McGill Faculties of Medicine and Dentistry
Strategic Research Plan

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Executive Summary

The Deans of the Faculty of Medicine and the Faculty of Dentistry have engaged in a strategic planning exercise that will assist the Faculties in establishing priorities for research, recruitment, space allocation, and for financial support for research activities. This strategic research plan (SRP) contains forward looking research priorities that will provide McGill with the greatest likelihood of success in ensuring continued leadership in health research over the coming decade. The research priorities build on current areas of excellence, and are strategically positioned to stimulate innovation in a fundable environment. The overarching goal is to achieve a high level of research excellence in selected areas, while training the next generation of health researchers in a highly competitive and inter-disciplinary research environment. The SRP is anchored on a renewed focus on translating knowledge from basic research into improved clinical practice, better health outcomes and enhanced economic activity. The SRP takes into account research directions from individual schools, academic and clinical departments, centers and networks of the Faculty but also of research institutes from affiliated teaching hospitals.

The plan acknowledges that future research at McGill should not only focus on promoting and improving health over the life course, but should also aim to improve health outcomes in disease areas of major medical and societal importance including cancer, infections and inflammation, neurosciences and mental health, aging and chronic diseases. To optimize research activity, the plan proposes several timely cross-cutting priorities that aim at advancing knowledge and improving clinical practice in health and in the above-mentioned disease areas. These priorities build on current strength while taking advantage of recent investments in infrastructure and people. Focus of these priorities aim at improving patient experience, population health and health services; Identifying and characterizing the genetic and environmental determinants of health and disease; Developing and implementing systems and networks approaches to health research; Prioritizing personalized medicine and customized approaches to patient care. The plan elaborates novel implementation strategies to maximize research output, and to facilitate knowledge translation of research results into improved and better clinical care. Supporting key infrastructures and technology platforms will be prioritized. Building new groups to foster multidisciplinary research and training at unique interfaces will be undertaken, including creation of the Initiative in Public and Population Health Research, and the Initiative in Computational Medicine. The impact of research will be enhanced through the creation of new partnerships with the public sector and with industrial partners.

The SRP acknowledges the breadth of current research streams in the Faculties, and also recognizes the dynamic and rapidly evolving nature of health research. Hence, the SRP will be a living document that will be periodically reviewed and updated to take into account novel and timely research opportunities. An Implementation Group will be created to a) activate the plan, b) monitor progress on its stated objectives and using pre-defined metrics, and c) develop a process to acquire feedback from the community on an on-going basis and d) update the SRP.
1. Introduction

The educational mission of the Faculties of Medicine and Dentistry is reinforced by a broad, dynamic and highly successful research enterprise that extends from fundamental molecular and cellular biology, to computational biology, to public and population health, to clinical research at the bedside and in the community. This robust research activity within the Faculties of Medicine and Dentistry represents the core of McGill’s research effort, accounting for more than 60% of total research funding to McGill, while supporting undergraduate, graduate and post-doctoral education as well as training of health care professionals.

Our goal has been to develop a plan to support research excellence in strategic areas, train the next generation of health researchers, and facilitate the translation of new knowledge into beneficial health outcomes for patients, the population of Quebec, and policy makers. To this end, the Faculties of Medicine and Dentistry have developed a joint strategic research plan (SRP). The strategic research plan will assist the Faculties in establishing priorities for recruitment, attribution of space, direct financial support for research activities, as well as help with targeted fundraising.

Primary responsibility for the SRP was given to the Planning Committee (see attached membership list), which made initial recommendations on strategic research priorities. The final product was overseen by the Steering Committee (membership attached), which further developed and refined the document. Together, the two committees identified the key areas of health and diseases to be targeted, developed a set of strategic areas of research, and designed an implementation strategy which was used to produce the current document. An international advisory committee reviewed the SRP, and made final recommendations to the Deans.

This plan must be considered in the appropriate context. It aims to complement the University’s own SRP, providing specific applications of that plan within the Faculties. It similarly does not supersede more focused research plans developed in parallel by individual units, departments, schools or affiliated research institutes from teaching hospitals. Nevertheless, it was not possible for the SRP to represent all areas of excellence in health research at McGill without losing strategic focus. In particular, health professional educational research will be the subject of separate strategic planning process. The very dynamic and rapidly evolving nature of health research, including the profound and sudden transformative effects of technological advances, makes it imperative that the SRP be periodically reviewed and updated to take into account evolving research context and emerging opportunities.
2. Outline

The overarching goal of the exercise was to develop a plan that would support a very high level of research excellence in selected areas, while training the next generation of health researchers in a highly competitive and interdisciplinary research environment with a clear focus on translating knowledge from research results into beneficial health outcomes for patients. We recognized that health research activities of the Faculties cover an enormous range of disciplines and approaches. Hence, it was not possible (nor was it desirable) for an SRP to encompass and accurately represent all areas of excellence in health research at McGill without losing strategic focus. Rather, strategic research areas were identified through a broad consultation and consolidation process.

Given the complexity and scope of the research effort in the Faculties, the SRP looks at strategy from 3 perspectives: i) health and disease areas to focus on, ii) strategic priorities that cut across multiple disease entities, and iii) cross-cutting implementation strategies. The choice of disease areas and priorities reflects input from a broad consultation of faculty members, coordinated by the SRP planning and the steering committees. The identified strategic research themes and activities correspond to areas of established or emerging strength in which McGill can excel and which bring together the efforts of multiple groups across the campus and in the teaching hospitals. These will be supported by a series of implementation initiatives aimed at ensuring that these strategic priorities can move forward. Mechanisms will also be put in place to execute these initiatives, and develop new ones based on regular feedback from the community.

