYGB), dérivation biliopancréatique (BPD-DS), dérivation duodéno-iléale associée à une gastrectomie verticale (SADI-S) ont été pratiquées chez des rats Wistar nourris avec un régime riche en graisse causant l'obésité. Les poids et la prise alimentaire furent mesurés chaque jour durant huit semaines. Les hormones glucagon-like peptide-1 (GLP-1) et le peptide tyrosine tyrosine (PYY), l'insuline ainsi que le glucose ont été mesurés à la 8e semaine postchirurgie. Les échantillons de fécès furent récoltés avant la chirurgie et à la 2e et 8e semaine postchirurgie. Les échantillons de fécès furent analysés par séquençage du gène de l'ARNr 16S. La teneur en acides gras à courte chaîne des fécès a été déterminée avant la chirurgie, à la 3e et 8e semaine post-chirurgie. Comparés aux rats SHAM et SG, les rats RYGB, BPD-DS et SADI-S présentaient de faibles gains de poids, une diminution de la masse adipeuse, une amélioration du métabolisme du glucose et une augmentation des niveaux de GLP-1 et PYY. Le séquençage du gène de l'ARNr 16S sur des échantillons fécaux a révélé des altérations du microbiote intestinal telles qu'une diminution de la diversité et de l'abondance bactériennes à la 2e et à la 8e semaine post-chirurgie chez les RYGB, BPD-DS et SADI-S, qui ont été associées à une augmentation des proportions des Enterobacteriales et une baisse des Clostridiales. De plus, le microbiote intestinal issu de ces chirurgies a été associé à des changements dans la production des acides gras à courte chaîne tels qu'une augmentation de butyrate et propionate, mais une diminution des niveaux d'acétate. L'augmentation de butyrate et propionate corrélait avec les niveaux élevés de PYY. Les résultats montrent des effets bénéfiques des chirurgies sur le métabolisme qui sont associés à des changements dans la composition et la fonction du microbiote intestinal chez le rat obèse.

GEOCHEMICAL TRAJECTORIES AND PHOSPHORUS CYCLING IN LAKE SEDIMENT UNDERGOING REMEDIATION TREATMENT

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The increasing biomass of cyanobacteria in eutrophic lakes is a major environmental issue worldwide. They produce cytotoxins that results in risks for human and aquatic life. Phosphorus (P) is often the culprit, sustaining excessive biomass growth. Its sources are either external, via terrestrial fluxes, or internal, via accumulated stores of P bound to sedimentary organic carbon (C), iron (Fe), Aluminum (Al) and calcium (Ca) minerals. Despite internal P load being a widespread phenomenon, the role of sediments in supplying P, and the coupling of

the P biogeochemical cycle with that of other elements, is poorly quantified. Here I present a research plan aiming to evaluate the timing and magnitude of the internal loading, by acquiring comprehensive datasets suitable to improve numerical models for sediment diagenesis. I have so far selected one eutrophied lake that underwent artificial fertilization (Lake 227, Experimental Lake Area) and a culturally eutrophic lake that underwent remediation treatment using lanthanum-modified bentonite (LMB) clay (Lake Bromont). Preliminary data at Lake 227 reveal Fe and humic-bound P, while P in Lake Bromont sediment were initially bound to Al and Fe (oxy)hydroxides and Ca carbonates and apatites. To complete existing datasets, I will retrieve two cores at each site, one in the epilimnion and one in the hypolimnion. Core 1 will be analyzed for solid-phase, and core 2 set aside to retrieve sediment porewater using rhizon samplers. Core 1 will be analysed for i) solid phase speciation using sequential P extraction method (SEDEX), to estimate labile and recalcitrant P phases, ii) 31P nuclear magnetic resonance (31P NMR), to characterize organic P compounds which are considered important source of soluble phosphorus, and iii) X-ray based spectroscopy, to ascertain crystalline P-bearing phases of Fe, Al and Ca. Porewater will be analyzed for total concentrations of key elements using ICP-QQQ-MS. I will discuss the significance of the dataset to be acquired and its potential to improve current sediment models for P diagenesis.

CHARACTERIZATION OF MGLL-/-MOUSE MICROBIOTA TO HIGHLIGHT THE MICROBIOME-ENDOCANNABINOIDOME AXIS IN METABOLIC HEALTH

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The microbiome is involved in many pathological processes, including diabetes, though the molecular mechanisms through which it acts remain to be elucidated. As such, the relationships between the microbiota and various signalling systems such as the endocannabinoidome (eCBome) are growing fields of study. The eCBome—a network of lipid signalling molecules, their receptors and regulatory enzymes that are related to, endocannabinoids—is involved in many of the same biological functions as the gut microbiota, including regulation of glucose metabolism. Recent work indicates that the interaction between the gut microbiome and the eCBome is bidirectional, suggesting the existence of a biologically relevant microbiome-eCBome axis. To study this axis, we will utilize eCBome genetic mouse models such as monoacylglyceride lipase (MGLL) knockout mice (Mgll-/-). MGLL degrades the endocannabinoid 2-arachidonoyl-glycerol (2-AG), which activates cannabinoid CB1/2 receptors, and related mono-acyl-glycerols, which instead often activate GPR119. Mgll-/-mice exhibit high tissue levels of these signalling lipids, with subsequent CB1 desensitization and/or altered GPR119 activity and are resistant to high fat diet-induced insulin resistance. Mgll-/-mice are therefore an interesting model in which to study the relationship between metabolic disorders and the gut microbiome-eCBome axis, with the aim of identifying bacterial species, which, may be partly responsible for its metabolic phenotype. In this work, we first characterized the microbiota of Mgll-/- mice under normal and high-fat diet by 16S metagenomic sequencing. Then, we used culturomics in order to determine whether 2-AG, which is abundant in the intestine and present at even higher levels in Mgll-/-mice, has an impact on intestinal microbial diversity. We cultured stool samples from normal mice supplemented with 2-AG in liquid media; these cultures were then analyzed by 16S and on agar plate through culturomics to identify direct effects on the microbiome in vitro and identify responsive bacterial species. The preliminary results show that the gut microbiota of Mgll-/- and wild-type mice are clearly separated according to genotype by 16S sequencing, suggesting that the presence or absence of MGLL may interact with the gut microbiome of mice. Further, the Roseburia and Parabacteroides genera, which have been associated with improved glucose homeostasis, were increased in Mgll-/—mice. This analysis opens up the prospect of identifying and characterizing commensal bacteria influenced by altered levels of mono-acylglycerols and the activity of their receptors, which possibly mediate the phenotype of Mgll-/-mice and play a role in metabolism. Funding: We thank the Canada Excellence Rsearch Chair on the Microbiome-Endocannabinoidome Axis in Metabolic Health (CERC-MEND), Université Laval.

THE ECOCHIP: A WIRELESS MULTI-SENSOR PLATFORM FOR COMPREHENSIVE ENVIRONMENTAL MONITORING

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The EcoChip is being developed in the course of the Sentinel North sub-project 3.2 - Comprehensive environmental monitoring and valorisation: From molecules to microorganisms. Sentinel North's Technology maturation fund is now allowing our team to address some remaining technical challenges before we can undertake the next steps towards final validation and technology transfer to industry. The EcoChip has been jointly developed and validated in the laboratory by our multidisciplinary team, and utilized to collect bio-environmental data in the field from the northern soils and ecosystems of Kuujjuarapik (2017) and Puvirnituq (2018), during two expeditions. We are currently working toward the development of a precommercial version, thanks to the Technology maturation fund, and we plan to release a prototype and test it in the field this summer. We believe the EcoChip will fill the gap in the field of bioremediation and global bio-environmental monitoring, which both may represent major markets. The technology has reached a development stage that justified recently filing a provisional patent application. We are now seeking industrial partners that could use this technology in commercial applications. The EcoChip is a new autonomous wireless sensor platform intended for culturing and monitoring the growth of microorganisms and their environmental conditions in situ, in harsh environments, such as in northern climates. This platform includes a layered multiwell plate that allows the growth of single strain microorganisms, within a well of the plate, isolated from environmental samples from northern habitats. It can be deployed in the field for continuous monitoring of microbial growth within 96 individual wells through a multichannel electro-chemical impedance (EIS) monitoring circuit. The EIS monitoring system uses high-performance off-the-shelf electronic components, presents low excitation voltage signal not to harm the cells and has a calibration network for high-precision. Additional sensors are provided for measuring environmental parameters such as luminosity, humidity, and temperature. The embedded electronic board is equipped with flash memory to store sensor data over long periods of time, as well as with a low-power micro-controller, and a power management unit to control and supply all electronic building blocks. When a receiver is located within the transmission range of the EcoChip, a low-power wireless transceiver allows transmission of sensor data stored in the flash memory. The performance of the system was successfully measured in vitro in a laboratory setting. The EcoChip can perform EIS analyses over an excitation frequency range of 750 Hz to 10 kHz with an accuracy of 2.35%. The complete system presents an average power consumption of 114.6 mW in normal operating mode and of only 0.14 mW in sleep mode.

UNDERSTANDING THE IMPACT OF RECIPROCITY ON THE RESILIENCE OF COMPLEX SYSTEMS

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The resilience of a complex system is its capacity to return to a healthy steady state after it has been perturbed or attacked. It is a critical feature of ecological or climatic systems for instance. Reciprocity is another fundamental property of dynamical systems. If the activity of element A promotes the activity of another element B, does the activity of B promote or diminish the activity of A? In the first case, we say that the reciprocity of the system is positive while in the second case, the reciprocity is negative. For example, cooperation leads to a positive

reciprocity while competition leads to a negative one. How reciprocity influences the resilience of a system is an important and unresolved question which we investigate from a theoretical point of view. We work on abstract representations of complex systems that are well described by the mathematical formalism of "dynamical systems". In these representations, elements (such as animal species) are represented by nodes on a graph and interactions between these elements (such as predation or cooperation) are represented by edges on a graph. How the activity of an individual element evolves depends on the activity of other elements from which it receives a connection. We first obtain absolute and unconditional bounds on the resilience of dynamical systems. These bounds show that a positive reciprocity tends to decrease the resilience of a system while a negative reciprocity promotes the resilience. We also investigate models of random networks in which the mean reciprocity is characterized by a continuously tuneable parameter r. We prove that the expected resilience of the system continuously depends on the parameter r: the larger the value of r, the smaller the resilience. Finally, we consider models in which the evolution of the activity of each element depends on individual features of this element. For example, the growth of an animal population is not only influenced by the activity of other species, but also on features specific to that species such as its reproduction rate. In this case, we find a subtle interaction between 1) the distribution of these individual features, 2) the reciprocity of the system, and 3) its resilience. We believe that in the long term, this line of work could contribute to the preservation of real complex systems. Indeed, in a scenario in which one could act either on the strength of interaction between the elements of a system or on the individual features of the elements, one could use our theoretical investigations to identify the connections or individual features that should be targeted in order to create positive impacts on the system's resilience.

