



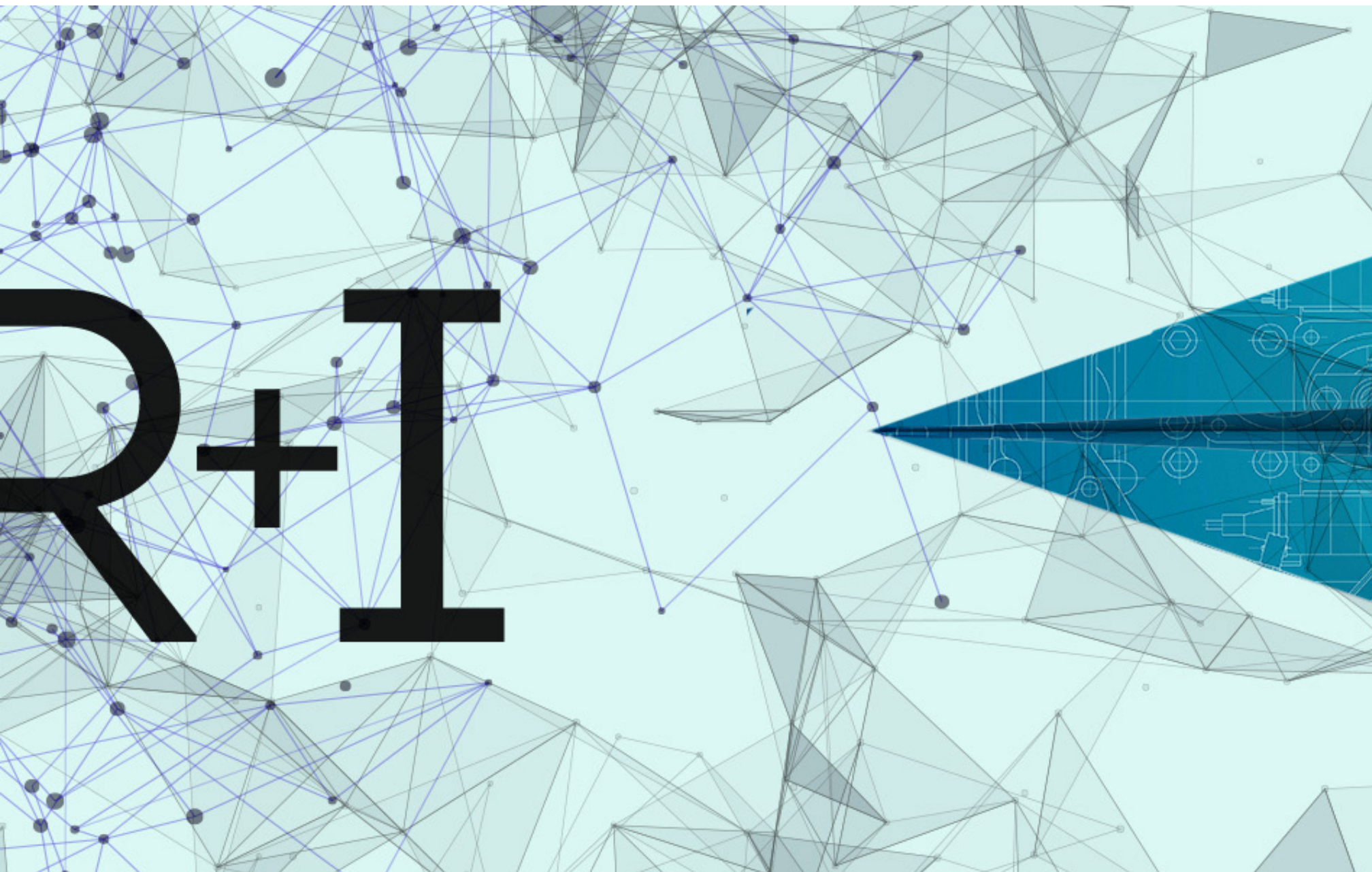
McGill

Research and
Innovation

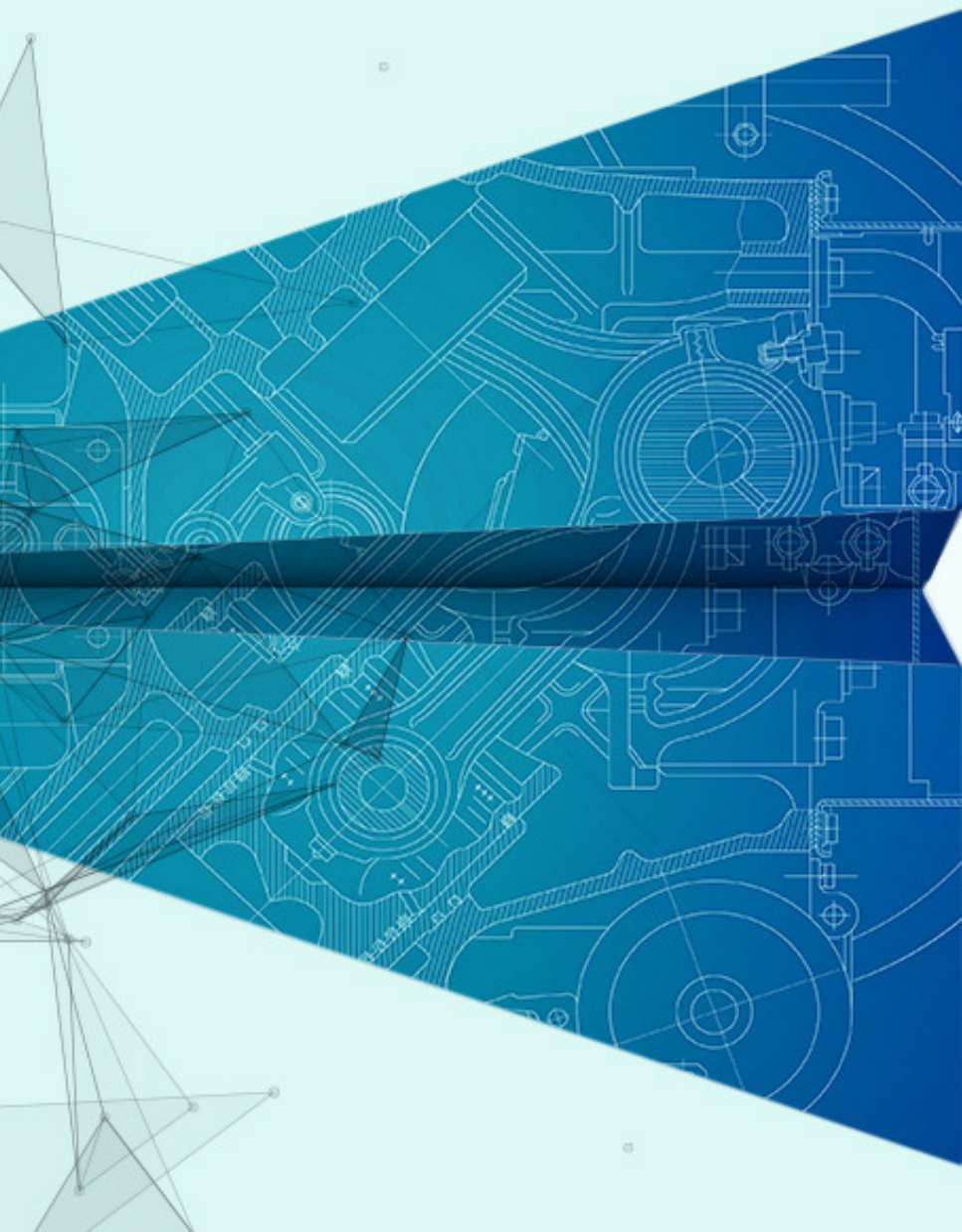
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MCGILL STRATEGIC RESEARCH PLAN