The major disease groupings include: 3.1) Infection and Inflammation; 3.2) Cancer; 3.3) Neuroscience and Mental Health; and 3.4) Aging, Disability and Chronic Disease. The cross-cutting strategic priorities include: 4.1) Patient experience, population health and health services; 4.2) Genetic and environmental determinants of health and disease; 4.3) Systems and networks approaches to health research; and 4.4) Personalized medicine: Customized approaches to Patient Care. The implementation strategies will build on existing tools (recruitment, training, knowledge translation), and favor novel multidisciplinary groupings (new institutes, virtual programs), while exploring novel strategies for financial support (strategic funding, commercialization, targeted fundraising).
3. Disease Areas

Emerging from the very wide areas of interest within the Faculties are four major disease themes: Infection and Inflammation; Cancer; Neuroscience and Mental Health; Aging, Disability and Chronic Disease. In addition to addressing the most important health issues of the moment, McGill has specific opportunities to enhance its research performance in each of these areas.

3.1 Infection and Inflammation

The 21st century is witnessing the re-emergence of infectious diseases as a major threat to global health. This is due in part to increased prevalence of highly antibiotic-resistant microorganisms as well as the continuous appearance of new and highly virulent pathogens. Antimicrobial overuse, increased globalization, population mobility, and a changing climate all additionally contribute to the growing threat of infectious disease. At the same time, studies of inflammatory and immune responses to infection and tissue injury are providing novel insight and new therapeutic opportunities in major chronic inflammatory disorders ranging from inflammatory bowel disease, multiple sclerosis and periodontal disease to asthma, that are major sources of morbidity and healthcare costs in Canada. Most recently, we have come to better understand the complex relationship between the host and the microbial world around it. We now recognize that the microbiome found on the body’s mucosal surfaces plays a central role in the programming and regulation of the immune response, and is a major determinant of health and disease.

At McGill, the efforts in this area will build on long-established strengths and will take advantage of the presence of substantial resources in genomics, informatics and epidemiology. Specific areas of effort will be in the field of tuberculosis, chronic viral diseases (including human papilloma virus) and, in concert with McGill’s Institute of Parasitology, key parasitic infections such as *Leishmania* and malaria. Work on the microbiome will be pursued by the Innovation Centre and by the Microbiome and Disease Tolerance Centre (MDTC) in the Department of Microbiology and Immunology. Vaccine development will be focused in the Centre for Innovative Medicine at the RI-MUHC, taking advantage of new facilities at the Glen Yards campus.

We will also build on longstanding excellence in clinical and fundamental research in connective tissue diseases, inflammatory bowel disease and chronic inflammatory diseases of the airways. These efforts will bring together strengths in clinical, epidemiologic and translational research at the MUHC and JGH, with the study of fundamental mechanisms in the Complex Traits Group, and efforts in genomics and epigenetics at the Innovation Centre.
3.2 Cancer

Cancer remains a leading cause of premature death in the western world and is now a significant global challenge in the developing world. The complex nature of cancer reflects the interaction between genetics and the broad range of environmental factors including exposure to carcinogens to lifestyle choices to infectious agents that contribute to cancer development. Although new treatment modalities have improved outcomes, where the care of some cancer patients increasingly involves the management of a chronic condition over long periods of time, our ability to successfully treat cancer has yet to be fully realized. One of the greatest challenges is the recognition that cancers are highly heterogeneous and rapidly evolving. This poses challenges for effective therapeutic intervention. Improved outcomes reflect enhanced mechanistic understanding of genetic and epigenetic changes as cells move from pre-malignancy to invasive cancer. Cancer research at McGill will continue to focus on these basic mechanisms of neoplastic transformation at the genomic as well as cellular level, interaction of tumor cells with host microenvironments, dissemination and metastasis of cancer cells, response to radiation, chemotherapeutic and targeted treatments as well as mechanisms of resistance. This will be complemented by a parallel focus on developing novel marker sets for refined clinical diagnosis, and that can support improved screening programs as well as targeted and more efficacious treatments.

The McGill clinical cancer research community has and will continue to take part in clinical trials. Future success of such activities will depend on improved collaboration and cooperation among the major cancer research units, bringing together bench scientists and their clinical counterparts. This effort will be centered in the Department of Oncology, which hosts the Rossy Cancer Network (RCN). Key goals of the RCN are to harmonize not only treatment strategies but also informatics and outcomes measurement, initially across McGill teaching hospitals and eventually branching out across the McGill RUIS. In addition to enhancing our capacity to carry out outcomes research, the advent of the RCN will provide an opportunity to grow McGill’s efforts in psychosocial oncology, palliative care and related fields.

By bringing together the cancer care efforts of the new MUHC Cancer Centre, the Segal Cancer Centre at the JGH and the cancer program at St. Mary’s hospital, the RCN will provide a platform for excellence in translational research in cancer, complementing the leading edge fundamental research underway in the Goodman Cancer Research Centre, the Lady Davis Institute and the RI-MUHC. Specific areas of focus will include molecular and genomic markers for breast, colorectal and lung cancer, leukemia and familial cancers as well as metabolic programming as part of the development of approaches to personalized cancer interventions, which allow for adjustment of therapy to match the biological behavior of malignancies. The study of these novel approaches will be comprehensive, taking advantage of McGill’s strengths in health outcomes research, model systems, molecular pathology and clinical trial infrastructure. Also considered priority is the considerable strength that McGill has in the area of population health research on cancer prevention. McGill’s cancer epidemiology teams have been instrumental in bringing to the world HPV vaccination, and new molecular-based technologies for cervical cancer screening.
3.3 Neuroscience and Mental Health

Although considerable progress has been made in the management of stroke and other acute brain injuries, chronic diseases of the nervous system remain a major source of morbidity in all age groups. Central nervous disease also manifests itself as severe neurological and psychiatric disorders, which account for an enormous burden of disease. All of these disorders have limited therapeutic options, creating the need not only for better understanding of the underlying neurobiology, but for improvements in rehabilitation strategies and models of care delivery that better take into account the needs of patients and their families. To better address these needs, McGill will move toward a unified approach to chronic brain disease, bringing together psychiatry, neurology, rehabilitation science and related clinical disciplines such as nursing and family medicine.