SENSOR NETWORKING IN SENTINEL NORTH

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Our project addresses the communication requirements for Sentinel North research directions. To know the North more, researchers have deployed numerous sensors in northern communities as well as in the wild. These sensors gather information in different forms, such as temperature, humidity, and so on. Of particular importance is the impact of human activities and global warming on permafrost. Datasets from these deployed sensors, in addition to serving academia, also help the local communities to monitor infrastructures for their construction, transportation and living. This monitoring function is gaining in significance; gathered data should be exploitable to prevent dangers such as land sliding and destabilization. Field tours by Centre d'études nordiques (CEN) researchers, at a frequency of once or several times a year, have been the main way to fetch the data collected by the deployed sensors. This raises two main drawbacks: the field tours are labor-heavy and costly, and the delay caused by yearly data collections prohibitively hinders the real-time monitoring and forecasting. The main focus of Pitutsimaniq is to integrate the sensors deployed by CEN in Arctic communities, with a short-term focus on Salluit. We have focused on a minimal network composing of three data nodes: station A, station B and station GN. The commercial dataloggers are designed to a local WiFi network. We have engineered a means of connecting these commercial systems to a gateway. Data can then be transmitted via community LTE service to the Internet, and ultimately to researchers at Université Laval. As some sensing facilities are powered by only batteries and solar panels, power consumption is an issue of critical importance. Therefore, instead of real-time data fetching, we program the sensing facilities to push captured data to the cloud server with pre-designed time intervals, trading off battery consumption and connectivity. Currently, the data from Station B is uploaded to the server regularly. Another consideration in this work is the compromise of data rate and range. WiFi, as a broadband access technology, can service over a short range with a large data rate, and with higher power consumption. For our implementation within a sensing network, long distance with limited data rate is preferred, and excessive power consumption is not allowed. Our future work will introduce Internet of things (IoT) communication technologies such as the LoRa protocol, to serve a longer distance, with lower power consumption.

TOWARDS AN ULTRAFAST ALL-FIBER LASER SOURCE FOR MID-INFRARED SPECTROSCOPY

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Recently, there has been much interest in environmental monitoring to quantify and model the climatic changes affecting our planet. One of the objectives of the BOND project within Sentinel North is to develop mid-infrared lasers to detect and quantify atmospheric pollutants fluxes escaping from thermokarsts in the Arctic in real time. These devices could enable year-round real time flux measurements by replacing more expensive setups such as Eddy towers or devices such as closed or dynamic chambers that require more work force and that cannot stay in place year-round [1]. In the last few years, efficient supercontinuum emission in the transparency window of the atmosphere between 3 μm and 5 μm and efficient ultrafast laser emission tunable up to 3.6 μm have been generated from laser oscillators emitting ultrafast pulses near 2.8 μm [2, 3]. These kinds of laser sources are promising for probing the strong fundamental ro-vibrational resonances of multiple atmospheric pollutants at the same time such as CH4 and CO2 over long distances, but they must be robust and reliable if they are to be used in harsh environments such as Arctic regions. In this contribution, we study alternative designs using either a semiconductor saturable absorber mirror (SESAM) or a Dy3+-doped silica fiber for generating ultrafast pulses with a linear laser cavity to design a robust ultrafast all-fiber laser operating near 3 μm to replace previous sources for broadband mid-infrared laser emission. The mode-locked Er3+-doped fluoride fiber laser generates pulses as short as 15 ps with an average power of 58 mW at a repetition rate of 55 MHz using a SESAM (BATOP, GmbH) and is stabilized at 2791 nm by a fiber Bragg grating. By butt-coupling the SESAM directly to the fiber tip, an all-fiber design could be implemented to provide the robustness and reliability required for field applications. Alternatively, the use of a Dy3+-doped silica fiber as saturable absorber to generate ultrafast pulses will be studied. The measured absorption spectrum of this fiber should provide enough saturable absorption, and its form factor makes it very durable. Moreover, numerical simulations show promising results with at least passive Q-switching occurring. Finally, the ultimate objective of this project is to generate a broadband laser emission tuned for methane spectroscopy by amplifying the shortest pulses generated by the ultrafast laser and integrate it into a remote sensing device to quantify the fluxes of methane.

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MECHANICAL DEGRADATION OF PERMAFROST EMBANKMENT

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Roads and highways in cold regions are affected by the settlement of embankments leading to dangerous trafficability issues. There are uncertainties about the understanding of the mechanical behaviour of embankments built on permafrost. The objective of this project is to quantify the relative importance of consolidation, frost heave and long-term creep of the embankment material. Understanding the leading instability mechanism and the deformation of the embankment for different types of soil is helpful in order to develop efficient mitigation strategies, thus, contributing to performance improvement of transportation infrastructure for northern communities in permafrost regions. In order to assess the influence of soil types on the mechanical degradation processes involved, three experimental sites are studied. The main site is located in continuous permafrost at kilometre 82 of the Inuvik Tuktoyaktuk Highway 10 (ITH) in the Northwest Territories, where vertical and horizontal inclinometers have been installed to monitor and collect data on the movements of the embankment. Investigation also includes temperature recording with thermistor strings to monitor the influence of the embankment on the thermal regime of the ground. Then, ITH data will be compared with data collected at Salluit airport access road (Nunavik, Quebec) and along the Provincial Road (PR) 373, 200 km southeast of Thompson, Manitoba.

BIOPHILIC DEVELOPMENT OF ADAPTIVE FAÇADES FOR HEALTHY AND ENERGY-EFFICIENT BUILDINGS IN QUEBEC'S NORTHERN TERRITORIES

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This research aims at developing biophilic adaptive façades as a promising solution to promote occupants' health and building energy efficiency in the extreme-cold climate of Quebec's northern territories. Adaptive façades point to the (self-) adjustment of façade components (such as shading panels, windows and blinds) to occupants' needs and environmental conditions in order to improve the overall performance of the building. Meanwhile, biophilic design offers several recommendations to promote human-nature relationships in buildings. The biophilic development of adaptive façades has considerable potentials to deal with the challenging state of living and working in northern latitudes. Strong seasonal light/dark cycles (photoperiods) come with very low average weather temperatures creating an extreme climate for living and working in northern latitudes. In such harsh climates, occupants spend most of their time inside buildings and their health is highly affected by the indoor environment. More specifically, accessibility to natural light and cycles affects occupants' health and behavior as well as energy consumption of buildings. In this regard, photobiological research shows that the lighting ambiance and local photoperiods have significant impacts on the biological clocks, alertness and performance of building occupants. Thus, northern buildings should mediate the extreme climate and satisfy occupants' needs through offering them a sufficient accessibility to natural cycles and providing them a healthy lighting ambiance. These issues have thus far received negligible attention in designing buildings in Quebec's northern territories. The southern imported models of buildings have been constructed to mainly respond to thermal comfort dependent on mechanical systems. Occupants' access to outdoor environment and natural cycles is severely limited in such building models. This research develops biophilic adaptive façades which could respond to northern occupants' needs and climate conditions. The research particularly focuses on lighting adaptation strategies. The study produces several prototypes of such adaptive façades optimized for northern Quebec. The research uses experimental methods and runs a parametric study to analyze and assess the productivity of such façade systems. The results of this research could be used by designers and developers to promote the living and working ambiance in northern territories which result in significant benefits in terms of public health, environmental footprints and economy.

CHARACTERIZATION AND OPTIMIZATION OF HUMAN IPSCS DERIVED MIXED NEURONAL CULTURES TO IDENTIFY WITH HIGH RESOLUTION MULTIMODAL MICROSCOPY TECHNIQUES RISK BIOMARKERS OF SCHIZOPHRENIA

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Schizophrenia (SZ) is a neuropsychiatric disorder affecting over 1% of the world's population, which is characterized by distortions in thinking, perception, emotion, language, sense of self, and behavior. In many neuropsychiatric disorders such as schizophrenia, a complex interaction between genetic susceptibility and environmental insults leading to alteration of the brain development has been reported. Specifically, profound modifications in anatomy, physiology, and functional properties of cortical networks during adolescence have been described. Furthermore, these disorders are accompanied by synergistic effects and interactions of various neurotransmitter abnormalities, which makes disease phenotypes and characteristics extremely

heterogeneous. Alterations in neuronal connectivity due to abnormal gene expression may alter the homeostasis plasticity (HP) of neuronal circuits during brain development making them particularly vulnerable to environmental stressors. This is sometimes called childhood risk syndrome, which may lead to schizophrenia and other neuropsychiatric disorders. Furthermore, it has been shown that in vitro neural differentiation of induced pluripotent stem cells (iPSCs) recapitulates to some extent some important steps of the in vivo neurodevelopment. Therefore, the first step of my study is to develop a methodology to generate from iPSCs cells, coming from patients and their high-risk offspring, cultures of mixed cortical neurons. An important part of this work is dedicated to optimize and characterize this neuro-differentiation process in order to obtain highly reproducible neuronal cultures, recapitulating some important step of the forebrain development and representing thus an in vitro model of cortical diseases, including psychiatric disorders. The advanced cell reprogramming tools helped us to successfully develop the human-iPSCs from urothelial cells, obtained from schizophrenic patients as well as healthy controls by using integration-free methods. Then iPSCs are differentiated into neurons following commercially available protocol and culture media. The characterization was performed using flow cytometry and immunostaining tools. These cultures exhibit different kinds of neurons including glutamatergic, dopaminergic GABAergic, serotonergic and cholinergic neurons as well as glial cells. The functional activity was measured by whole cell patch clamp technique and calcium imaging. In the next step, we plan to analyze with multimodal digital holographic microscopy (QP-DHM) the activity and maturation of these human iPSC-derived neuronal cultures. Specifically, the excitatory/inhibitory (E/I) balance, which has been shown to be altered in neurodevelopmental psychiatric disorders, will be explored. QP-DHM is a high-resolution non-invasive microscopy technique which allows assessing cell structure and dynamics with a nanoscale axial sensitivity. Such an approach, combining cutting edge imaging techniques with in vitro model of cortical diseases, is highly promising for identifying cellular risk biomarkers of major neurodevelopmental psychiatric disorders including schizophrenia. Our approach could easily be applied to identify some vulnerability versus resilient states within northern populations, including Inuit.