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MCGILL STRATEGIC RESEARCH PLAN

EXECUTIVE SUMMARY

For close to two centuries, McGill University has attracted some of the world's brightest researchers and young minds. Today, McGill remains dedicated to the transformative power of ideas and research excellence as judged by the highest international standards.

The Strategic Research Plan (SRP) expresses McGill's commitments to fostering creativity; promoting innovation; problem solving through collaboration and partnership; promoting equity, diversity and inclusion; and serving society through seven identified Thematic Areas of Research Excellence.

McGill is a large, diverse institution with research activities spanning two campuses, 10 Faculties, multiple hospitals, research centres and institutes. It is home to more than 1,700 tenured or tenure-track faculty members. Defining Research Excellence Themes that cut across these entities is a difficult but necessary challenge to promote areas of collaboration with partners, attract people and resources, and envision a research future emerging from existing strengths. To that end, we have identified seven Research Excellence Themes, which strive to:

- Develop knowledge of the foundations, applications, and impacts of technology in the Digital Age
- Understand the potential of the human brain and nervous system
- Design and create sustainable materials, technologies, landscapes, and communities

- Advance biomedical and health sciences for healthy populations
- Strengthen public policy and organizations, and create a deeper understanding of society and social transformation
- Explore Earth's biological and physical systems and the universe
- Examine fundamental questions about humanity, identity, and expression

The SRP lays the groundwork for McGill to reach into the future by enhancing its research capabilities, building and strengthening its strategic relationships, and growing its societal impact through knowledge mobilization beyond academia.

The SRP also aims to promote exciting and creative responses to new challenges and opportunities as the research landscape and the social, cultural, economic, and technological realities of our world change.





A researcher works in the McGill Nanotools Microfab (MNM), a state of the art facility in micro and nano-technology. Ultraviolet (UV) blocking filters create an environment suitable to the UV-sensitive photoresist, which is used to pattern micro or nanometre sized structures.

SECTION 1

INTRODUCTION AND OVERVIEW

VISION

McGill is a world-class research-intensive, student-centred university with an enduring sense of public purpose. We are guided by our mission to carry out research and scholarly activities that are judged to be excellent by the highest international standards. Our researchers ask important questions and contribute within and across disciplines to address the most pressing and complex challenges facing humanity and the natural environment in the 21st century.

Fundamental to realizing this vision is the expansion of a culture that nurtures and facilitates research excellence, enabling faculty and student researchers to explore rich intellectual pursuits, respond to new global realities and co-create knowledge with partners that will have impacts at local, national, and global scales.

This Strategic Research Plan (SRP) expresses McGill's core commitments to research, identifies ongoing Research Excellence Themes, and outlines our implementation strategy and objectives over the next five years.

ACHIEVING OUR GOALS

McGill has a strong history of achievement, consistently ranking as one of the top universities in the world across a wide range of disciplines and subject areas. We are renowned for attracting some of the brightest researchers and young thinkers, who contribute immensely to the advancement of knowledge.

This SRP reaffirms our dedication to the transformative power of ideas and research excellence. To these ends, we commit to:

- Fostering creativity
- Promoting innovation
- Problem solving through collaboration and partnership
- Promoting equity, diversity and inclusion
- Serving society

This document goes on to describe the scope and reach of McGill's research enterprise through each of seven Research Excellence Themes. The Research Excellence Themes describe ongoing research but they are also forward looking and imbued with aspirational goals, for example, of advancing technology to improve the human condition, reducing disease burden and building sustainable societies. Under each of the Research Excellence Themes the reader will find examples, provided by our research community, that are intended to bring the Research Themes to life. The final section identifies strategic objectives designed to enhance McGill's ability to provide distinctive contributions to research, teaching and training, and community engagement, both locally and beyond. These objectives build on the University's ongoing and continued efforts to streamline administrative procedures, increase opportunities for interdisciplinary collaboration, and explore new organizational models for strategic research teams.

Overall, the SRP aims to extend the global impact of our research activities, encourage new and stronger partnerships, deliver quality research experiences for trainees, and help McGill tap into the worldwide pool of knowledge while contributing to its advancement.



THE UNIQUE CHARACTER OF MCGILL RESEARCH

Founded in 1821, McGill is a research-intensive university with a history of producing important contributions to the arts and humanities, science and technology, and health. The University both belongs to the world and is firmly rooted in Montreal—a global destination for scholarship and a city where different languages, cultures, and perspectives not only co-exist, but come together to create a unique community that is stronger because of its diverse parts.

McGill University is located on land, which has long served as a site of meeting and exchange among Indigenous peoples, including the Haudenosaunee and Anishinaabeg nations. McGill honours, recognizes, and respects these nations as the traditional stewards of the lands and waters on which we stand today.

McGill benefits immensely from its place at the centre of a vibrant hub of intellectual, cultural, and scientific activity. In addition to Montreal's many academic institutions, major government laboratories and research-intensive industry are situated in the city. These organizations anchor research clusters in life sciences, sustainable resource utilization, aeronautics, and artificial intelligence.