From a biological point of view, McGill will build on our strengths in neuroscience, particularly imaging and genetics, as well as on research examining the molecular mechanisms of neural networks and neuronal signaling, and the development of disease-relevant transgenic animal models. The Montreal Neurological Institute and Hospital (collectively, the Neuro), and the Douglas Mental Health Institute will be major players in these efforts, forming a nucleus of excellence in fundamental neuroscience research, neuroimaging and bioinformatics. The Neuro will work in close collaboration with the RI-MUHC to bring together the neuroscience efforts across the MUHC, including the MGH based Centre for Research in Neuroscience. With the recruitment of new leadership, the Douglas research centre is poised to serve as a leading partner in neuroscience research related to severe mental illness, and to capitalize on the Douglas Institute’s strengths in clinical-research integration and the study of psychosocial determinants of brain disorders.

Researchers based at the Neuro and the Douglas will work closely with those at the Lady Davis Institute of the JGH, which has developed a leading program on Alzheimer’s Disease. These efforts will be complementary to active research programs in basic neurosciences and that are taking place in academic departments such as Pharmacology, Physiology, Biomedical Engineering, as well as Brain@McGill, which is an international collaborative partnership involving neuroscientists at McGill, University of Oxford, Imperial College London and the Neuroscience Center of Zurich.

There will be continued emphasis on understanding the biological and developmental determinants of disease, making use of existing strengths in neuroimaging, bioinformatics and animal models. Genomics technology will be used to better understand the interaction between genetics and environment and its impact on the development of chronic neuropsychiatric disorders. These efforts will be complemented by continuing clinical research programs in eating disorders, social and trans-cultural psychiatry, novel strategies for neurorehabilitation and recovery, as well as studies of mental health services, and policy.
As a result of important demographic changes in our population, and our continuing success in managing acute illnesses, aging and chronic diseases constitute overwhelming challenges for the coming decades. In addition, disability is not solely a consequence of aging: it can be congenital but can also be acquired at any time during the life-course, in the form of physical, cognitive or mental impairments that are accompanied by diminished health and limitation in everyday meaningful activities.

Such disabilities have important consequences not only for the affected individuals but also their families and for society at large. The complexity of managing chronic diseases and disabilities requires a multidisciplinary approach, including efforts at preventing, treating or repairing chronic conditions, and development of optimized management strategies and effective health and social policies. To address this challenge, McGill will bring together the efforts of the Schools of Nursing, Communications Sciences and Disorders and of Physical and Occupational Therapy, in partnership with the clinical departments to work towards the development and implementation of approaches that improve the quality of care offered to patients, and to optimize outcomes.

In addition, a small number of risk factors such as smoking, obesity, physical inactivity and poor nutrition, have an overwhelming impact on health status. Developing strategies to effectively modify or diminish the negative impact of these behaviors will engage all elements of the community, including not only health professionals, but also families, educators, and neighbors in participatory research and action processes. The participatory research group in Family Medicine and at the School of Nursing will co-lead this effort.

McGill has a rich history and will continue to build on research excellence in endocrine and metabolic disorders including studies of osteoporosis, bone, calcium homeostasis, diabetes and other chronic diseases of metabolism, which together contribute enormously to morbidity and disease burden in our society. In cardiovascular health, McGill will focus its efforts on fields in which it can make unique contributions including congenital heart disease, hyperlipidemia and hypertension as well of the study of risk factors and behavioral interventions aimed at prevention. Expertise in health outcomes research will be combined with McGill’s strengths in genomics to help better understand the interaction between genes and environments in these high-prevalence conditions.

McGill has a long tradition as a leading centre for pain research. With the recent awarding of a Canada Excellence Research Chair in Pain Research, the Faculties will further develop pain research as a key priority, which brings together clinicians, hospital-based researchers and basic scientists from several departments and divisions.

McGill has an excellent level 1 trauma centre based at the MGH, providing an opportunity to conduct interdisciplinary research in areas related to trauma, such as traumatic brain injury. The Faculties will build on the established successful programs in trauma, ranging from the development of novel approaches to trauma programs in developing countries to the development of novel tools. In addition, research in trauma requires an effort at improving our
ability to repair injury. This will be pursued in the form of device development in orthopedics, cardiac surgery and other areas and the development and application of stem cell therapies.

These efforts will be complemented by new initiatives, built around the CIHR’s Strategy on Patient-Oriented Research (SPOR), which is about to be extended to primary care. Led by the Departments of Family Medicine and Epidemiology, research will be extended to community-based clinical settings in an effort to improve the pertinence of research programs and its translation into the promotion of wellness and better health outcomes across the lifespan. Using an interdisciplinary approach with diverse strengths in Medicine (Internal Medicine, Family Medicine, Epidemiology, Nursing, Physical and Occupational Therapy, Psychiatry) and Dentistry, McGill will collaborate with the healthcare system to build on established excellence in participatory and health outcomes research.
4. Strategic Priorities

4.1 Patient Experience, Population Health and Health Services

Through the following themes, McGill will build on its traditional strengths in fundamental research by taking on the complementary goal of studying the roles of the environment, socioeconomic factors and lifestyles as determinants of health outcomes.

4.1.1 Social and environmental determinants of health

Most diseases that have broad societal impact are multifactorial in origin, reflecting complex interactions between genes and the social and physical world we live in. The major determinants of health and disease status in populations include the social and economic environment, the physical environment, and the person’s individual characteristics and behaviors. McGill will take advantage of its strengths in epidemiology, public health, sociology, nursing and other fields, to work in concert with our teaching hospitals and the McGill RUIS. By bringing together key units within the Faculties such as the Department of Family Medicine and the Institute for Health and Social Policy, as well as units across the University including the Center for Population Dynamics in the Faculty of Arts, we aim to be Canada’s leading centre for research on social and environmental determinants of health.