MODELLING ARCTIC MARINE FOOD WEBS UNDER CLIMATE CHANGE: SUSTAINABILITY OF MARINE HARVEST AND FOOD SECURITY IN COASTAL COMMUNITIES OF THE CANADIAN ARCTIC

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Climate change is leading to shifts in Arctic marine food web structure and functioning and consequent changes in the availability, quality and accessibility of country foods for Inuit communities. As sea ice coverage declines and gets thinner, Arctic animals facing deep modification of their habitats up to their possible loss, are forced to seek out alternative prey, affecting their body condition. Meanwhile, Inuit hunters face more risks when travelling and harvesting on the sea ice. Marine foods are not only important sources of protein, vitamins, minerals, and omega-3 fats, but also part of the cultural identity of Inuit. It is thus critical to understand the link between climate change, marine ecosystem structure and health, and food security, to better inform management and adaptation strategies. To fill this gap, we aim to 1) create mass-balance ecosystem models using Ecopath with Ecosim in western Baffin Bay (Nunavut) and eastern Hudson Bay (Nunavik) to model and predict changes in biomass, and contaminant dynamics in marine food webs; and 2) build model scenarios through participatory research with the community of Qikiqtarjuaq in Nunavut. For that, we will fit bioecological and environmental parameters from the oceanographic project GreenEdge in Baffin Bay, and the multidisciplinary project BriGHT in Nunavik, along with data from existing data on species diet and abundance, as well as environmental drivers, to forecast future changes in the availability and nutritional content of marine species locally relevant for Inuit.

Results from the marine ecosystem model in Baffin Bay will be used as the basis for discussion with community representatives in Qikiqtarjuak (e.g. hamlet, hunters, fishermen). Through this participatory research framework, we will validate model results and structure based on Inuit knowledge and observations, and develop community-relevant future scenarios that can better inform adaptation plans to support food security and sustainable marine harvest. This project will provide a deeper understanding of the dynamics of marine food webs facing rapid climate changes, and how that relates to Inuit food security and needs for adaptation. This work may also serve as a model to be used in coastal regions elsewhere, dealing with global changes and natural resource management issues that relate to local food and food security.

DEVELOPMENT OF A REFLECTANCE PROBE TO MEASURE SEA ICE INHERENT OPTICAL PROPERTIES

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More detailed characterization of the spatially and temporally varying inherent optical properties (IOPs) of sea ice is necessary to better predict sea ice energy and mass balance and under ice primary production. Here we present the development of an active optical in situ probe for measuring IOPs of a small volume of ice (mm3 to cm3) non-destructively and within short time. The precision, efficiency and ruggedness of the concept allows scientists obtaining sea ice IOPs values within a 2" hole directly in the field within minutes. It provides high-resolution vertical profiles of sea ice IOPs and allows for the investigation of IOPs' relationship to other physical sea ice properties. The probe is based on the diffuse reflectance technique used to measure IOPs of human tissues. Conceptually, the instrument emits light into the ice by an optical fiber. Backscattered light is measured at multiple distances from the in situ source using other fibers. Measured reflectance vs distance curves are compared to values derived from Monte Carlo simulations of radiative transfer. A pre-computed look-up table and an inverse algorithm allows for inferring the absorption coefficient, the reduced scattering coefficient and the asymmetry parameter of the scanned sea ice. Here we present the design of the instrument, as well as first results from field tests acquired in the Canadian Arctic in 2018 and 2019. This includes the first vertically resolved in situ measurements of sea ice IOPs.

A SYSTEMIC ANALYSIS OF ARCTIC SECURITY

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This paper will focus on the governance of the Arctic ocean system, through the prism of security. By analyzing security policies and treaties from coastal countries around the Arctic ocean we aim at understanding how they apprehend the changing Arctic. A series of interviews conducted in Norway and Canada in the winter and spring of 2019 - as part of a Sentinel North mobility grant - will complete this discourse analysis. We argue that when tackling the issue of the governance of an ocean system, two key processes must be taken into account: environmental processes on the one hand, and social processes on the other. Both are currently undergoing important changes in the Arctic, implying new variables in the security equation. Two main challenges can characterize security and its governance in the Arctic: climate change and globalization. Each can be declined manyfold, at different scales, implying a wide array of variables. We aim at (1) broadly delineating the state of the security system in the Arctic today, through a cross-analysis of the actor network at play and the referent objects for security put forward in Arctic strategies. Doing so, we will focus on the coastal states around the Arctic Ocean. This will allow us, then (2) to conduct a multiscalar analysis of this security system. Still focusing on the ocean as a core territory of study, we want to question the scale of 'Arctic Security' and how it faces external powers becoming increasingly interested in the region

SOURCES OF HIGH-POWER INFRARED LASER PULSES BASED ON THE MAMYSHEV ARCHITECTURE AND THEIR POTENTIAL FOR REMOTE SENSING

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Essentially all molecules of interest for climate studies have specific spectral signatures in the infrared. Multiple mid-infrared laser sources have been developed in order to detect the molecular species present in the atmosphere and map their spatial distribution. Recent progress has recently been achieved with broadband fiber lasers emitting in the first window of atmospheric transparency between 3 and 5 μm. The second transparency window between 8 and 12 μm, often called the "fingerprint" window, is of particular interest since it is very sensitive to the molecular composition and structure. This spectral window can be reached through nonlinear optical conversion of photons emitted by powerful laser sources operated at shorter wavelengths. Such laser sources do exist at present, but they are mostly based on expensive solid-state systems that have a large footprint. We have followed another approach by developing fiber-based sources of ultrafast laser pulses that take advantage of the Mamyshev architecture. Mamyshev oscillators incorporate two fiber amplifiers and two spectral filters configured in such a way that only short pulses can be emitted by these oscillators. We will present recent results obtained with these laser sources. We will also describe strategies to operate Mamyshev oscillators in all-fiber configurations that would be easily portable.

LINKING DISSOLVED ORGANIC CARBON WITH LIGHT ATTENUATION TO UNDERSTAND PAST AND FUTURE ECOLOGICAL CONSEQUENCES OF BROWNING

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Lakes are valuable ecosystems that provide critical freshwater resources, but they are threatened by many human-caused stressors that can fundamentally alter their structure and function. During the past several decades, many northern lakes have experienced "browning" caused by increases in dissolved organic carbon (DOC) due to increases in rain and storm events plus reduced atmospheric acid deposition. Increases in DOC result in reduced water transparency and greater light attenuation, which determine the vertical light and heat environment of lake ecosystems. In turn, DOC and its effect on light attenuation regulate a variety of ecosystem properties, such as thermal structure and oxygen availability. In Lake Giles, a pristine lake in the Pocono Plateau (Pennsylvania, USA), three decades of detailed physio-chemical data show the effects of this browning phenomenon on the light and optical environment, thermal structure, and oxygen depletion. Lake Giles has had more than a doubling of DOC in the past 30 years, resulting in reduced water transparency, warming surface temperatures, cooling deepwater temperatures, and increased deepwater oxygen depletion. However, this fundamental link between DOC and light attenuation and the resulting ecosystem responses is absent in many lake ecosystem models; here, we present a new version of the daily timestep MyLake ecosystem model that includes this important linkage. Previously, light attenuation by colored DOC was fixed via parametrization, with only chlorophyll concentrations dynamically impacting the remaining attenuation. The new version allows for both chlorophyll and DOC concentrations to dynamically determine light attenuation over time and depth. In the context of lake browning, this new version can be used to assess long-term ecological responses to increased DOC via its influence on light attenuation and water transparency, which the model successfully reproduced in comparison with the historical records at Lake Giles. Future climate change scenarios for Lake Giles suggest continued increases in DOC due to projected increases in precipitation in addition to air temperature warming. Combined, these climate scenarios will likely lead to continued or amplified decreases in water transparency, surface water warming, and deepwater oxygen depletion. Such ecosystem changes in future decades may alter biogeochemical processes, threaten habitat availability, or interfere with trophic interactions. Hence, the key link between DOC and light attenuation in lake models is vital for realistic predictions

and understanding of future ecological consequences of browning.