The intellectual and cultural vitality of Montreal contributes to McGill's ability to attract the very best faculty members and students from Quebec, Canada, and around the world. It is telling that McGill consistently recruits undergraduates with the highest entering grades in the country and has the largest percentage of international students among Canada's top research-intensive universities. McGill nurtures this talent by placing a special emphasis on the nexus between research and education, recognizing that top students at all levels are inspired by

novel ideas and practices and are the leaders of the future. McGill has a comparatively high ratio of graduate to undergraduate students, a metric fitting of a research-intensive university that prioritizes the training of the next generation of researchers. It simply cannot be overstated that graduate students and postdoctoral researchers are fundamental to the University's research enterprise and that their support and training are vital to the University's research mandate.

PURPOSE OF THE DOCUMENT

The SRP informs the University's strategic distribution of Canada Research Chairs (CRC), applications to Canada Excellence Research Chairs (CERC), and Canada Foundation for Innovation investments. It is also a reference for promoting our world-class researchers and students to our public and private supporters. For a summary of McGill's current CRC allocation and projections, see Appendix 1.

The spirit of the document aligns with the Principal's Priorities, the Strategic Academic Plan 2017-2022, the Final Report of the Provost's Task Force on Indigenous Studies and Indigenous Education 2017, the University's Vision 2020 Climate and Sustainability Action Plan 2017-2020, as well as strategic research priorities from our Faculties and affiliated hospitals. Finally, implementation strategies included here rely on institutional commitments to increase efficiency and connectivity across a broad spectrum of University endeavours.

The SRP provides McGill faculties, departments, centres, institutes, and individual researchers with the freedom and flexibility necessary to pursue their specific goals in the context of the University's strategic vision.

SECTION 2

CORE COMMITMENTS

The following five core commitments illustrate McGill's dedication to the pursuit of research excellence. We believe that fundamental research extends the boundaries of knowledge so that it can inform problem-focused research and equip us to respond to new challenges as they emerge. There is no single metric that effectively measures the success of research and its impact on society. We recognize that all forms of research outputs advance knowledge and affect society, either directly or indirectly, and contribute to social, economic, environmental, or cultural benefits.

FOSTERING CREATIVITY

Universities are grounded in a long history of reflection and inquiry in all aspects of the arts and humanities, science and technology, and health. Wherever research may ultimately lead, all advances begin with creative ideas. McGill has been an active participant in this tradition for almost two centuries, and we strongly believe that universities must continue to be spaces where leading minds are free to pursue discovery and create new knowledge.

PROMOTING INNOVATION

Increasing the emphasis on innovation in all its forms—social, pedagogical, and organizational as well as through the development of new products and processes—allows us to play a leading role in a knowledge-based society. We invent and we increase the impact of research by translating the results into social and commercial applications. This translation can take many forms—communicating research discoveries to decision-makers, transferring knowledge and know-how, protecting ideas and inventions, licensing discoveries, and creating new spin-off companies or non-profit organizations.

PROBLEM SOLVING THROUGH COLLABORATION AND PARTNERSHIP

McGill is dedicated to facilitating mutually-rewarding research partnerships across academic fields, both on our campuses and with external partners. Our researchers collaborate with community organizations, citizens' associations, as well as with government and industry partners. Partnerships and team approaches often require extra organizational effort and special institutional support. These efforts are necessary to deliver benefits of partnerships which may include enriched research endeavours and outputs as well as new opportunities for applied learning experiences for students. Bringing together leaders – regardless of discipline, background, or affiliation – can generate new ideas and approaches. At home and abroad, our faculty and students build bridges with colleagues from other leading research institutions, governments, private industry, and community—based organizations.



A McGill researcher in the Department of Geography walks at “Stolz Diapir”, a field site located at Whitsunday Bay on the southeast corner of Axel Heiberg Island, in Nunavut.

PROMOTING EQUITY, DIVERSITY, AND INCLUSION

Research excellence and equity go hand in hand. The underrepresentation of voices among our researchers and students is an unacceptable loss of human potential that we are striving to overcome. True and full inquiry into all aspects of the arts and humanities, science and technology, and health happens when the visions, experiences, knowledge, traditions, and epistemologies of multiple peoples are embraced.

SERVING SOCIETY

McGill researchers apply their ingenuity and creativity in service to society. Drawing on the strengths and expertise of different stakeholders, they co-create and apply evidence-based research to address shared challenges; guide and develop policies, practices and products; provide innovative learning environments and professional experiences for students at all levels; improve professional practices; and seek out and support initiatives that result in tangible improvements for individuals and communities.

SECTION 3

RESEARCH EXCELLENCE THEMES

The seven **Research Excellence Themes** group McGill researchers into broad areas of strategic importance. The themes are not perfectly orthogonal; in other words, some research areas could fit into multiple themes. For example, features of *Impacts of Technology in the Digital Age* appear in multiple themes, because many research areas are experiencing technologically-driven paradigm shifts. The set of themes imperfectly accounts for the full diversity and complexity of research strengths at McGill but their breadth allows for most faculty members to find themselves reflected within them. Together the themes will be used as a roadmap for setting institutional-level objectives and supporting both disciplinary and interdisciplinary research. Our nomenclature is designed to help generate and reinforce novel linkages that address issues of local, regional, and global importance. The Research Excellence Themes are, by necessity, broad ways of grouping areas of strength and strategic importance and so our researchers have written a few emblematic **examples of research areas** that fit within the themes. These examples are by no means exhaustive - they are intended to allow the reader insight into some of McGill's varied research endeavours within the themes. We would like to thank all of the researchers who kindly provided these examples.

1) DEVELOP KNOWLEDGE OF THE FOUNDATIONS, APPLICATIONS, AND IMPACTS OF TECHNOLOGY IN THE DIGITAL AGE

One of the distinguishing features of humans is our ability to build technologies in the hope of improving our collective condition. Pure science, applied mathematics, algorithms, and software provide foundations

that enable new discoveries of components, tools, and applications ranging from large-scale transportation systems to new manufacturing technologies to small-scale digital communication systems. Profound changes have occurred in the ways in which we interact using technology and in our expectations of what technology will deliver in terms of speed and content. Advances in broadband and communication technologies continue to expand communication between non-humans—the “Internet of things”—while advances in machine learning and artificial intelligence open up new ways for humans to communicate with and rely on machines for an increasingly broad range of tasks. Even before recent technological advances—digital media, big data, and the use of wireless and optical networks—questions, such as “How do we make sense of the previously unimaginable amounts of information now at our fingertips?” and “How can individuals, businesses, and organizations utilize technologies to improve how they function?” have long been at the centre of McGill research. Our work in the fields of mathematics, physics, and engineering enables a wide spectrum of industrial-technological applications. Our work in social sciences and humanities helps us better understand technology's role in societal institutions, such as education and health care, and changes to society, such as those to labour markets, commodity supply chains, and the sharing economy. The impacts on society of present and future technologies are potentially profound. The social, ethical and legal frameworks to respond to and navigate these impacts are yet to be articulated—they are a wonderfully rich and important research frontier.