4.1.2 Healthcare information technology

Health care is a supremely data-driven activity and the advent of modern information technology is central to current approaches to clinical management, investigation and treatment. There is an enormous need for the development and use of advanced health informatics. McGill's unique strengths in health information technology and in the analysis of large-scale, linked databases, have led to ground-breaking research in pharmaco-epidemiology and drug safety, patient self-management tools, clinical decision tools, public health surveillance, and population health research. The Faculties will build on recent recruitments and research initiatives to enable McGill to become an international leader in the application of health informatics to population based research including genetic epidemiology. In addition, the Faculties will focus on key areas of additional inquiry to understand the rapidly evolving cognitive needs and contexts of technology users, to develop innovative analytical methods and systems, and to evaluate their impact through rigorous trials. Robust models of how people interact with technology are critical to ensure that novel systems address important needs. The development of novel statistical and informatics methods to manage and analyze complex, longitudinal data is a unique opportunity given McGill's strengths in biostatistics.

4.1.3 Patients’ experience with health and illness, patient/family engagement, and interactions across the continuum of care

In recent years, embedding the patient perspective has come to be considered a hallmark of quality in clinical research, as it takes into consideration individuals’ preferences, needs and values – elements that are crucial to understanding health-related behaviours and outcomes. Patient experience in healthcare is the sum of all interactions, shaped by an organization’s culture, and that influence patient perceptions across the continuum of care. Recently, significant progress has been made to develop and implement sophisticated approaches to probe multiple aspects of patient experience, and to use this information systematically to intervene and modulate healthcare delivery, and to inform re-engineering of the healthcare system. These
reforms have become a more global endeavor, where patient experience and patient-oriented research are at the centre of national priorities (e.g., CIHR in Canada and the US ‘Triple Aim’ framework for quality improvement). McGill will develop innovative approaches to understanding the patient experience and will use this knowledge to improve and optimize the quality of care delivered to patients.

4.1.4 Optimal health trajectories over the life-course

The health status of populations and individuals cannot be adequately understood without recognizing the influence of health determinants, genetic, environmental and social. There is a need for an improved understanding of health trajectories and their determinants, with a particular focus on childhood and adolescence. McGill has unique expertise and experience in life-course research with projects such as the Canadian Longitudinal Study of Aging as well as unique methodological strengths to develop new models for the analysis of these complex data systems. In addition, working together with units such as the Centre for Population Dynamics in Arts, the Faculties of Medicine and Dentistry will focus on using these data and expertise to provide new knowledge on population trends to better understand the relationships of a wide range of social, economic, educational and other factors on health trajectories among Canadians. We will renew emphasis on the necessity of McGill researchers to take part in provincial and national opportunities in longitudinal cohort studies.

4.2 Genetic and Environmental Determinants of Health and Disease

The “disease state” results from interactions between intrinsic genetic risk factors of the individual and extrinsic environmental triggers. The intrinsic genetic component may be simple as in rare disease-causing and highly penetrant mutations, but is often complex and heterogeneous, involving additive contributions of multiple weak genetic effects modified by unknown environmental determinants. Research in these areas is rapidly evolving and is expected to be distributed across the campus, taking place at multiple sites in academic departments, centres and research institutes, while building on McGill’s substantial investment in genomics and bioinformatics at the Innovation Centre. The Faculties will explore this area along the following themes.

4.2.1 Gene discovery in rare diseases and in common complex disorders

The advent of whole-genome sequencing now permits the systematic characterization of simple and complex genetic effects in disease. McGill researchers and clinicians will work together to identify the cause of rare disorders and neglected diseases that affect isolated populations, or that are found in populations with strong founder effects, including ultra-rare disorders of little economic value for the pharmaceutical sector. Modern genome technologies can now be used to tackle more common diseases, which have a complex and heterogeneous genetic component. Further, in order to define genetic risks shared across multiple diseases and to identify disease-specific genetic signatures, detailed clinical, demographic and life-style data, along with other assessments of environmental factors, will be incorporated into the analysis of complex common human diseases in large and very-large patient cohorts.
4.2.2 Epigenetic modulation of the genome in disease

Regulated genome expression is a complex process that involves assembly of transcription complexes that bind to specific sites in the genome, the access of which is modulated by many chromatin-modifying enzymes that are expressed in a cell- and time-specific fashion. The epigenetic regulation of genome expression is critically positioned at the interface of genome-environment interactions, and is a major determinant of health and disease. Recent technological advances now permit genome-wide monitoring of histone modification status, binding of transcription factors, and measuring levels of individual gene transcripts with unprecedented accuracy and sensitivity. Researchers in the Faculties will establish at the tissue and cell level the patterns of genome expression and associated epigenetic modification in order to determine how such modifications are associated with disease causation, onset, progression, response to treatment and outcomes. Research will also focus on studying the impact of discrete genomic variations, and environmental factors on epigenetic regulation, and how these ultimately influence health and disease status.

4.2.3 Extracellular matrix in normal cell signalling and in pathological situations

The sensing of environmental and positional cues in the extracellular milieu is a dynamic process that is essential for homeostasis including tissue patterning during development, and tissue repair following injury. McGill researchers are using novel genetic, cell biological and imaging approaches to study physiological calcification in mineralized tissues whose disruption leads to severe defects in joint, bone, tooth and otoconia formation and function. They are also studying the mechanisms responsible for immune cells trafficking and sensing of injured, damaged or infected tissues, which represent critical steps in tissue repair and remodelling that are often compromised in patients suffering from chronic inflammatory conditions. Research in these areas will focus on studying the interaction between extracellular cues, their cognate receptors, and their intracellular signaling pathways that together modify cellular metabolism and cell function during normal development and to maintain tissue homeostasis.

4.2.4 Host-microbe interactions in health, infection, inflammation, development and cancer

The interaction between the genetic background of an individual and the outside microbial world is being recognized as a major determinant of health and disease. This is not only true in revealing obvious primary immunodeficiencies, or severe infections, but also for common inflammatory diseases such as inflammatory bowel disease, systemic lupus erythematosus and rheumatoid arthritis that are all thought to have a microbial and/or autoimmune component. Microbial populations at mucosal surfaces (microbiota) are also suspected to play a role in many unrelated diseases including cancer, diabetes, obesity, and autism. McGill researchers are engaged in implementing novel approaches to gain better understanding and characterization of these relationships. McGill will develop and implement novel omics-based approaches to characterize changes in microbiota that are associated with health or disease, including defining unbiased qualitative and quantitative genetic fingerprints of otherwise impossible-to-cultivate microorganisms. Specific efforts will be made to define the potential role of microbiota in the modulation of cancer biology.
4.3. Systems and Networks Approaches to Health Research

New advances in the “omics” and imaging fields have generated highly precise biological datasets on an unprecedented scale, which hold the promise of enabling the detailed analysis of biochemical, physiological, and environmental interactions that determine health and disease, both in humans and in animal models. This opens the door to a systems or network approach to understanding biology, which will be explored in the following themes.