SPECKLED ILLUMINATION HILO MICROSCOPY FOR FAST CALCIUM IMAGING OF ZEBRAFISHES' BRAINS

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The brain-gut-microbiome axis is a way the central nervous system (CNS), the gastrointestinal tract (GI tract) and the gut microbiota communicate with each other via biochemical signaling. Indeed, it has been shown by preclinical and clinical studies that there is a circular communication loop amid the brain, the gut and the gut microbiome. Any perturbation can propagate dysregulation throughout the circuit and affect molecule secretion, gene expression, molecule interaction and more; a simple physiological stress can compromise the equilibrium of the floral ecosystem of the gut, which can influence the development of the CNS. These changes in the metabolism can then affect entirely the mental health of an individual. Although the influence of the microbiota on its host, particularly on the host's brain, is still misunderstood and more research needs to be done. A wide-field imaging technique, called HiLo microscopy, is presented here to obtain an incomparable and fast optically sectioned imaging of GCaMP transgenic zebrafishes' brains for the study of the brain-gut-microbiota axis. Indeed, HiLo microscopy has been proven to acquire images as fast as confocal microscopy, but the simplicity, robustness and versality of HiLo microscopy makes it an interesting technique for obtaining information of in vivo thick samples. Also, analyzing the activity of multiple neurons simultaneously is the key for increasing our knowledge of how the brain works. Thereby high temporal resolution could be acquired by the fusion of two raw images in HiLo microscopy; the first acquired with speckled illumination and the second acquired with uniform illumination. These images are used to extract high-frequency (HI) and low-frequency (LO) components of the focal plane so the fusion of both extractions produces an optically sectioned image of the zebrafish's brain. More optimization needs to be done, but this volumetric microscopy technique is promising for the study of neuronal activity.

TUNABLE ALL-FIBER LASER FOR REMOTE SENSING OF METHANE NEAR 3.4 MM

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As global warming causes permafrost to melt, it sometimes leaves behind thermokarst lakes rich in methane, a climatically-active gas. In order to study the methane emissions from these lakes, climate scientists require a tool capable of measuring a wide range of gas concentrations over a large area with great precision and reliability. In this regard, mid-infrared fiber lasers, with their exceptional beam quality, power and portability, as well as their ability to target methane absorption lines up to 100 times stronger than in the near-infrared wavelength range, are prime candidates. However, while some previous experiments have targeted methane bands under 3.3 μm in wavelength, little work has been done to push fiber laser detection tools past 3.4 μm, where methane absorption lines are mostly decoupled from the absorption spectra of water and other atmospheric constituents. This is especially relevant when probing methane through a gas mixture with relatively high water content, such as the case presented. To this end, we present a tunable all-fiber laser emitting near 3.43 μm and operating at high average power. The laser design is based on an all-fiber dual-pumping scheme, which combines core-pumping at 1976 nm with clad-pumping at 976 nm in a single-mode erbium-doped fluoride glass fiber to reach, in the present case, up to 3 W of output power at the desired wavelength. The laser cavity itself is delimited by two fiber Bragg gratings (FBG): a highly-reflective (HR) FBG at the input, which has a narrow bandwidth to dictate the laser wavelength, and a lowly-reflective (LR) FBG at the output, which has a large bandwidth to accommodate shifts of the HR FBG. Tuning of the laser cavity is achieved by mechanically stretching (i.e. lengthening) the HR FBG via the beam bending technique: the HR FBG is nested within an Invar-based metallic groove and fixed using a polymer of sufficient elasticity, the groove is then deformed using a piezoelectric actuator (PA). This allows for rapid wavelength tuning over a wavelength range of a few nanometers. By using this method to tune the laser

between extrema of the methane absorption spectrum, we achieve continuous referencing of the measurement. Early gas cell experiments show detection potential better than 1300 ppmm, an enticing result that implies enough sensitivity to detect the ~4 ppm normal atmospheric methane concentration when surveying an area of a few hundred meters in length. While further engineering refinement and competing avenues of development are considered, the project shows good promise for future deployment in northern regions by climate scientists.

DISTRIBUTION OF A UNIQUE ARCTIC CYANOPHAGE IN ELLESMERE ISLAND'S FRESHWATERS

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The lakes on Ellesmere Island in the Canadian High Arctic have a rich and fragile microbial flora, and microbial communities generally dominate the flora of these lakes. Viruses are the most abundant and diverse microorganisms in aquatic environments. Their lytic activity allows them to control microbial populations and redistribute the organic compounds used by these populations, thus enhancing the microbial loop and contributing to the distribution of carbon in the aquatic environment. However, very little is known about the viral communities in the Arctic. In Ellesmere Island's freshwater lakes, cyanobacteria are very abundant. Despite this, the distribution of their corresponding phage, cyanophages, has been little studied. Consequently, the proportion of this type of virus in the Arctic environment is unknown. In 2008, the cyanophage S-EIV1, infecting a polar strain of Synechococcus, was isolated from the freshwater of lakes in the northern Ellesmere region and would represent a new evolutionary line of cyanophages. The project presented here aimed to use the results of recent viral metagenomic studies to assess the abundance and distribution of S-EIV1 sequences in freshwater samples from lakes on Ellesmere Island. Preliminary results indicate that the freshwater viral communities of these lakes are similar, despite significant differences in their watersheds and lake chemical structure, both of which will be critically affected by climate change in the future. Finally, since cyanobacteria are often the main primary producers in polar oligotrophic ecosystems, it is essential to determine the distribution and diversity of the phages that infect them.

ADAPTIVE LIQUID CRYSTAL-BASED CAMERA FOR SUBNIVAL OBSERVATION OF LEMMINGS IN THE CANADIAN ARCTIC

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Lemmings are essential species in the Arctic ecosystem and their role in the food chain is fundamental. It is known that their population fluctuates intensely, peaking about every four years and then decreasing almost to extinction. The key to understanding such oscillations is the winter dynamics of reproduction, and now most studies of subnivean processes use comparisons of data before and after the snow season. This is the reason why we are working on creating an adaptive camera that can be used for continuous lemming observation under the snow during winter. We prepared the first prototype devices and installed them in the field in 2018. They have been working in the field over 9 months in sites with a high probability of lemmings' presence. Meanwhile the improved second-generation cameras were being prepared for next year data collection (2019-2020). To prevent depth hoar formation on the camera lens due to temperature gradient and high humidity, we place our cameras on the lateral sides of the boxes. However, for this configuration, distance to the object varies, so optical power should change to achieve the maximum image quality and assess relative size of observed individuals in order to categorize them. To achieve this, we are working on a liquid crystal (LC)—based tunable lens with an autofocus algorithm. Liquid crystal lenses are widely used in imaging applications thanks to their tunability, miniature size, low cost and power consumption. However, these lenses are often characterized at constant (room) temperature and adapting a LC lens to large temperature variations remains a challenge (few research efforts have been devoted to address the problem of using LC lenses

at low temperatures). To study the effect of temperature change, we start with a traditional modal control lens design. Main material parameters of such a lens were measured at a wide range of temperatures in order to optimize the lens design by choosing appropriate materials and control parameters. We propose an approach allowing to "athermalize" a LC lens by adapting the working AC frequencies to temperature variations. Experimental prototypes of LC lenses were created and characterized in the range of temperatures from -20oC to +40oC. It was shown that it is possible to achieve almost the same values of optical power (OP) despite different environmental conditions. To decrease the response times, low-viscosity LC was used. The effect of thermal expansion/contraction has been studied and additional OPs were measured and compared with the theoretical estimation in order to compensate them by adjusting the working frequency. Other factors and limitations affecting lens optical performance are also discussed. The present study is useful to evaluate lens operation at various temperature ranges (including the low temperature applications of LC lenses), in particular when low power consumption is required. Implementation of this technology will help us to explore the subnivean reproduction cycle of lemmings and fully understand the factors affecting it.

A MULTISPECTRAL PULSED LASER LINE SCANNING SUBSEA LIDAR FOR ARCTIC AUV APPLICATIONS

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The physical and biological properties of Arctic sea-ice and coastal benthos remain poorly understood due to the difficulty of accessing these substrates in ice-covered waters. A LiDAR system deployed on an autonomous underwater vehicle (AUV) can interrogate these 3D surfaces for physical and biological properties simultaneously. Using our understanding of the absorption, inelastic scattering (e.g., chlorophyll fluorescence at 685 nm), and elastic scattering properties of photosynthetic micro- and macro-algae, we present the results of initial field tests of a pulsed laser line scanning subsea LiDAR utilizing a single excitation wavelength (532 nm) and two detection wavelengths (532 nm, 685 nm). We evaluate the 3-D imagery of calibration, man-made, and macroalgal targets using elastic and inelastic fluorescence returns from the LiDAR during pole-mount ship-based testing. AUV deployment constrains LiDAR power (1-24 kWh) and volume (<20 L). To resolve Arctic macroalgae on the coastal seafloor as well as O(10 cm) patches of Arctic micro-algae on the bottom of sea-ice, a ground sample distance of ~2 cm is required. Arctic bio-optical conditions at a distance of 10-15 m requires laser energy of ~10 μJ / pulse. These design constraints are met by using a commercially-available pulsed fiber laser (200-400 kHz), scanned horizontally at 200 lines/sec using a rotating polygon mirror. To minimize collection of near-field scattered light, four overlapping optical receiver assemblies are used, each with a narrow (~15º) instantaneous field of view. Analog-to-digital conversion of photomultiplier tube output of each detector at 2.5 GSamples/s yields O(5 cm) range resolution. The digitized time history of each pulse return is post-processed to create range and intensity images across a 60º field of view when all four detectors are used at 532 nm. Alternatively, two pairs of detectors can be aligned in parallel to achieve simultaneous elastic (532 nm) and fluorescence (685 nm) imaging at 30º field of view. Calibration targets were deployed during pool tests to evaluate the contrast and resolution performance of the LiDAR under ideal conditions. Initial results from the spatial resolution targets confirm the theoretical prediction of resolving cross-track features of less than 2 cm. The LiDAR was subsequently deployed at the end of a pole mounted to a small coastal research vessel. LiDAR scans were acquired in the waters offshore of Dania Beach, Florida in April 2019 cruising at 1-2 m/s. Using the multispectral mode (30º IFOV), it was possible to resolve fine details of sub-meter size sea floor macroalgae in both elastic and fluorescence images. For classification purposes, we have five dimensions of data (x, y, range, elastic intensity, and fluorescence intensity). Per-return fluorescence information is key to confirming that a sea floor (or ice bottom) target is living (chlorophyll-containing) material. Future work will reduce the sensitivity of the LiDAR to ambient light, increase the overall FOV with additional detectors, incorporate inertial measurement unit data into LiDAR return processing, produce data in open standard LiDAR format, integrate the LiDAR into a commercially-available AUV, and apply deep learning approaches to N-D point cloud object detection, segmentation, and recognition.