Core elements of McGill's research activities in robotics emphasize the use of robust autonomous locomotion, sensing, environmental inference, and learning, as well as the interaction of robotic systems with the world around them.

EXAMPLES OF RESEARCH AREAS

Artificial intelligence, specifically machine learning—the study of algorithms that can learn from data and experience, such as for natural language processing—is a growing focus at McGill. Our researchers work on the development of reinforcement learning systems, which have the ability to interact with an environment and learn from this interaction to achieve specified goals. Applications of machine learning span diverse areas, such as robotics and automated dialog systems as well as life sciences, medical imaging, clinical monitoring, and various other domains of scientific, social and commercial interest.

Robotics is a cornerstone for research in the allied disciplines of artificial intelligence and computer vision. Core elements of McGill's research activities in robotics emphasize the use of robust autonomous locomotion, sensing, environmental inference, and learning, as well as the interaction of robotic systems with the world around them. Our research activities address the manner in which robots can learn more and move more efficiently, the ways in which behavioural knowledge can be abstracted and transferred between one domain and another, and the ways in which teams of robotic systems can jointly achieve a task with increasing efficiency.

New musical forms have appeared that are mostly, or totally, based on digital technologies, transforming the way we think, generate, and interact with sounds. We study how expert musicians develop, or adapt, their music performance skills when interacting with technology. Discoveries in this domain create novel technologies that fulfill the needs of highly-skilled musicians, allowing them to perform in an expressive way, independently of the form that the music takes now or in the future.

RESEARCH EXCELLENCE THEMES

Additive manufacturing, also known as 3D printing, is a layer-by-layer fabrication technology. McGill researchers are developing fast and precise digital pre-manufacturing solutions, by integrating physics-based process modeling with optimization algorithms and validating their manufacturability on industrial platforms. The wide variety of research applications of additive manufacturing is touching all fields of materials manufacturing.

Optical fiber communication systems are the backbone of the connected world. Virtually all information transmitted over the global communications network is represented as binary data and transformed into optical pulses. The rapid increase in demand for connectivity can only be met by continued innovation in optical fiber communications systems. McGill researchers are working to produce breakthroughs both in “long-reach systems” (transmission distances between 300 and 6,000 km) and “short-reach systems” (transmission distances of 2 to 300 km). The research effort capitalizes on the synergies that exist between the two systems and adopts a mix of theoretical, analytic, simulation, and experimental research using state-of-the-art experimental optical fiber transmission test beds.

Commodity supply chains benefit from the development of new smart digital technologies that integrate pertinent aspects of supply and demand in decision-support systems, capable of intelligently accounting for and managing supply and demand uncertainties. New smart technologies, for example, integrate sustainability and responsibility in mineral supply and value chains, resulting in higher revenues for industry and improved environmental management. Resource scarcity and growing

environmental concerns associated with our linear use of resources are driving innovations in closed-loop resource utilization and initiating a profound transition toward a circular economy.

2) UNDERSTAND THE POTENTIAL OF THE HUMAN BRAIN AND THE ENTIRE NERVOUS SYSTEM

McGill is one of the world's leading centres for research and education in the neurosciences and related fields. Our researchers cover a tremendous range of study, from the genetic, molecular, and cellular foundations of the nervous system to the networks supporting complex behaviours, including pleasure, emotions, decision-making, and language. This range, which spans Faculties, sites and themes, makes McGill uniquely positioned to advance knowledge in cognitive neuroscience and brain plasticity across the life course, models of neurodegenerative disease, population neuroscience, and neuroinformatics and computational modeling—all aimed at the understanding of the human brain and the prevention and treatment of mental and neurological disorders. Our researchers are driven by questions, such as: “Which factors are associated with mental health, and how are mental and physical health connected?”, “How do we ease the burdens of individuals and families whose lives are affected by neurodegenerative disorders?” and “How can we develop new approaches for deciphering, applying and sharing the enormous amounts of data we can now collect on the brain and nervous system?”



Healthy Brains for Healthy Lives (HBHL) is a high priority, multidisciplinary and cross-sectoral initiative funded primarily by the Canada First Research Excellence Fund (CFREF). HBHL is devoted to reducing the human and socio-economic burden of psychiatric and neurological illnesses. The program aims to transform many brain disorders from terminal or life-long afflictions into those that are treatable, or even curable. HBHL brings together world-leading researchers in genetics, epigenetics, neurophysiology, imaging, behavioural, social and environmental determinants to understand the individual brain in health and disease. Using the latest neuroinformatics and big data analytics, we can now distill vast amounts of raw data into unprecedented insight into brain development and function. Findings from HBHL will contribute to the development of a Canadian Framework for Brain Health – a suite of evidence-based best practices, guidelines and policies for improved patient care.

RESEARCH EXCELLENCE THEMES

EXAMPLES OF RESEARCH AREAS

Neurodegenerative disorders such as Alzheimer's disease, Parkinson's disease, amyotrophic lateral sclerosis, and vascular cognitive impairment have devastating effects on individuals and their families, many of whom are also caregivers. The symptoms of these disorders vary, but they are all marked by a gradual decline in cognitive abilities and memory resulting from a progressive loss of brain cells or brain cell function. As our population ages, the number of people affected and the cost of treatment is expected to rise dramatically. Researchers at McGill are world leaders in the investigation of the biological mechanisms behind these disorders and in the development of new precision therapies to eradicate or at least slow down their effects.

Mental health and how the brain codes emotions and behaviours are among the ultimate frontiers of modern medicine. Over the last 40 years, we have seen significant changes in the understanding of mental illness, which to a large degree comes from advances in neurosciences and increased acceptance in psychiatry that psychiatric illness results from disturbances of brain function. Researchers at McGill are investigating disorders that start during the first two decades of life, such as schizophrenia, eating disorders, mood disorders, and suicidal behaviour. McGill has been an international leader in the investigation of mechanisms that help explain the impact of early-life experience on the risk of developing these disorders or other psychopathologies in general.