4.3.1 Integrated “omics” approaches to biomedical research

Whole genome sequencing is generating deep and high-quality sequence data for thousands of individuals; RNA sequencing in the same biological samples makes it possible to link intrinsic genetic information with epigenetic regulation of RNA expression (transcriptome), but also with other large datasets from patients’ clinical samples such as profiles of metabolites and abundance of proteins. McGill will build on its substantial strategic investments in infrastructure and personnel for data acquisition to investigate how the different “omics” datasets relate not only to each other but also to biological effects at the cell and organismal levels, including determinants of health and disease. The future of “omics”-based research at McGill will involve multidisciplinary teams of clinicians and scientists working together to develop new and effective analytic methods for integrating different kinds of “omics” datasets with clinical data.

4.3.2 Integrating with health data

Public health research using large linked datasets from electronic medical records, healthcare administration, and surveillance offers a unique opportunity to understand the complex interplay between genetic, environmental and behavioural determinants of health, the interaction with the healthcare system and ultimately health outcomes. This constitutes an area of current and future strategic interest to McGill researchers, who will build on previous successes such as in drug safety research. To move this forward, the Faculties will promote the development of advanced methodologies and systems for storage, retrieval and handling of electronic data, and advanced methods in pattern recognition, causal inference, and epidemiology.

4.3.3 Computational approaches to quantitative biology

The future of biological research is quantitative, and mathematics, computing and engineering are in turn increasingly influenced by biology. The major limiting factor in biomedical research is now rapidly shifting from data production to data processing, interpretation and modeling. Investigators within the Faculty of Medicine have long been pioneers in the development and application of mathematical biology and biophysics to questions of biomedical and clinical relevance. For example, the recently created and expanded Centre for Applied Mathematics in Bioscience and Medicine (CAMBAM) has developed applications of mathematics to address challenges in bioscience and medicine through partnership with industry, government and other stakeholders in society. The Faculties will build on these accomplishments, with the goal of translating new knowledge into practical solutions for problems of societal and industrial importance. McGill scientists will continue to develop innovative and efficient mathematical and statistical approaches to analyze massive amounts of data generated by “omics” research as well as highly dynamic systems involving the simulation...
of protein dynamics or metabolite changes on a time-scale of milliseconds with a time resolution of femtoseconds

4.3.4 Imaging of cellular networks

Advanced imaging techniques from cryo-electron microscopy to magnetic resonance imaging are allowing scientists and clinicians to resolve tissue architecture in real time and with remarkable precision. They are also rapidly advancing our understanding of cellular networks and circuits in animal models, in healthy individuals, and in disease states, thereby providing a framework for the design of computational models of cellular networks. The activity of these networks can be manipulated experimentally by enhancing or silencing individual components, permitting an evaluation of their role in cell and organ function and behaviour as well as disease state. McGill will build on its internationally-recognized excellence in these areas to foster the development of new imaging technologies and their application to fundamental research, translational and clinical domains.

4.4. Personalized Medicine: Customized Approaches to Patient Care

The advent of powerful tools allowing detailed genetic analyses and careful marker-based patient stratification opens the door to novel clinical approaches that are specifically adapted to the patient’s needs. This burgeoning area of research will be pursued in the following themes.

4.4.1 Biomarkers- and molecular signature-based strategies for disease diagnosis, monitoring and treatment including clinical trials

Personalized approaches are being developed to capture an individual’s “molecular signature” in order to reliably establish a correct diagnosis, provide accurate information regarding prognosis, enable tracking of disease activity even when subclinical, and contribute to making the most informed treatment decisions that together maximize the balance between efficacy and safety for each individual patient. McGill researchers will explore the development of platforms that can define risk, separate disease from non-disease and detect prognostically important disease subtypes as well as monitor disease progression and response to therapy. McGill clinical investigators will lead international efforts to applying the use of biomarkers to stratify patients in innovative clinical trial designs that accelerate the development of new treatments. Additional efforts will be made to use a pharmacogenomics approach to optimizing therapy as a key focus of pharmacologic studies at McGill.

Personalized medicine also applies to psychosocial aspects of disease prevention, of coping with illness and treatment and also of optimal rehabilitation and re-establishment of health in all dimensions (‘survivorship’). These efforts will be complemented by studies aimed at enhancing the quality of patient-centred care, involving personalized interventions in management of clinical disease by bringing together providers from different disciplines, as well as involving families and patients in participatory research.

4.4.2 Personalized health improvement devices and delivery systems

Because of its dependence on detailed biological information, personalized medicine will require reconfiguration of the multidisciplinary therapeutic team to include a central role for
expertise in bio specimen collection and analysis. McGill will pioneer interdisciplinary training, research and clinical practice to optimize the implementation of personalized health care. McGill will, in partnership with manufacturers and information technology providers, work to develop analytical technology, both for discovery research and for clinical application. Work will also focus on enabling the ‘patient partnership’ by complementing electronic health records with patient portals to provide access to medical records and molecular data. In addition, as noted above, McGill will continue its research into the development of devices and approaches aimed at improving health, including mechanical engineering (e.g. stents, pumps) as well as stem cell engineering, to replace neural, osseous, pancreatic and cardiovascular tissue, amongst others.