PORTRAIT OF THE DRINKING WATER QUALITY IN NUNAVIK

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Access to safe drinking water is one of the most important environmental determinants of health. In Canada, access to drinking water for populations served by Arctic community water systems may be limited, in terms of quantity and quality. The water in these systems is particularly vulnerable to microbiological and chemical contamination and much is under drinking water quality advisories (boil water and drinking water avoidance advisories). In Quebec, this vulnerability is particularly present in Nunavik. This vast northern territory has a population of 12,000 in 14 coastal villages. In Nunavik, most small systems are supplied by surface water and the water treatment process generally consists of double disinfection (UV treatment and chlorination) without filtration (in at least 12 of the 14 villages). First, this water treatment method may present a risk of microbiological contamination, especially in the presence of chlorination-resistant parasites (protozoa) in the water, and therefore of acute toxicity to the population, although UV treatment limits this risk. Secondly, this water treatment method can generate the formation of disinfection by-products (DBPs) at high concentrations, which may present a risk of chronic toxicity for the population. Finally, the chlorine taste is often disliked by a portion of the population and may lead to undesirable consumption habits (e.g., consumption of untreated water or sugary drinks). Except for Kuujjuarapik (the southernmost village in Nunavik), the development of underground pipelines for carrying drinking water is impossible due to the presence of permafrost. Water is generally distributed in the villages using water trucks and stored in domestic tanks. This method presents a high risk of contamination during both the distribution and storage of water. Despite these risks of contamination, few data are available on drinking water quality stored in water tanks at home. Regulatory water quality monitoring focuses on distributed water quality in water trucks. Our project therefore proposes to develop a portrait of drinking water quality consumed by the population, particularly water stored at home. For this end, historical data will be collected and will be supplemented by additional data generated this summer (including the portrait of the drinking water quality stored in water tanks at home). This poster will present the portrait of the Nunavik drinking water quality based on regulatory data as well as their interpretation.

LES ANOMALIES D'INTÉGRATION ET DE TRANSFERT INTERMODAL POUR UNE DÉTECTION DE LA VULNÉRABILITÉ AUX GRANDES MALADIES PSYCHIATRIQUES

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Les grandes maladies psychiatriques (GMP) que sont la schizophrénie, la maladie bipolaire et la dépression majeure récurrente présentent toutes une vulnérabilité neurodéveloppementale commune en raison d'anomalies neuronales et sensorielles précoces. Plusieurs évidences soutiennent qu'un développement harmonieux du soi, connu pour être perturbé précocement dans les GMP, exige une perception synchronisée et une intégration adéquate des afférences sensorielles provenant de soi et du monde qui nous entoure (p. ex. tactile, visuel, auditif et proprio/intéroception). Une altération précoce du transfert intermodal (TIM) et de l'intégration multisensorielle (IMS) viendrait nuire au développement du soi et d'une représentation du monde stable et unifiée. Le TIM est la capacité à transférer un percept provenant exclusivement d'une modalité sensorielle (p. ex. tactile) vers une autre modalité (p. ex. visuel). L'IMS est la capacité à intégrer des afférences sensorielles provenant de différentes modalités (p. ex. visuel et auditif) pour effectuer un meilleur traitement de l'information. Ce projet vise à explorer si des anomalies dans ces fonctions pourraient être considérées comme un marqueur de vulnérabilité aux GMP. Tâches de TIM : Chaque condition comporte 12 essais et, lors de la palpation, les formes sont cachées de la vue des participants. Condition T-T : Une forme tridimensionnelle cible est palpée pendant 10 secondes et doit ensuite être reconnue par le toucher parmi un distracteur. Condition T-V : Une forme tridimensionnelle

cible est palpée pendant 10 secondes et doit ensuite être reconnue visuellement parmi un distracteur. Condition V-T : Une forme tridimensionnelle cible est présentée visuellement pendant 10 secondes (vidéo 3D) et doit ensuite être reconnue par le toucher parmi un distracteur. Tâche d'IMS : Tâche de temps de réaction simple comportant 80 essais avec présentation unimodale des stimuli (Auditif OU Visuel) et 40 essais avec des stimuli multimodaux AV (auditif ET visuel simultané) présentés aléatoirement. En raison de stimuli plus prégnants, les temps de réaction sont plus courts en AV. Le modèle de Race calcule la probabilité de réponse attendue pour chaque temps de réaction sachant que les temps de réaction AV sont naturellement plus courts qu'en unimodal. Les temps de réaction plus courts que ceux prédits par le modèle de Race montrent une facilitation multimodale et refléteraient une IMS adéquate. Quatorze jeunes de 9 à 15 ans à haut risque génétique (EHR) de GMP et 10 contrôles appariés sur l'âge ont été recrutés dans la cohorte Intercept (Maziade et al.). Les données préliminaires montrent de plus faibles performances pour certains EHR dans la condition TT à la tâche TIM. Ils montrent aussi moins de facilitation AV que les participants contrôles à la tâche IMS. Les présents résultats indiquent que des anomalies des TIM/IMS sont observables chez les EHR, soutenant l'hypothèse qu'ils pourraient constituer des endophénotypes de risque pour aider au dépistage précoce de la vulnérabilité aux GMP. De plus, les deux nouvelles tâches développées se sont avérées valides, sensibles aux altérations précoces du développement du soi. Elles sont également ludiques, brèves, sans réponse verbale, les rendant utilisables pour le dépistage des GMP dans des populations nordiques.

INFLUENCE DE LA NORDICITÉ SUR LE MÉTABOLOME DE VÉGÉTAUX : INVESTIGATION PHYTOCHIMIQUE D'HUILES ESSENTIELLES NORDIQUES

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Dans le contexte actuel de changements climatiques, certains écosystèmes subissent d'importantes modifications. Les écosystèmes nordiques sont particulièrement affectés. Certaines espèces végétales s'établissent dans des régions de plus en plus nordiques en profitant d'un climat de plus en plus chaud, entraînant des perturbations qui ont un impact important sur les espèces végétales et animales de ces milieux(1). D'un autre côté, ces plantes qui colonisent les écosystèmes nordiques vivent des stress climatiques et environnementaux différents de ceux des mêmes espèces végétales retrouvées à des latitudes plus basses. Le métabolome des plantes, soit les métabolites produits par ces organismes, est fortement influencé par les facteurs biotiques et abiotiques. Les stress environnementaux et climatiques différents peuvent engendrer des modifications importantes de la composition moléculaire des végétaux. Tout particulièrement, les huiles essentielles produites par les plantes sont sujettes à être fortement influencées par ces stress puisque les plantes les produisent pour des raisons de défenses et de protection vis-à-vis des facteurs externes(2). Ainsi, l'étude des huiles essentielles, qui sont des mélanges complexes de molécules organiques volatiles, est un sujet fascinant et prometteur en contexte nordique. Puisque la production d'huile essentielle requiert des quantités importantes de matières végétales, la sélection des plantes à l'étude dans ce projet s'est faite sur la base de la disponibilité de la ressource, tout en prenant en compte l'intérêt de ces plantes (utilisation traditionnelle, activités répertoriées, aspect novateur, etc.). Ainsi, trois arbustes abondants dans le nord du Québec qui font partie des espèces en progression vers les hautes latitudes ont été retenus : le thé du Labrador, le myrique baumier et le bouleau glanduleux. Le projet de recherche implique donc, d'abord, la préparation d'huile essentielle à partir des feuilles de ces plantes. Des rendements intéressants ont été obtenus avec ces matières végétales. Ensuite, ces huiles essentielles sont caractérisées, principalement par chromatographie gazeuse couplée à la spectrométrie de masse, pour en connaître la composition moléculaire. Les travaux préliminaires ont permis l'identification de plus de 85 % des composés observés. Des tests d'activités biologiques seront effectués afin de déterminer si des applications sont envisageables dans divers domaines comme la cosméceutique, la pharmaceutique ou l'industrie alimentaire. Les huiles essentielles des plantes récoltées en milieu nordique seront aussi comparées à celles obtenues des mêmes espèces récoltées à des latitudes plus basses, afin d'en observer des différences associées au niveau de nordicité. Parmi les visées de ce projet de recherche, on retrouve une volonté de valoriser la nordicité, de comprendre l'influence des stress environnementaux et climatiques sur le métabolome

et d'investiguer de nouvelles sources de produits naturels bioactifs, des composés qui présentent un grand intérêt dans plusieurs domaines. 1. Bhiry, N.; Delwaide, A.; Allard, M.; Bégin, Y.; Filion, L.; Lavoie, M.; Nozais, C.; Payette, S.; Pienitz, R.; Saulnier-Talbot, É., Environmental change in the Great Whale River region, Hudson Bay: Five decades of multidisciplinary research by Centre d'études nordiques (CEN). Ecoscience 2011, 18 (3), 182-203. 2. Fernandez, X.; Chémat, F., La chimie des huiles essentielles : tradition et innovation. Vuibert: Paris, 2012; p xi, 274 p.