Pain is a prevalent and economically burdensome human health problem, and the continuing challenges of treating chronic pain underlie the opioid crisis in North America. McGill researchers are working on the

development of novel, non-addictive analgesics to provide new options for the treatment of people in pain. Ongoing efforts range from the elucidation of the brain and spinal cord circuits sub-serving chronic pain, to the development of new ways of measuring pain in animal models, to performing clinical trials of promising new treatments.

3) DESIGN AND CREATE SUSTAINABLE MATERIALS, TECHNOLOGIES, LANDSCAPES, AND COMMUNITIES

Informed by systems thinking, McGill researchers respond to the challenges of sustaining the life support systems of the planet for now and for future generations with fundamental and applied science that advances renewable materials, energy, agricultural, and transportation systems. Global landscapes provide vital “ecosystem services”—air, water, food, energy, and natural resources but can do so only when they are biologically diverse and maintain their ability to adapt. By working together across disciplines, McGill researchers are driving the new field of evolutionary cell biology and molecular biodiversity, linking the study of cellular processes to the fitness of organisms faced with rapidly changing environments. Biological diversity and adaptive capacity of landscapes depend on advances in clean technology and renewables along with development of sound environmental policy that involves and impacts multiple stakeholders, jurisdictions, and timescales. The vast majority of Canadians, and more than half of the global population, live in urban communities. Sustainability challenges of rapid urbanization will mean that cities will be at the forefront of the adoption of technologies and policies that allow humans to thrive while protecting the ecosystem services of global landscapes.



The McGill Sustainability Systems Initiative (MSSI) supports researchers from multiple disciplines and Faculties to co-develop projects that move society toward a sustainable model of existence along major research themes such as sustaining landscapes, creating sustainable materials, and adapting urban environments for the future. Integral to the MSSI are emphases on student research opportunities and engagement with stakeholders, including industry, government, non-governmental organizations, and civil society.

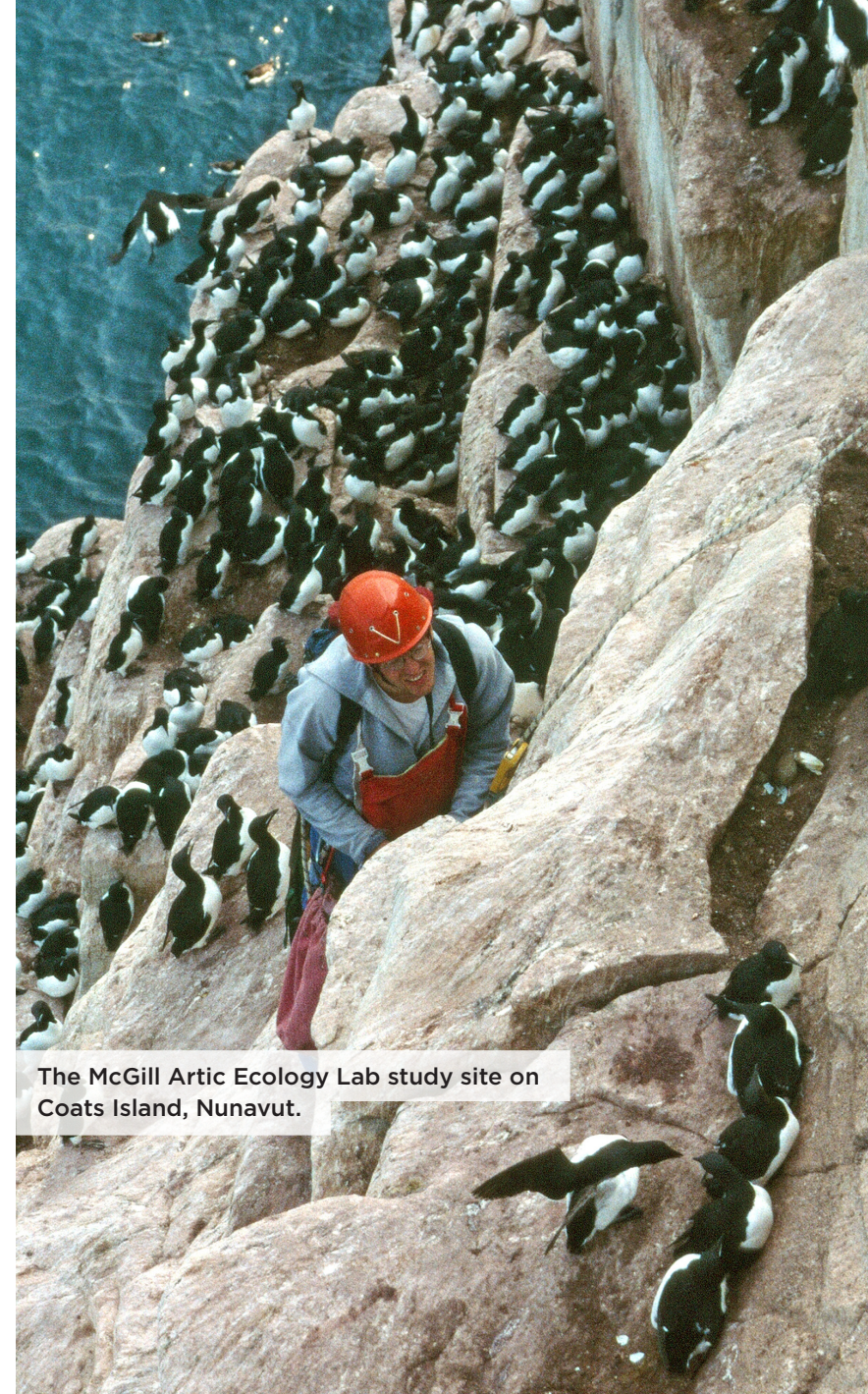
RESEARCH EXCELLENCE THEMES

EXAMPLES OF RESEARCH AREAS


The study of **sustainable working landscapes**—land actively used for production of resources, such as food, fish, and forest products—is an active area of research at McGill. Historically, the focus in working landscapes has been on the cheap, reliable, and efficient production of individual ecosystem services, such as food, energy, or timber. Sustainability-focused research in this area provides an understanding of how human activities and social-ecological dynamics can alter productive landscapes, affect biodiversity and the provision of a suite of interconnected ecosystem services across a range of scenarios.

Northern, arctic, and circumpolar researchers at McGill study Northern systems from a combination of physical, social, and health perspectives. McGill's approach to Northern research emphasizes university-community partnerships dedicated to the interdisciplinary study of Northern landscapes, community well-being, and environmental sustainability. Northern researchers at McGill focus on a diverse, interrelated set of issues, from infectious and zoonotic disease, mental health, housing, Indigenous food systems and food security, through to arctic contaminants, the cryosphere, biogeochemical cycles, climate change, and sustainable mining.