4.4.3 Precision engineering of animal-, cell- and protein-based models of human disease

To further the understanding of the cellular and molecular basis of disease requires precise animal, cell-based and molecular models that accurately mimic both the normal and the pathological state. McGill will continue to lead in the development of novel technologies to design models in which to test and validate personalized medicines, including in vitro (cell lines) and in vivo animal models. Pluripotent stem cells (iPS), in which the cause of disease can be modeled, will be studied using novel and highly effective genome modification technologies. McGill will continue and expand its focus on the study of protein structure and function at the atomic level by nuclear magnetic resonance, X-ray scattering and diffraction, cryo-electron microscopy and other biophysical methods that enable elucidation of static and dynamic structures of proteins of medical relevance. These technologies will be linked to molecular diagnostics and therapeutic efforts to better understand disease and design treatments.

4.4.4 Customized health care delivery for vulnerable groups

Problems of access to high quality health care in Canada, particularly among vulnerable groups, are well recognised. Furthermore, the changing demographics and cultures, education and finances, health problems and health care needs of people living in Canada, along with the fast-changing health care technologies and communication means of today, represent considerable challenges and opportunities to improve health care delivery. McGill’s health professional schools are well positioned to work together and with their multiple primary health care and community partners to develop and test innovative means to deliver health care to, for instance infants, children and youth, the institutionalized elderly, recent immigrants, the working poor and aboriginal groups. Using a combination of the SPOR and Pathways programs at CIHR, among other opportunities, McGill will build teams embedded in the community to affect change in health service delivery and government policy enabling the timely delivery of high quality care to vulnerable groups.
5. Implementation Strategies

The implementation strategies for the SRP will follow key principles at the core of the educational and research missions of the University. The overarching objectives of research activities in the Faculty of Medicine and in the Faculty of Dentistry are to improve health by preventing illness, and by searching for of novel ways to detect and treat disease. A cross cutting goal of the SRP is to develop and implement innovative research frameworks tailored to prioritized areas, and that aim to facilitate translation of research results into tangible health outcomes, and this at all levels of medical care. This will be accomplished by promoting interactions between different groups along a continuum of research and innovation, and by establishing partnerships between laboratory scientists, clinical investigators, health professionals and patients.

To implement the SRP, we wish to promote creative environments that will foster innovation and entrepreneurship in health research, and that will support the development and testing of novel ideas and concepts. The SRP aims to encourage novel groupings of health researchers with diverse but complimentary expertise, perhaps not traditionally aligned, but that can create novel synergies and innovative research continuum. It is also anticipated that such groupings will train the next generation of health researchers in a dynamic and productive interdisciplinary environment. The SRP will also provide opportunities for timely and productive partnerships with Canadian industrial partners to develop new technologies to improve quality of life, and to detect and treat diseases. These will rely on traditional intellectual property-based approaches but will also explore novel mechanisms of open innovation and open source access to research results.

To fully realize the strategic research priorities outlined above, the Faculties will develop implementation initiatives aimed at improving the working environment and maximizing research performance. These will rely on existing tools and mechanisms while developing new initiatives. These fall into 3 categories: organizational, infrastructure and administrative. The Faculties will also create an Implementation Group for the SRP. This group will be tasked with a) developing operational frameworks, monitoring progress, and evaluating performance of these strategic initiatives, b) creating tools and mechanisms to consult the community, receive and evaluate suggestions to develop further strategic initiatives, in response to new and emerging priorities, c) organize annual reviews of the SRP, d) ensure that all strategic priorities are designed and implemented for maximum knowledge translation and to meet the overarching mission of the Faculty to improve population health and to better patient care. Membership of this group will have representation from research and teaching units from the Faculties, as well as affiliated schools and research institutes from teaching hospitals.

Finally, translating research results into better health and improved treatment of illness will be a central and penetrating component of our implementation strategy. Although knowledge translation can follow different paths, we will encourage transfer along a linear path, from basic research in the lab, to clinic, to patient outcomes, to community impact. This path will be marked by flagship activities grouped around the theme “Discovery”, and that would include epidemiological findings, studies on molecular targets, biomarkers of disease, candidate molecules, mechanistic studies, and technology development. Translation of such research in clinical assets may be another pillar that would regroup activities such as validation of animal model data into humans, clinical evaluation of diagnostic and therapeutic candidates, regulatory
approval of new techniques, molecules, devices, methods and procedures. More mature stages of translation will rely on dissemination of knowledge, new molecules, tests, and procedures to key stakeholders, including patients, health care providers, and regulatory agencies, and community engagement to increase uptake. Activities such as acceptance to practice, understanding barriers to uptake, and post-implementation evaluation at all levels would rely on population based approaches and research to monitor outcomes.

5.1 Organizational

To encourage inter-disciplinarity, the Faculties will build on the existing structure such as schools, departments, and divisions, to develop novel groupings that can further synergize research activities and maximize past and future investments. Future advances will largely come from interdisciplinary groups making use of a broad range of technologies and combining approaches that range from molecular to clinical to epidemiological, while creating novel productive research interfaces. As a first step, two new interdisciplinary organizational units are proposed, complementary to the initiatives outlined above. Rather than being an exhaustive list, these are expected to be the first of several, which bring together investigators from multiple units and institutions. The Faculties will develop a framework and set of criteria for the establishment of such units, which will ultimately be approved by the Deans.

5.1.1 Initiative in Public and Population Health Research (IPPHR)

McGill is fortunate to host many leading scientists and scholars in fields such as public health, epidemiology and biostatistics, global health and public policy. While individually successful, these groups do not have the collective impact that might be seen at other institutions that feature a School of Public Health or similar unit. It is time to bring together core quantitative disciplines such as Epidemiology and Biostatistics and those involved in the social sciences (Social Studies of Medicine, Institute for Health and Social Policy, Global Health, Bioethics) to establish a unit that would take the lead in developing interdisciplinary approaches to research in fields related to public and population health, and the social and conceptual organization of medicine. To fulfill its mission, the IPPHR will work toward the development of the necessary infrastructure to support these research fields and build on longstanding collaborations with the hospital research centres, the clinical departments and the schools.