"SENSOR-IN-FIBRE" OPTICAL PROBES FOR MOLECULAR SENSING IN THE GASTRO-INTESTINAL TRACT OF MURINE MODELS

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Obesity and cardiometabolic diseases (CMD) are major public health issues throughout the world. It is believed that the exponential rise in CMD incidence is due to numerous environmental factors, which are driving important changes in the gut microbiome. This microbial community that populates our intestinal tract plays a key role in nutrient and energy absorption but can also drive pathogenic mechanisms when its interaction with the host is disrupted. This understanding has highlighted the lack of predictive tools and biomarkers for diagnostic of various diseases within the medical field. Current analysis of the gut microbiota is mostly based on sequencing technologies to determine microbial composition and gene expression, while functional analyses are limited to surrogate markers of microbial activities through stool metabolites. The goal of this study is to develop a "Sensor-in-Fibre" probe with the capacity to detect key microbiome-derived molecules relevant to CMD pathogenesis in real-time in vivo. The optical probe takes advantage of evanescent fields generated on its peripheral interface to excite species-selective surface-grafted sensing nanomaterials that have varying fluorescent properties based on the target molecules present in the surrounding environment. As a model system, fluorescein isothiocyanate (FITC) functionalized with aminopropyltriethoxysilane (APS) was grafted on the periphery of an optical fiber, which was then successfully implanted in the gastro-intestinal tract of model rats, permitting in vivo pH measurements to be taken. This pH sensitive prototype will soon permit temporal in vivo measurements without inhibiting the mammal's routine. In time, this fibre will be combined with multichannel architectures and fluorescent sensing structures responsive to various microbial molecules, hence making this a flexible tool for sensing the intestinal microbiome with unprecedented resolution.

LIGHT-ACTIVATED HYBRID MATERIAL: TOWARDS A NOVEL LIGHT-DRIVEN MICROFLUIDIC PUMPING SYSTEM

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Over the last decade, microfluidic systems have been shown as a promising tool for improving both medical diagnostics and bio-sensing research through the development of technologies that aim to replace traditional macro-scale assays. The manipulation of small amounts of fluids to perform reactions, analysis, or fundamental investigations in biology, physics, or chemistry is an important challenge with great impacts on science, society, and economy; and the success in such operations requires

fine control of fluid motion at the micro-scale. This motion is mostly controlled by means of mechanical, electro-kinetic, hydraulic or pneumatic forces and usually relies on the implementation of external transducers, such as syringe pumps, valves, or electrodes. Even though the viability of these approaches has been demonstrated, the necessity of implementing external elements tends to require complicated off-chip components increasing the fragility of microfluidic devices, costs, and most importantly, limits their use in applications outside the laboratory setting. Recent advances in polymer science developing multi-responsive materials have proposed the use of these polymers as actuators in microfluidics systems, however, most of them have weak mechanical properties due to their porous structure, low reversibility and low responsivity, which limit their use as valves and pumping components in microfluidic systems. To overcome these limitations, this project proposes the development of a light-activated hybrid material based on plasmonic nanoparticles coated with a thermo-responsive polymer for being implemented as nano-actuators into a novel light-driven microfluidic pumping system. The high absorption cross-section of noble metal nanoparticles will significantly increase the response of the hybrid material as well as decrease power requirements for its implementation in a light-actuated microfluidic platform. This innovative system will be incorporated in a "Sensor-in-Fiber" intestinal probe to bring the solutes in contact with the sensing region and thus measure in vivo microbiota metabolites in the gastrointestinal tract of murine models to study how the changes in the gut microbiome are related to obesity and cardiometabolic diseases.

CHIP-SCALE POLARIMETER FOR PORTABLE INTERROGATORS IN DISTRIBUTED SENSOR NETWORKS

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State of polarization (SoP) is one of the essential properties of light. It conveys some unique information on optical sources and light-matter interactions. For example, measuring the SoP arising from sunlight scattering within the earth's atmosphere, we can obtain information on the particles, aerosols, and gases in the atmosphere. The SoP of light reflected by the ground can help us identify the material of the ground (Water? Ice? Snow? Frozen soil? Or others?) according to the variation of the SoP. Monitoring the SoP of the sunlight under the water, we not only can know the quality of the water (such as the concentration of microbes within the water) but also can get the thickness of the ice on the top of the water. Therefore, the polarization sensor (usually named polarimeter) is a useful tool for characterizing and understanding the environment. The bulky and costly discrete optical components used in conventional polarimeters limit their broad adoption. Nanophotonic structures and integrated photonic circuits can, in many circumstances, replace traditional discrete optical components for miniature polarimeters and chip-scale polarimetry systems, and thus significantly improve robustness while minimizing footprint and cost. Here, we will introduce how to build and optimize a chip-scale polarimeter in the silicon photonics circuits. Then we will propose and experimentally demonstrate several silicon photonic division-of-amplitude polarimeters (DOAP) which are fabricated by the CMOS-compatible photonic fabrication process. The further theoretical examination is performed to compare the performance of the proposed devices, and the result reveals that within the optimal measurement frames for full-Stokes polarimeters, the DOAP with four PDs has the minimal equally-weighted variance compared to those with a greater number of PDs. To the best of our knowledge, the proposed four-photodetectors DOAP is the first demonstration of a chip-scale, solid-state full-Stokes polarimeter with an optimal measurement frame in the presence of the additive white Gaussian noise and the signal dependent shot noise. The proposed solid-state polarimeter is a system-on-a-chip with exceptional compactness, stability, and speed so that it will have a vast potential for portable interrogators in distributed sensor networks.

STUDY OF BREATHING PIEZOMETERS OF THE IMMATSIAK NETWORK IN THE DISCONTINUOUS PERMAFROST ZONE AT UMIUJAQ, NUNAVIK, CANADA, DUE TO AIR MASS MOVEMENT WITHIN AN AQUIFER

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As part of the Réseau de suivi des eaux souterraines du Québec (RSESQ) for monitoring the impacts of

climate change on groundwater, a subnetwork, called the Immatsiak network, was installed in summer 2012 in a small watershed in the discontinuous permafrost zone near the Inuit community of Umiujaq in Nunavik, Canada. A total of nine piezometers to monitor groundwater levels were drilled in the watershed. Three piezometers are located in an upper unconfined aquifer in a surficial unit of littoral and pre-littoral sands while the six other piezometers are in a lower aquifer in glaciofluvial and glacial sands and gravels. This second aquifer is confined downstream of the watershed by a unit of low-hydraulic conductivity marine silts where isolated permafrost islets known under the name of permafrost mounds are found. The lower aquifer is unconfined upstream of the watershed and hydraulically connected to the ground surface within the recharge zone. Air inflow and outflow were observed in three piezometers in the lower aquifer. They are the only ones where a part of their screen is not fully submerged and above the groundwater table. Since the hydraulic conductivity of the lower aquifer is enough high, air mass movement can occur within the unsaturated zone of this aquifer due to differential air pressure. These air flows also induce noise in the variations of hydraulic heads measured in the piezometers with leveloggers even if the variations in atmospheric pressure were taken into account in the assessment of hydraulic heads. Moreover, the air mass movement in the lower aquifer may affect the dynamics of permafrost. As a complex hydrogeological system, two conceptual models were developed to explain air flows in the piezometers. The first one at the scale of piezometer locally disturbing the confined aquifer at depth under pressure or vacuum relative to the atmospheric pressure is based on the principle of a pierced air balloon (air expiring) or a pierced vacuum chamber (air inspiring). In the second model, the lower aquifer is rather considered as a whole. When high atmospheric pressure occurs, atmospheric air is infiltrating into the unsaturated zone of the aquifer through its hydraulic connection with the surface in the recharge zone upstream of the watershed. The reverse with air expelling happens when a low atmospheric pressure occurs. The air flows observed in the piezometers are therefore caused by air mass movement in the confined section of the lower aquifer downstream of the watershed. Air density gradients induced by temperature gradients in the aquifer may be also a source of air mass movement within the unsaturated part of the lower aquifer. To monitor the air inflow and outflow in the piezometers, the air temperature and difference in air pressure at depths of 0 and 2 m using thermistors and differential air pressure sensor are recorded in two piezometers since 2016. Air and ground temperatures, and atmospheric pressure, are also recorded. Using the Bernoulli equation, the velocity of air inflow and outflow in the piezometers is about 1 m/s.

REFRACTIVE MODAL CONTROL LIQUID CRYSTAL FRESNEL LENS

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Monitoring of permafrost is an issue of increasing significance in light of concerns about global warming. Degradation of permafrost can lead to such consequences as slope instability, damage to buildings, infrastructure and other hazards. That is why there is a need to improve our ability to detect and predict changes in ground movement dynamics. We are planning to design large aperture (at the order of 6 mm) electrically tunable liquid crystal lenses (TLCLs) which will be incorporated into cameras to increase the quality of observations. Liquid crystals (LCs) are materials with anisotropic optic and dielectric properties. They are widely used in electro-optical devices such as displays, variable optical attenuators. Controllable birefringence of LCs makes them suitable materials for construction of adaptive lenses. Electric field applied to a LC cell results in a torque to the induced dipole moment of the molecules, changing their orientation. A nonuniform reorientation of LC's director (a unit vector representing the local average orientation of long molecular axes of the LC) creates distribution of effective refractive index (close to parabolic) within the cell, which starts to act as a lens. Variation of applied voltage (or frequency) changes focal length of such a system. We are introducing a promising new concept of a refractive Fresnel LC lens that is based on a modal control principle. Two separate inner ring (indium tin oxide, ITO) electrodes are used along with an outer circular electrode to control molecular orientation and focus incident polarized light. A layer of semiconductor (weakly conductive layer, WCL) is deposited on the top glass substrate (facing inwards) to provide gradual decrease (and proper shape) of electric field within the LC cell. The entire clear aperture is divided into two separate zones, for which phase shifts are controlled independently. In the proximity to inner electrodes an abrupt rise of wavefront is achieved, resembling the one of conventional glass Fresnel lenses. The phase shift can be controlled with both voltage and frequency of applied signal. The dynamic range of optical power variation is of about 2.5 diopters. At the same time

the lens has a simple driver (simple manufacturing which also leads to low cost per unit), as only three electrodes are needed. Newly created cameras will enable us to perform adaptive imaging of ground surfaces at large distances and evaluate their positions (and their changes).