Precision agriculture science is a transdisciplinary area of research that relies on emerging technologies to improve the efficiency of modern agricultural production systems and reduce their negative effects on the environment. This research focuses on the development of new soil and plant sensing technologies, the integration of multiple spatial and temporal data sources to enhance farm management, and



The McGill Arctic Ecology Lab study site on Coats Island, Nunavut.



the implementation of automated solutions to increase farm efficiency. The resource optimization from precision agriculture leads to increased farm yield, maximized profitability, improved food quality, farming sustainability, and climate adaptability of farmland, with the ultimate aim of addressing global food security.

Green chemistry replaces critical chemicals and processes with cleaner, more sustainable alternatives. These alternatives underlie the transition to sustainable resource utilization (energy and materials)—enabling new methods for clean resource extraction and harvesting, utilization, and reutilization. Our researchers focus on the discovery of new, “benign-by-design” catalytic and solvent-free chemical processes to make functional molecules, advanced materials including polymers, and nanomaterials, as well as the creation of novel highly functional materials, such as semiconductors for solar cells, electrodes for batteries, membranes for water desalination/purification, and much more.

4) ADVANCE BIOMEDICAL AND HEALTH SCIENCES FOR HEALTHY POPULATIONS

Building on a long history of outstanding contributions to health research, McGill is a world leader in translating discoveries from basic research in disease mechanisms at the molecular and cellular levels into improved clinical outcomes. We are focused on using basic and applied research to provide solutions for efficient and high-quality health care and rehabilitation for a diverse set of diseases and conditions. These solutions range from advancing stem cell research, regenerative medicine and bioengineering (including tissue engineering and the use of nanomaterials in medicine) to the development of precision therapies,

surgical innovations, and medical devices. A fundamental question rests at the heart of our work in these fields: “How can we best prevent and treat disease?” In response, we are developing new approaches to better understand and provide novel solutions, over the life course, to complex health problems, such as many types of cancer, infections and immunological disorders, cardiometabolic and musculoskeletal diseases, as well as rare and neglected diseases. Our multidisciplinary approach considers the intrinsic genetic determinants of human health while addressing how environmental and social factors influence individual and collective well-being. The approach also recognizes that the burden of disease and poor health is most acute in vulnerable populations, and so McGill health researchers work with communities to understand and reduce health inequities in Quebec, Canada, and around the globe.

EXAMPLES OF RESEARCH AREAS

Genomic medicine research at McGill harnesses unprecedented opportunities afforded by advances in genetics and genomics in order to find disease therapies that are targeted to individual patients. Advances in bioinformatics allow research in genomic medicine to improve diagnoses, interventions, and treatments for a wide range of conditions, including cancers, infection, neurological disorders, and chronic diseases of aging. Working together with genomics researchers at McGill are those advancing our understanding of the policy, legal, and ethical implications of the medical applications of genomics.

RESEARCH EXCELLENCE THEMES

Human health and well-being is profoundly shaped by the physical and social environments where we live, work, study and play. Building on longstanding Canadian and Quebec leadership in population health and public health, McGill researchers work on better understanding the role of the built environment and neighbourhood design to lower the population level burden of chronic disease, and seek to understand how socio-demographic changes like aging, immigration, and the increase in people living alone influence social connections, health, and well-being.

The disease burden of all **cancers** remains high and is growing globally due to aging and to population increases. McGill cancer research priorities include identifying modifiable risk factors and overcoming drug resistance in metastatic disease, together with translating fundamental discoveries to expand the reach of cancer therapies. By integrating clinical, imaging, and laboratory test data with fundamental discovery, technology advancement, and outcomes research, McGill researchers develop patient-oriented and precision medicine-based strategies for hard-to-treat cancers.

Stem cell discoveries from the mid-20th century paved the way for a revolution in biomedical sciences. McGill researchers are working to improve our understanding of embryonic and adult stem cell biology and are establishing human stem cell banks from multiple diseases. McGill's research expertise in clinical grade therapeutic cell production ensures our contribution to leading cellular processing technologies, fostering productive partnerships with private sector entities and ultimately delivering our biological therapeutics to Canadians and the international community.

Infectious and inflammatory diseases are global health challenges. McGill researchers work at the levels of molecules, cells, patients, and populations to discover new mechanisms underlying the development of infectious and inflammatory diseases. They advance novel diagnostics and therapies for these conditions and deliver solutions to the populations that need them the most. Areas of research span viral, bacterial, and fungal disease-burden around the world, and include hospital-acquired infections, antibiotic resistance, and auto-immune and inflammatory diseases.

5) STRENGTHEN PUBLIC POLICY AND ORGANIZATIONS, AND CREATE A DEEPER UNDERSTANDING OF SOCIAL TRANSFORMATION

While economic globalization, regional integration, transnational environmental and security issues, international law, conflict and human migration erode the power of sovereign states from without, multiculturalism and multinationalism, federalism, and decentralization, as well as the recognition of the distinctiveness of Indigenous peoples are transforming states and societies from within. McGill is already at the vanguard of global and comparative scholarship examining these issues, in many ways thanks to its setting in a linguistically and culturally diverse Montreal, Quebec, and Canada. The challenges of this century require new forms of global accountability as well as creative, multidisciplinary approaches to implementing change that builds on the strengths of the public, private, and social sectors. We can now see inside societies and follow human behaviour and decision-making like never before. The capacity to harness and make sense of information about people and places is both a challenge in terms of privacy protection and an enormous opportunity. McGill researchers ask questions, such as "How are today's





Researchers and students in McGill's Department of Economics collect data in Kenya.

societies organized and how are they changing?”, “How can we create more productive, equitable, and inclusive societies?” and “How can we use data to improve lives and livelihoods while protecting individual rights to privacy?” In doing so, they are defining, critically analyzing, and implementing social improvements for individuals and communities, as well as the economic, legal, educational, family, and religious institutions that organize and serve them.

EXAMPLES OF RESEARCH AREAS

Research at the interface of **international relations**, political theory, anthropology, and law has shed light on how **human rights** movements emerge and gain traction; how troubled conceptions of state sovereignty have shielded abusive institutions and individuals; and probed the meaning and value of claims made by different groups for recognition and respect of their rights. Yet institutions dedicated to advancing human rights are under profound strain. Ongoing work by researchers concerned with international relations and human rights applies a wide range of methods, from ethnography to normative analysis, in order to diagnose and understand the nature of these evolving challenges and chart responses to them.