5.1.2 Initiative in Computational Biology and Medicine (ICBM)

In many ways, the future of biology and medicine is computational. Diverse problem sets, ranging from clinical and epidemiological research to molecular biology are dominated by the need to analyse massive datasets. In response to the challenge of “Big Data”, the ICBM will bring together expertise in the mathematical, physical, and biomedical sciences so as to develop and facilitate implementation of novel technologies and analytical skills. The ICBM will create novel interdisciplinary research interfaces, train the next generation of health researchers, and carry out innovative research programs in all aspects of Big Data and its associated use in health research and healthcare delivery. A key goal of the ICBM will be to link rich leading-edge patient-based datasets acquired in the clinical setting, to fundamental research results in fields such as imaging, genomics, metabolomics and other areas of high throughput biology, using novel computational tools, methods and interdisciplinary groupings unique to the ICBM. This initiative will build on McGill’s established leadership in genome technologies, in computer approaches to brain imaging analysis, established programs in bioinformatics, in structural
biology and in drug discovery, as well as in emerging programs in community health, disease surveillance and electronic patient records, and public policy and societal issues that arise from analysis of large health-related datasets.

5.2 Infrastructure

In the face of limited resources, key choices must be made for infrastructure investment. For these difficult decisions, it is important to consider past investments, future opportunities and the need to develop infrastructure that is complementary to that being developed in the research centres of the teaching hospitals, while avoiding duplications. In addition, it is critical that while supporting research areas of key strategic interest, infrastructure investments have the maximum impact for researchers in the Faculties.

5.2.1 Policy on Platforms

Successful research programs rely on diverse enabling tools and platforms whose core elements and efficient utilization often lie outside the means of any single investigator. In recent years, CFI funding has been the main mechanism for the development of infrastructure. However, CFI funding does not bring long term operational support, leaving a substantial void. In order to optimize the impact of the available resources, the Faculties will prioritize platforms that are both cost-effective and which benefit multiple users. Top priority will go to platforms that are widely used, ideally across departments and disciplines.

The Faculties have also prioritized two specific areas for continued infrastructure investment. These areas are critical for the implementation of the strategic research priorities across different fields of health and disease.

5.2.2 Genomics

Given the central importance of genomics and related disciplines to modern biomedical research across different fields, and their the potential for multidisciplinary research and imminent impact on clinical outcomes, the Faculties will build on the already substantial investments in the McGill and Genome Quebec Innovation Centre (MGQIC) and will promote further development of computational biology capacity through the Institute for Computational Biology and Medicine. The Faculties will build on the substantial investment already in place, but promoting increased collaboration and efficiencies. A special effort will be made to promote knowledge translation so as to empower clinical researchers to partner with the strong core of genomics scientists.

5.2.3 Computation and Imaging

In recognition of the centrality of computing and information technology to the above priority areas, computational capacity will be a key area for future development and investment as part of the university’s overall IT strategy. In addition, the Faculties will promote as a priority the development of novel approaches and applications of imaging. This initiative will be two-pronged. We will build on the established excellence of the group at the MNI, to encompass imaging efforts at the Douglas in neuroimaging, the investments in research imaging technology at the RI-MUHC, as well as promoting the growth of imaging science in the Medical Physics Unit and Biomedical Engineering. The Faculties will also build on the solid infrastructure in the Department of Anatomy and Cell Biology and the Advanced Bioimaging Facility at the Bellini, to promote the development of advanced microscopies and live-cell imaging. These efforts
would also provide a strong basis for growing collaborations with other faculties, notably Engineering and Science.

5.3 Administrative Initiatives

5.3.1 Establishment of a Strategic Research Fund

The Faculties recognize that fostering truly innovative and transformative research will require development of a new financial framework that will involve increased financial resources. To this end, the Faculties propose the creation of a new Strategic Research Fund (SRF) that will be established and endowed over the next 5 years. This fund will support a wide array of activities across the Faculties including operating awards to sponsor groundbreaking, high-risk projects that hold the promise of being transformative, as well as timely investments in key infrastructure. This fund will be created through a combination of operating funds, corporate and private philanthropy, as well as through reinvestment of income generated from discoveries, and other commercialization activities.

5.3.2 Development of Faculty and Students

Targeted recruiting of talented young investigators is required to renew and invigorate the Faculties. It is well-understood that critical mass in a research field fosters collaborations within and even outside a group of investigators. The added value of research teams resides in the convergence of different perspectives and methodologies, and in a similar-minded focus that generally adds value to the overall research effort. Emphasis will be given to forming new interdisciplinary groups, and strengthening existing successful groups. Measures of success and potential will be integrated with the potential for added value in advancing priority research areas. For those groups/centres that receive financial support from the Faculties and/or the VPRIR, annual reporting and formal review every three years will be required.

The development of strong mentoring programs will be encouraged and the demonstration of success of mentoring programs will be a criterion for evaluation of unit heads. Better mentoring of individuals for the skillsets they need for a given career path will be built into the system; in addition, juxtaposition of individuals with different skillsets but sharing common objectives can build an environment in which patient care and research can benefit from a coordinated approach to all these aspects of “health” services and care.

The success of research programs is dependent on the quality of the graduate and post-doctoral students they can attract, and retain. In turn, these trainees and the research they perform in these programs are at the core of achieving success. To this end, those financial that support graduate students and post-docs in the two Faculties will be focused on the strategic priorities outlined in this document. Moreover, the Faculties will foster the development of new integrated training programs that cross disciplines, building on successful models such as the integrated program in neuroscience.

A crucial element in the future development of the Faculties of Medicine and Dentistry is the need to develop and recruit clinician-scientists. While McGill continues to attract excellent PhD scientists, regulatory issues limit our ability to recruit clinician-scientists in mid- or late-career stages. Hence, the programs for development and training of future clinician scientists must be strengthened. The MD-PhD program will be revised in accordance with a recent external review, so as to recruit separately from the regular MD program. The new medical curriculum
now requires completion of a research project before graduation, and efforts will be made to provide students who become interested in a research career with opportunities to develop their skills. In addition, the Clinical Investigator Program, which provides research opportunities at the residency level, will be enhanced and coordinated with the other initiatives aimed at promoting research among clinical trainees.