SEA SURFACE DIMETHYLSULFIDE (DMS) HOTSPOTS LINKED TO SEA ICE DYNAMICS AND SOLAR RADIATION IN A FINE-SCALE STUDY OF THE CANADIAN ARCTIC ARCHIPELAGO

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The sources and strength of dimethylsulfide (DMS) oceanic emissions, a climate-active biogenic gas, could be modified in the Arctic due to reductions in snow cover, sea ice extent and thickness. Understanding the impacts of climate change on DMS dynamics is crucial since DMS-derived sulfate is thought to be the main precursor of secondary marine aerosols that lead to cloud formation and therefore contribute to moderate solar energy input in the Arctic. Using a novel automated instrument (ACT-MIMS), DMS samples were collected at high frequency in the surface waters of the Canadian Arctic Archipelago (CAA) during the summer of 2017 (July-August) and 2018 (July) aboard the Canadian Coast Guard Ship Amundsen. More than 3500 DMS measurements were collected alongside ancillary measurements of sea surface salinity, sea surface temperature, fluorescence (chlorophyll a proxy), photosynthetically active radiation, sea ice concentration and the algal precursor of DMS, dimethylsulfoniopropionate. DMS concentrations ranged from ca. 0.2 to 43.0 nmol L-1 (average of 8.1 nmol L-1) in 2017 and from ca. 0.8 to 55.0 nmol L-1 (average of 13.7 nmol L-1) in 2018 over an area covering a wide range of contrasting marine environments from coastal to open ocean ice-free waters, as well as under-ice waters. Surface water DMS hotspots were measured at the ice edge and in marginal ice zones, as well as in ponded first-year ice (FYI) areas. This suggests the synthesis of DMSP by sea-ice algae in response to environmental stressors such as solar radiation or large variations of salinity or sea surface temperature due to ice melt. Nighttime increases and daytime decreases in DMS concentrations were observed in the northern Labrador Sea and Davis Strait. The relationship between DMS concentrations and diurnal solar radiation variations suggests the involvement of photobiological processes. Overall, our results strengthen the view that the cycle of marine DMS in the Arctic is closely related to sea ice dynamics and physiological responses to light. As such, future changes in the seasonality of the Arctic cryosphere are likely to play an important role in shaping DMS emissions, although the sign and magnitude of this change remain highly uncertain.

SEGMENTED LIQUID CRYSTAL LENS FOR ABERRATIONS CORRECTION IN ENDOMICROSCOPY

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Aberrations and light scattering are the most common limitations for thick tissues imagery. The scattering can be reduced by using rod gradient index (GRIN) lenses. We have developed a lens design (based on liquid crystals) with eight independent electrodes that can be used to manipulate the wavefront in an optical micro imaging system. This can be used in combination with the rod GRIN lens to compensate aberrations. Firstly, we have demonstrated that the aberrations that appear with a high optical power in those lenses have been partially compensated. This correction has been demonstrated with a Shack-Hartmann sensor by decreasing Zernike coefficients. The results show a 40% reduction of total RMS wavefront error. Then, the same drive signals have been applied on electrodes while imaging a calibration target. This resulted in an increase of resolution (a maximum of 60% of improvement in specific areas of the Field of View) and contrast as well as reduction of distortion in the global image. Secondly, a piece of glass with non-homogeneous optical glue has been placed on top of the target to add aberrations (simulating the imaging thought nonuniform media). We were able to increase the contrast and the resolution of the system (two times on some area of the field of view) by means of additional adjustment of drive signals over various segments of the electrode. The distortion was also compensated. Those

lenses of 550 μm of clear aperture are well suited for endomicroscopy imagery and will be implemented in one of these devices in the near future.

UNDER-ICE BIO-OPTICAL PROPERTIES AND PHYTOPLANKTON COMMUNITIES IN STRATIFIED LAKE ECOSYSTEMS OF THE CHANGING HIGH ARCTIC

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Arctic regions are experiencing warming at a faster rate than other parts of the planet with a result of losses of ice and snow. One of the thickest ice covers was recorded over Ward Hunt Lake (WHL), Canada's northernmost lake, which maintained a perennial ice cover around 4 m thick for about 60 years from the 1950s. This ice cover rapidly decreased from 2008, with complete loss in the summers of 2011, 2012 and 2016. This loss can result in pronounced ecological shifts caused by wind-induced mixing, changes in water temperature and oxygen, and light availability on primary production. WHL and other high Arctic lakes provide excellent models to study the impacts of climate change on aquatic ecosystems. A Canada-Japan project under the auspices of Sentinel North is being carried out in the Ward Hunt Island region to understand the responses of limnological characteristics, bio-optical properties and phototrophic communities in high Arctic lakes to climate change. CTD, oxygen profiles, incident and upwelled light spectra were obtained at mid-lake sites in WHL and Lake A, in mid July 2016. Lake A was covered by 92 cm of ice, with a layer of freshwater then extending to 12 m, then, a transition zone of rising salinity was characterized by a sharp drop in oxygen, and increasing temperature. This oxyline overlaid the upper anoxic zone, and the lower anoxic layer extends to the maximum depth of the lake (128 m), with cooling temperatures and a salinity close to that of Arctic Ocean seawater. Profiling of WHL showed that its water column was also stratified. WHL was overlain by a 162 cm layer of ice, and although the water column was entirely freshwater, salinities increased with depth. The middle of the water column was homogenous in salinity, with supersaturated concentrations of oxygen. The deepest waters showed increased salinity towards the bottom of the lake (9.7 m). Light spectra in Lake A indicated strong absorption in the UV waveband in the upper layer of the water column (extinction coefficient, kd = 0.82 m^-1) compared with WHL (kd = 0.31 m-^1). In Lake A, kd in 400–500 nm derived from absorption by chlorophyll and carotenoids increased from 15–20 m to 20–29 m, indicating high concentration of phytoplankton in this zone. In WHL, the kd was higher in all wavebands at an open water moat site when compared to the mid-lake site, indicating resuspension of particles by wind-induced mixing and the inflows from water tracks through the permafrost. At the mid-lake site of WHL, the kd for the UV and 400–500 nm wavebands increased in the deeper zone (3–9 m depth), suggesting high concentrations of coloured dissolved organic matter (CDOM) and phytoplankton. Upwelling light measurements indicated that the 560–580 nm waveband increased considerably, possibly as a result of fluorescence by cyanobacterial phycobiliproteins. We will evaluate these results in combination with pigment composition and CDOM concentrations in the water column, and will examine the potential responses of aquatic organisms and optical properties to ongoing climate change in the High Arctic.

DEVELOPMENT OF A SYSTEMIC APPROACH TO IDENTIFY INDICATOR SPECIES IN THE EAST BOREAL FOREST OF CANADA

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Climate change should have severe impacts on ecosystems, notably by modifying the net primary productivity and disturbance regimes in the boreal forest. These new conditions should have direct and indirect consequences on birds' species assemblages.

Our study aims at identifying indicator species of species assemblages depending on the biotic and abiotic conditions in order to test their ability to predict the species richness with changing environmental conditions. We used point count data from the birds breeding Atlas and null model statistical approach to identify species cooccurrence pattern in respectively 6 and 7 climatic regions of Ontario and Quebec. These regions have been identified with cluster analysis and ordination on the meteorological data corresponding to the bird's inventory years (using the BioSim software from Natural Resources Canada). Then we selected the best linear regression model with stepwise selection to be able to choose the best group of species able to predict the highest species diversity with the least number of species, for each province and each region. Further sub-regions were created using forestry and anthropogenic and natural disturbances data from the Canadian National Forest Inventory (CNFI) forest cover maps that have been taken in 2001 and 2011 with 250 m resolution. The satellite image was updated every year with information on forest harvesting and wildfire. We were able to identify a group of 39 species in the provinces of Quebec and Ontario predicting respectively 86% and 87% of the bird's diversity which represent a total number of 217 species. Additionally, we found that among those 39 indicator species, 29 were the same in both provinces. However, the indicator potential changed among the climatic region. While the Common Raven (Corvus corax) for example was a good indicator species either in the warm and in the cold region of Quebec. The Tennessee Warbler (Leiothlypis peregrina) was only a good indicator species in the cold region of Quebec. Regarding their habitat preferences, most indicator species in both provinces were found preferably in mature softwood forest but some were either generalist or found only in young hardwood forest like the Savannah Sparrow (Passerculus sandwichensis). The next step of this study will be to identify how functional traits are distributed among a bird's assemblage and indicator species and how they may change with environmental conditions. Finally, we will evaluate how anthropogenic and natural disturbances could change the indicator potential of the bird studied. Our results suggest that we can select a small subset of the total number of species found in the boreal forest of Quebec and Ontario, to predict most of the birds' diversity. Furthermore, as these species seems to change differentially with environmental conditions, we can expect some important turnover in indicator species associated with global change.

INTESTINAL MICROBIOME LOSS AFFECTS HEPATIC BILE ACID HOMEOSTASIS, AND LEADS TO ALTERED BILE ACID POOL COMPOSITION AND IMPAIRED BILE ACID DETOXIFICATION

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Bile acids (BAs) are formed from cholesterol exclusively in the liver, stored in the gall-bladder and secreted in the intestine during meals. In the intestine, BAs serve not only as emulsifiers for dietary fat absorption, but also as signalling molecules involved in a feedback mechanism allowing BAs to control their own synthesis in the liver. In addition, BAs and the intestinal microbiome are closely related to one another. While several BAs act as natural antibiotics to maintain the diversity and functionality of the microbiome, enzymes from the microbiome play essential roles in converting hepatic primary BAs into biologically active secondary acids. Overall, these observations suggest that the intestinal microbiome is a major controller of the BA pool composition. Accordingly, several studies showed that, in contrast to feces from conventionally-raised (CONV-R) animals, which were mainly composed of unconjugated-BAs, those from germ-free (GF) animals are highly enriched in taurine-conjugated primary BAs. Beyond its impact on fecal BA profiles, how the loss of intestinal microbiome impacts BA homeostasis in the liver has received only little attention. To address this question, we performed a comprehensive study aimed at comparing BA-related transcriptomic and metabolomic signatures of livers from CONV-R and GF mice. Livers from male— and female- (4 or 8 months-old) Swiss Webster GF or CONV-R mice were collected at sacrifice. Total RNA and proteins were isolated and BA-related gene expression was assessed through quantitative RT-PCR and western-blotting analyses. In parallel, more than 37 BAs were monitored in those livers, using LC-MS/MS quantification. Among the BA-synthesizing enzymes analyzed, only mRNA levels of the 12alpha-hydroxylase (i.e Cyp8b1) were significantly increased in both male (1.7-fold) and

female (1.6-fold) GF animals when compared to CONV-R. The rate limiting Cyp7a1 enzyme remained unaffected. Interestingly, a strong sex-related dimorphism was observed since the expression of several BA transporters (Bsep, Ntcp, Mrp2&3) was only induced in females. A similar observation also applies to the BA detoxification system, where only tissues from female GF mice displayed higher Ugt2b37 (8-fold) and Sult2a1 (3-fold) mRNA levels. The hepatic BA profile also revealed several major differences: livers from GF animals contained 3-times more bile acids, which actually reflected a 3.6-fold accumulation of taurine-conjugated BAs. While secondary acids were almost totally absent from GF samples, primary BAs were accumulating either as unconjugated (4.4-fold) or taurine-conjugated (5-fold) forms. The BA species which sustained the deeper change (7-fold accumulation) was the primary conjugated tauro-beta-muricholic acid. Overall, this study demonstrates that beyond the microbiome-catalyzed biotransformation of BAs in the intestine, the loss of intestinal microbiome also deeply affects hepatic expression and activity of genes controlling BA synthesis, transport and metabolism. Further studies are required to fully grasp patho-physiological consequences of such changes.