First Nations children are overrepresented in out-of-home care compared to non-First Nations. Work by McGill researchers into the prevalence and conditions of out-of-home care formed a key component of a ruling by a Canadian Human Rights Tribunal, which found that Canada had discriminated against First Nations children, families, and communities by failing to fund the type of placement prevention support services that are available to all other Canadians. The research addresses the first two of the 2015 Truth and Reconciliation Commission's Calls to Action.

RESEARCH EXCELLENCE THEMES

Public policy challenges can only be realistically and effectively addressed by combining the perspectives of researchers from different disciplines. The policies required to drive a substantial transition in global and local energy systems must combine insights from science, engineering, economics, management, political science, and law. Policies to redesign our social safety net in response to the technology-driven changes in the labour market must combine technological insights with those from law, ethics, economics, and public health. McGill is prioritizing research settings that foster the coming together of perspectives from researchers in normally distinct disciplines to shorten the trajectory of knowledge creation into policy options.

6) EXPLORE EARTH'S BIOLOGICAL AND PHYSICAL SYSTEMS AND THE UNIVERSE

Like others throughout history, McGill researchers investigate foundational questions, such as: "What are the origins of life?" and "What is the nature and origin of the Universe?", and "What physical laws govern the cosmos"? McGill is a major player in the rapid and extensive advances in our understanding of the natural world and its systems. This research has revealed the laws of physics, chemistry, and mathematics, the nature of life, the place of the Earth in the universe, and the evolution of our own species. Our knowledge continues to expand, with major discoveries being made every year in fields, such as molecular biology, astrophysics, cosmology, and subatomic physics. Observing and modelling the Earth, atmosphere, the world's ocean and fresh waters are fields of continuing importance at McGill. Our world-class researchers recognize the importance of translating theoretical work into applications for current local, regional, and global environmental challenges.

EXAMPLES OF RESEARCH AREAS

Instrumentation for **cosmology and astrophysics** developed at McGill is allowing astronomers to observe and interpret the earliest moments after the Big Bang and explore the most intriguing areas of our cosmos. Along with a network of international observatories, we can map the sky faster than ever before, enabling full-sky measurements that may unlock the mystery of dark energy that is powering the accelerated expansion of the Universe. Advances in digital instrumentation now allow us to detect, for example, an unprecedented number of fast radio bursts, a newly discovered and unexpected astrophysical phenomenon. These advances in instrumentation and fundamental knowledge have wide applications in communications and earth observation, but also in our understanding of our place in the Universe.

Research in ecology and evolution reveals how diverse biological communities persist, and respond to human stresses such as pollution and climate change. Ecological principles underlie the practical disciplines such as resource management and conservation biology. Evolution is the science that describes how organisms are all related to one another and explains our place in the natural world. Evolutionary principles are key to understanding and controlling some of the most urgent practical problems of our time, such as resistance to antibiotics or the tolerance to pesticides in the fungi and insects that attack our crops and forests. McGill research is revealing the great evolutionary malleability of organisms and how that evolution alters communities, ecosystems, and their services to people.

Nanoscience aims to discover and understand how traditional macroscopic material property scaling laws break down as one approaches the nanometer scale. At the nanometer scale, electrical



The Canadian Hydrogen Intensity Mapping Experiment, known as CHIME, one of the most innovative radio telescopes in the world, is helping McGill's researchers solve cosmic mysteries.



RESEARCH EXCELLENCE THEMES

conduction becomes quantized, nanomaterials exhibit mechanically vastly superior properties, and biochemical sensors can detect single molecules. Our researchers work on the development and application of nanotools, including computationally-intensive modelling methods, scanning probe microscopy, and nanosystem assembly and explore a range of quantum technologies including quantum optics and ultrafast optical sciences. A prime example of an application of nanoscience is the use of engineered DNA to construct targeted drug delivery systems.

7) EXAMINE FUNDAMENTAL QUESTIONS ABOUT HUMANITY, IDENTITY, AND EXPRESSION

McGill researchers deepen understanding of what it means to be a person living in the 21st century. They explore bold and challenging questions—such as, “Who are we?”, “Where have we come from?”, “What is good, right, or fair?” and “How do we express ourselves?”—that form the basis of critical and ethical thinking and self-awareness in an interconnected world. Close attention to histories and cultural differences reflects the need to understand the complex relationships between the temporality of the past and the spatiality of the present. At the same time, it is crucial to understand diverse societies – to understand and speak their languages, to know their histories through historiography and other approaches—in order to learn *from* them as well as to learn *about* them. Humanistic inquiry is the search for, and the creation and interpretation of, meaning. We, as humans, aspire to understand the human condition through careful observation and introspection, through the interpretation of cultural and religious narratives, by revealing societies through their legal traditions, their creative arts and performance, and through the analysis of literature, music, and visual arts.

EXAMPLES OF RESEARCH AREAS

Youth and girlhood studies have advanced in the last decade in ways that acknowledge the role of young people in identifying and acting on issues, such as gender-based violence, safety and security, homelessness, and gender and sexual identity in their everyday lives. Participatory visual and other arts-based methodologies through, for example, the use of cellphones and other devices to produce cellphlms, vlogs, and other media forms are helping to reshape work with and about youth, so that there is an increased recognition of the ways in which young people are co-producers of knowledge. McGill’s work in the area of youth and gender is helping to transform the ways in which schools, communities and international NGOs are conceptualizing this work, particularly in the context of youth-led, “from the ground up” community and policy dialogue.

In contemporary **jazz composition and performance**, there has been a decline in sustained improvisation-composition, in favour of other approaches. Researchers and performers at McGill reinvent the concept of a laboratory of rotating musicians, created by influential bass player Charles Mingus in the mid-20th century. The group of researchers and performers recreates a participatory, self-reflective melting pot in order to explore and better understand the tradition of collective improvisation in jazz music performance.

Language is a key part of what sets humans apart from all other species, and is central to both human cognition and cultural identity. **Linguistics** investigates the unique human capacity for language by working to understand the abstract system of grammar, from sounds to sentence structure to meaning, as well as the range and limits of variation found across human languages. Ongoing research partnered with Indigenous





McGill Jazz Orchestra I

communities finds ways in which language researchers and community-based language teachers can work together to advance our theoretical understanding of a diverse set of languages, while also contributing to documentation and revitalization of threatened minority languages.