5.3.3 Partnerships and Commercialization

In order to promote translation of research findings into novel therapies and innovative approaches to care, the Faculties will collaborate with the office of the VPRIR, with the hospital research institutes and with other stakeholders to promoting opportunities for commercialization and partnership with industry. These interactions may involve timely and synergistic collaborations to develop novel technologies, access to unique technology platforms, and training of a highly qualified work force for the industrial sector. Although such interactions will be based on traditional intellectual property-based approach, the Faculties recognize that the paradigm of innovation is becoming more collaborative. Therefore, the Faculties will work with the VPRIR office to develop and implement alternative models to foster open access and open innovation, with the goal of increasing McGill’s attractiveness as a nimble and agile industrial partner.

5.3.4 Administrative Excellence Centres (AEC)

In the face of severe budgetary restrictions, the Faculties have been moving toward shared administrative units responsible for HR and Finance. Although initially driven by financial concerns, by using higher level personnel, these units provide a higher level of quality of service. Experience so far suggests that AECs provide better support to departments and investigators, particularly with respect to grant management, Tri-Council compliance and other issues that otherwise consume the time of investigators. In addition, the establishment of AECs provides the opportunity to promote interdisciplinary collaboration. Examples include an AEC that provides support to the Departments of Psychiatry, Neurology and Neurosurgery and Ophthalmology, and an AEC that supports Epidemiology, the Institute for Health and Social Policy, Global Health, Social Studies of Medicine and the McGill AIDS Centre. The latter AEC forms the administrative infrastructure for the emerging Institute for Public Health and Population Research.

5.4 Evaluation Framework and Metrics

The performance of the implementation strategies, and their impact on the overarching goals of the SRP, will be monitored using an evaluative framework and associated metrics. The Implementation Group will be tasked with developing an overall evaluative framework for the SRP, its implementation, and outcomes. This will be done in collaboration with experts from the Faculty of Medicine, and other units with expertise in evaluation. The aim will be to produce a set of qualitative and quantitative parameters that will complement standard metrics and will monitor success of the different strategic initiatives.

Standard metrics of research productivity are well known and include the total amounts of research funding acquired by the Faculty under the SRP, the type, number and impact of scholarly publications produced form this work, as well as the different prizes, distinctions, awards and other accolades to individuals and groups involved. Other measures of success will
include our ability to attract international recognition and associated partnerships, recruit and retain the very best researchers, and our capacity to train graduate students, post-doctoral fellows, and clinician scientists that will become tomorrow’s leaders in all branches in health research. Successful implementation of sustainability initiatives to create, promote and support key technology platforms and cores will also be evaluated.

We will also develop metrics to survey the societal impact of the SRP-associated knowledge translation activities. This will include monitoring knowledge dissemination directed at informing and educating the public of research accomplishments and milestones. We will ask the Institute for Public Health and Public Health Research to develop and implement tools to document impact of SRP related translational research activities on public health, and patient care. Additional aspects of knowledge translation such as intellectual property, research contracts and other economic activity through commercialization of health research products will also be quantified, and analyzed for positive impact.
<table>
<thead>
<tr>
<th>Strategic area</th>
<th>Research focus</th>
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| Patient Experience, Population Health and Health Services | • Social and environmental determinants of health  
• Healthcare information technology  
• Patients’ experience with health and illness, patient/family engagement, and interactions across the continuum of care  
• Optimal health trajectories over the life-course |
| Genetic and Environmental Determinants of Health and Disease | • Gene discovery in rare diseases and in common complex disorders  
• Epigenetic modulation of the genome in disease  
• Extracellular matrix in normal cell signaling and in pathological situations  
• Host-microbe interactions in infection, inflammation, development and cancer |
| Systems and Networks Approaches to Health Research | • Integrated “omics” approaches to biomedical research  
• Integrating with health data  
• Computational approaches to quantitative biology  
• Imaging of cellular networks |
| Personalized Medicine: Customized Approaches to Patient Care | • Biomarkers- and molecular signature-based strategies for disease diagnosis, monitoring and treatment including clinical trials  
• Personalized health improvement devices and delivery systems  
• Precision engineering of animal-, cell- and protein-based models of human disease  
• Customized health care delivery for vulnerable groups |
## IMPLEMENTATION STRATEGIES

<table>
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<th>Key Objectives</th>
<th>Initiatives</th>
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| Encourage Inter-disciplinary research in strategic areas by supporting new research groupings | • Create the *Initiative in Public Health and Population Research*  
• Create the *Initiative in Computational Biology and Medicine*  
• Develop a mechanism to solicit, and build new centers, institutes and schools |
| Develop human capital and train the next generation of health researchers        | • Recruit talented junior investigators in the areas of strategic priority  
• Develop innovative training programs for graduate, post-graduate students and health professionals  
• Stimulate recruitment and training of clinician scientists |
| Foster creation and maintenance of enabling technology platforms                 | • Prioritize for infrastructure investments the areas of Genomics, Bioinformatics, and Imaging  
• Develop a framework to financially support other enabling technology platforms  
• Assist faculty in identifying needs and opportunity, and for obtaining funding |
| Develop mechanisms to support research in strategic areas                        | • Establish a strategic research fund to provide financial support  
• Continue to support existing programs in studentships, fellowships and bridge funding  
• Implement the Merck research funding program  
• Deploy centers for administrative excellence |
General Framework for Strategic Research

### Implementation Strategies
- Strategic Grouping
- Knowledge Translation
- Enabling Tools and platforms
- Building Human capital
- Strategic Research Fund

### Prioritized Themes
- Patient Experience, Population Health and Health Services
- Genetic and Environmental Determinants of Health and Disease
- Systems and Network Approaches to Health Research
- Personalized Medicine: Customized Approaches to Patient Care

### Disease Areas
- Infection and Inflammation
- Cancer
- Neurosciences and Mental Health
- Aging, Disability and Chronic Diseases