CHEMICAL, BIOCHEMICAL AND FUNCTIONAL CHARACTERIZATION OF NOVEL ENDOCANNABINOID METABOLITES FROM OMEGA-6 AND OMEGA-3 FATTY ACIDS

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Endocannabinoids (eCBs) are endogenous lipids mimicking most of the effects of cannabis, notably on brain functions, appetite, pain and inflammation. eCBs and eCB-like compounds contain fatty acids and are classified into two main groups: the eCB-glycerols and the eCB-ethanolamides. Each fatty acid leads to two eCBs or eCB-like lipids. For example, arachidonic acid (omega-6) leads to 2-arachidonoyl-glycerol (2-AG) and arachidonyl-ethanolamide (AEA), linoleic acid (omega-6) leads to 2-linoleoyl-glycerol and linoleoyl-ethanolamide, and docosahexaenoic acid (omega-3) leads to 2-docosahexaenoyl-glycerol and docosahexaenoyl-ethanolamide. Like arachidonic acid, 2-AG and AEA are metabolized by the cyclooxygenase and the 15-lipoxygenase pathways. As such, we postulated that eCBs containing fatty acids other than arachidonic acid would be metabolized by the 15-lipoxygenase pathway. This is important because the 15-lipoxygenase pathway participates in several inflammatory diseases and because food intake differs in fatty acid composition in northern populations. These putative 15-lipoxygenase-derived metabolites have never been documented. Our objectives were to investigate whether eCBs, other than those derived from arachidonic acid, are metabolized by the 15-lipoxygenase pathway and if they can be synthesized by 15-lipoxygenase-expressing cells. We developed several methods allowing for the synthesis of eCB-Glycerols, eCB-ethanolamides and their 15-lipoxygenase-derived metabolites. We also assessed if freshly isolated human leukocytes expressing 15-lipoxygenase enzymes could generate our novel metabolites. We also investigated whether these putative metabolites were present in vivo. We successfully developed chemical methods to synthesize eCBs and their deuterated derivatives. We also successfully developed a method to synthesize their putative 15-lipoxygenase metabolites. Notably, our methods work for all eCBs trialled so far. In addition, our data indicate that human eosinophils (which express the 15-lipoxygenase-1) and neutrophils (which express the 15-lipoxygenase-2) generate those never documented metabolites in a time- and concentration-dependent manner. Furthermore, we detected some of these novel compounds in the gastrointestinal tract of mice, confirming that their synthesis occurs in vivo. We are now exploring which cellular receptors they activate and how they might modulate physiological responses. We provide robust evidence that eCBs other than 2-AG and AEA are metabolized by the 15-lipoxygenase pathway, that human leukocytes can synthesize them, and that they are found in mice. We are the first group to document these metabolites. They likely participate and/or prevent inflammatory diseases, notably those involving the 15-lipoxygenase pathway. Their presence and effects deserve a thorough investigation. Funded by the Unité mixte internationale, Sentinel North and la Chaire d'excellence en recherche du Canada sur l'axe microbiome-endocannabinoïdome dans la santé métabolique.

MISE EN ŒUVRE DE CELLULES SOLAIRES ORGANIQUES À PARTIR DU PPDT2FBT ET DE SOLVANTS « VERTS »

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L'énergie solaire sera une énergie renouvelable hautement convoitée pour pallier la constante augmentation de la demande énergétique du 21e siècle. À travers les différents domaines de recherche qui lui sont associés, celui qui a trait aux matériaux photovoltaïques « verts », peu coûteux et efficaces, constitue un sujet grandissant. Parmi ces matériaux, les molécules organiques π-conjugués, tels que les polymères et les oligomères, peuvent avoir des propriétés de semi-conducteur et absorber la lumière dans la région du visible. Ils rejoignent les avantages des semi-conducteurs et des polymères organiques avec leurs propriétés mécaniques ainsi que leur solubilité. Pour ces raisons, ces molécules sont grandement à l'étude dans le domaine des cellules solaires organiques (CSO). Ces dispositifs sont particulièrement intéressants à des fins d'applications pour des instruments portatifs, où la masse du dispositif est cruciale. De plus, les propriétés mécaniques des polymères permettent la mise en œuvre sur des substrats flexibles, légers et robustes, ce qui facilite le transport et l'utilisation des dispositifs dans le Nord. En effet, les régions nordiques sont connues en raison de leurs conditions glaciales, ce qui pourrait endommager des dispositifs non résistants. Jusqu'à présent, des performances allant jusqu'à 15,6 % de conversion de puissance énergétique (CPE) ont été observées pour des CSO comportant une seule couche active. Ces dispositifs peuvent être fabriqués à grande échelle à la suite de la formulation d'encre de polymères, puis imprimés en continu par jet d'encre ou par le processus de rouleau. Parmi les différents défis à surmonter, les coûts synthétiques et la mise en œuvre dans des solvants dits « verts » sont des aspects importants à la mise à l'échelle de cette technologie. De ce fait, on s'intéresse à un copolymère de benzothiadiazole fluoré, le PPDT2FBT, puisqu'il permet de joindre l'obtention de bonnes performances à la simplicité synthétique ainsi que celle de fabrication de dispositifs. Dans un premier temps, nous avons développé la synthèse de ce polymère en flux continu par polymérisation par (hétéro) arylation directe (PHAD). La synthèse en flux continu est particulièrement intéressante, puisqu'elle est plus facile à reproduire à grande échelle que les synthèses « classiques » en vials. La fabrication de cellules photovoltaïques a ensuite été effectuée en prenant en compte certains critères de la mise à l'échelle, comme le choix de solvant. Il est également important d'avoir des performances indépendantes de l'épaisseur de la couche active du dispositif, car les techniques d'impression comportent une certaine incertitude par rapport à ce paramètre. Finalement, de nouveaux matériaux de type n ont été testés dans la couche active des dispositifs. Ces matériaux hautement performants permettraient d'augmenter l'efficacité des dispositifs. Au final, de la synthèse à la fabrication de dispositifs photovoltaïques, nos recherches ont montré une avancée prometteuse pour la mise à l'échelle des CSO.

WHAT THE AQUATIC MICROBIOMES OF STUCKBERRY VALLEY CAN TELL US ABOUT ENVIRONMENTAL CHANGES IN HIGH ARCTIC LAKES

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Many studies have shown that even the world's most northern ecosystems have been affected by climate warming, and High Arctic lakes are excellent indicators of this environmental change. Ellesmere Island is at the northernmost limit of Canada, and regime shifts towards taxa associated with longer growing seasons and warmer conditions have already been documented there. It has been projected that the northern coast of Ellesmere Island will experience the greatest annual warming in Arctic North America over the next 80 years, so it is imperative to study the intricate workings of its ecosystems before further changes occur in order to understand their current functioning and predict future responses to environmental change. Our transdisciplinary team is studying the microbiomes of a series of four northern Ellesmere Island lakes in Stuckberry Valley (82º54 N, 66º56 W) to give insight into High Arctic aquatic ecosystems and

geosystems and their role in the global climate system. These lakes are an excellent example of the complex environments found in the North, revealing a surprising diversity of ecosystem types. Shallow lakes (7-9 m deep) had hypoxic to anoxic waters below spring ice and a sulfuric smell, while deeper lakes (27-49 m) contained fully oxygenated water columns and in one of the lakes, Arctic Char was present. The goals of this study are 1) to identify and quantify the phytoplankton community composition of each lake using High Performance Liquid Chromatography (HPLC) pigment analysis, 2) to determine how the physical and chemical properties of the lakes affect each separate microbiome, and 3) to improve the understanding of High Arctic aquatic environments in the context of accelerating climate warming. As part of a multidisciplinary project combining researchers from several fields of study, this research will address a knowledge gap about microbial ecology in High Arctic lakes, and pave the way for on-going and future paleolimnological studies on these lakes that will further the understanding of the response of extreme northern environments to climate warming.

THE INSTRUMENTS DEVELOPMENT TECHNOLOGY PLATFORM— EXPERTISE, CAPABILITIES AND HOW IT CAN HELP YOU REACH YOUR PROJECT'S GOALS

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With more than 100 years of combined experience in various fields of expertise, the team of Sentinel North's Instruments Development Technology Platform has made it its mission to help the program's transdisciplinary community reach or even exceed its projects objectives. The Technology Platform team members' expertise includes many domains, such as microelectronics, optics, microbiology, mechanical design and fabrication, systems engineering, environmental testing, regulatory compliance, systems development for extreme environments, like space systems and implantable devices. This presentation will describe the resources and the capabilities of the Technology Platform, as well as when, where and how it can support the project's teams, or any person or organization involved in the Sentinel North program.