Montreal, like other large cities, is comprised of many different communities, with a variety of cultural narratives. These narratives provide entree into the collective psyche and can help us to understand a community's strengths, challenges and priorities, as well as its values and aspirations. They also point toward new actions, which can be

strategically leveraged to achieve collective aspirations. Researchers at McGill are developing methods and tools to capture these narratives, cross-reference them with quantitative social data and subject them to in-depth analyses, with a view to understanding the key issues and the conditions for social transformation. These research activities are based on the hypothesis that innovations will only lead to meaningful and sustainable social transformations when they are linked to local culture and when they, in turn, create positive transformative narratives.

SECTION 4

SRP STRATEGIC OBJECTIVES ACHIEVING OUR GOALS

As an institution, McGill aims to provide researchers with the best planning, policies, and infrastructure possible, facilitate the development and reinforcement of research excellence through our programs, and connect people and organizations. This SRP sets a path for the University to be responsive to new challenges and opportunities as they arise on the research landscape and as the social, cultural, economic, and educational realities of our world evolve.

Implicit in this SRP are a number of overarching mechanisms that will allow us to achieve our vision. This section presents the main strategic objectives that we will use to achieve our goals. In the coming five years, McGill will:

- Strengthen its innovation and partnership agenda
- Steward research trajectories toward collaborative, large-scale initiatives and international partnerships
- Promote and draw on diversity in all aspects of research
- Lead in open science and research data management

OBJECTIVE 1: STRENGTHEN THE INNOVATION AND PARTNERSHIP AGENDA

Creativity and innovation fuel a knowledge-based and digitally-interconnected society. The innovation ecosystem increasingly involves diverse partners and benefits from breaking down barriers between academia, industry, government, non-profit organizations, and communities. We seek to turn collaborative efforts into shared benefits while addressing issues of partner responsibilities and intellectual property. To lead the way in a fast-evolving environment McGill will:

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Green chemistry replaces critical chemicals and processes with cleaner more sustainable alternatives.

- Support pre-commercialization and pre-application proof-of-concept studies, prototyping, and the further development of early-stage technologies with strong potential for commercial or social impact.
- Assume an international leadership role in the development and implementation of best practices in risk and value-added assessment as well as intellectual property management.
- Develop proactive strategies to attract diversified funding from external sources.
- Engage with industry, from local companies to multinationals, in all priority areas.
- Strengthen local and regional connections.
- Invigorate platforms dedicated to breaking down barriers and enabling collaborative exchanges of ideas across disciplines and between actors from academia, industry, all levels of government, as well as local and distant communities.
- Promote entrepreneurship and develop community engagement.

OBJECTIVE 2: STEWARD RESEARCH TRAJECTORIES TOWARD COLLABORATIVE, LARGE-SCALE INITIATIVES AND INTERNATIONAL PARTNERSHIPS

In collaboration with faculties, research groups, and networks, we will develop long-term plans and map the road ahead for high-potential projects to grow into successful, large-scale initiatives. Research trajectories are “built from the ground up,” and Research and Innovation will support excellence at all stages—from individual to multi-institutional research, and from the generation of ideas to their application in society. We are especially conscious of the needs of early-career researchers who are

at the beginning of their research trajectories. We will provide early-career researchers with targeted information sessions and, together with faculties, will contribute to mentoring early research careers at McGill.

Specific actions to achieve this objective include:

- Supporting creative, ambitious initiatives with appropriate frameworks.
- Allocating resources toward collaborative and outreach-focused activities.
- Developing and building upon governmental and international partnerships in key areas of McGill research excellence.
- Seeking out and supporting emerging areas of research expertise and leadership.
- Acquiring tools and building in-house expertise in analytics for research planning and projections.
- Advising early-career researchers in planning for their research future and navigating the funding landscape.
- Providing opportunities for interdisciplinary dialogues to address complex research questions.
- Coordinating strategic development and acquisitions of new research infrastructure.
- Supporting the operations of existing research infrastructure with an eye to the sharing of facilities to maximize resources.
- Contributing to the growth and long-term planning of research centres and other research entities.

SRP STRATEGIC OBJECTIVES

OBJECTIVE 3: PROMOTE AND DRAW ON DIVERSITY IN ALL ASPECTS OF RESEARCH

McGill is strongly committed to equity, diversity, and inclusion (EDI) and promotes EDI within all training and career opportunities, including within our research mission and activities. We strive to create an environment in which diversity is valued and a range of perspectives is sought, enriching and affecting change across all levels of the institution.

The commitment to EDI in research takes many forms. To promote EDI in research, McGill will:

- Develop and share expertise that our researchers can draw upon to build EDI into their everyday practices, research, and lab groups, and support the development of research proposal-related EDI implementation plans.
- Draw on diverse perspectives in peer-review committees, panels, and working groups.
- Shine light on excellence in areas that may have been overlooked, specifically through nominations to prizes and awards.
- Sensitize researchers that integrating EDI principles into the research teams and programs leads to new avenues of research and innovative ideas.

OBJECTIVE 4: LEAD IN OPEN SCIENCE AND DATA MANAGEMENT

Research activities create a massive volume of data that need to be effectively managed, with a view to improving the discoverability, reproducibility, reuse, and transparency of research—all of which are foundations of modern scholarship and scientific discovery.

Not all research data are suited to be shared broadly. Ethical, legal, or commercial reasons can justify some restrictions. However, adopting best practices in making data available in the public domain for uptake by others can lead to discoveries never even imagined at the outset of research data collection. By becoming the first academic institution globally to adopt an Open Science policy, the Montreal Neurological Institute at McGill is expanding the impact of its research by sharing it with a global community in order to accelerate the discovery of new treatments.

In order to continue to lead in Open Science and data management, McGill will:

- Establish an institutional strategy for research data management, ethics and stewardship.
- Develop the infrastructure for data management including supports for researchers in data management planning.
- Implement data management policies and procedures in keeping with our commitment to First Nations Principles of OCAP (Ownership, Control, Access, and Possession) for data stemming from Indigenous-led or Indigenous-partnered research.
- Recognize researchers for their adoption of data management processes and for sharing best practices.



CONCLUSION

This Strategic Research Plan supports and furthers research excellence at McGill. It reinforces the aspirations of individual researchers as well as teams by providing broad direction, especially within areas that bridge traditional disciplinary boundaries. Continual reflection, appraisal, and strategic reinvestment will help us nurture a creative research environment that explores new ideas, contributes to the advancement of education, and mobilizes knowledge with our partners for the benefit of society.

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