

2008 STRATEGIC RESEARCH PLAN – SUMMARY

Université de Montréal, together with its university hospital centres and its two affiliated schools, École Polytechnique and HEC Montréal, is a university complex of exceptional scope on both the national and the international fronts. The University ranks among the best public research universities in North America and the top 100 universities worldwide, the only university in La Francophonie in such an enviable position.

Université de Montréal elaborates its research activities in three major strategic directions:

- Provide, at every academic level, relevant and high-quality intellectual and scientific training, firmly grounded in both the new knowledge emerging from research and the workplace and practice environments;
- Integrate research efforts and higher education around mobilizing projects in its areas of excellence, and anchor them in an interdisciplinary and international perspective;
- Reconfigure the University on the basis of its distinctive features and its strengths, considering the available resources.

The University's strategic planning draws on developments carried out over recent years. It is based on an assessment of research achievements, scope and benefits. Strategic axes are set with a view to maintaining or developing performing fields and emerging areas.

Université de Montréal subscribes to the values of integrity, intellectual probity and research ethics, and recognizes the merits of diversity in research models and the need to pursue developments in all fields of knowledge.

MAIN OBJECTIVES

The University's Strategic Research Plan is designed to mobilize University resources as a whole, to:

- Further develop training environments that meet the highest criteria of scientific and academic excellence on one hand, and on the other, Canada's substantial needs for a highly qualified workforce;
- Confirm its national leadership in its various sectors of activity and its place among the front runners of great international research universities;
- Continue its contribution to scientific breakthroughs and, through valorization of research results, to cultural, social and economic progress.

CONTEXT

Our strategic research planning is based on a set of favourable conditions:

- Acquisition of additional space for a very necessary expansion and flexibility for the development of research platforms;

- Availability of programs specifically funding research infrastructures and allowing the University to acquire equipment comparable to that of the best international research centres;
- Recent successes of Université de Montréal researchers in structuring programs and national initiatives;
- Recruitment and retention of international calibre faculty through various chair programs, in place and in development;
- Formation of groups able to tackle inherently interdisciplinary themes and the association of university departments with hospital research centres whenever this may result in significant synergies;
- Convergence of internal and external means likely to strengthen research environments, making it possible to achieve major scientific breakthroughs;
- Development of graduate and post-graduate programs connected with the major research themes.

Furthermore, certain recent or relatively recent strategic orientation choices have transformed the institutional research landscape, for example:

- Creation and implementation of a scientific and technological hub regrouping the Université de Montréal, École Polytechnique and HEC Montréal, notably active in the field of nanoscience and nanotechnology and in operational research;
- Formation of critical masses of expertise in various areas, sometimes the most substantial in Canada, combined with a first-rate clinical environment and cutting-edge technological infrastructures;
- Important developments in immunology and virology (creation of the Institute for Research in Immunology and Cancer), in genomics, metabolomics, proteomics and related disciplines, along with the study of associated ethical and social dimensions;
- Major initiatives on the issues surrounding the mother-child-family triad;
- Large-scale programs in the areas of social statistics, ethics, cultural studies, governance and social diversity/cohesion, as well as in multidimensional studies on populations;
- Structuring carried into the broad areas of the arts, literature and humanities through the creation of observatories and centres involved in literary, theatrical, artistic, music and cultural history studies.

STRATEGIC RESEARCH AREAS

The strategic research areas have been grouped into three broad sectors: arts, humanities and social sciences; natural sciences and mathematics; and biomedical and health sciences. A sign of cross-disciplinarity, most areas and themes associate disciplines belonging to more than one sector. All the research areas listed below are closely linked to existing and soon to be created training programs, especially at the graduate levels.

A. – Arts, humanities and social sciences sector

Literary and cultural studies, including *Quebec studies*, focuses on cultural and thought systems in a national and international perspective, and involve research teams from various disciplines: literature, history, philosophy, sociology of culture, film studies, musicology, art history, museology, ethnography, anthropology, religion studies and communications. An important place is given to creation and research on creation. Solid expertise in literature, film, music and world cultures can also be found.

In *ethnic studies* and *studies on cultural and linguistic pluralism*, the University exercises strong leadership, particularly in respect to: the adaptation of educational environments to multiethnicity; policies and educational programs intended for culturally heterogeneous populations; heritage languages; the study of major religious traditions; racism and discrimination; ethnomusicology; and sociology of ethnicity. The theme of identity issues in contemporary societies is ever-present.

International studies and globalization covers research fields delineated along two axes: one, geographically based or relating to zones of influence (e.g., research centres on the European Union, on German-speaking countries or on East Asia) and the other, a thematic axis along which the consequences of globalization are analyzed in various respects, for example: demographics and immigration (including from a historical perspective through historical demography); law and international trade; international economic development; globalization of labour; policies and international institutions; and defence, peace and foreign policy programs.

In the field of *applied social sciences*, the quantitative and qualitative analysis of economic and social data make it possible to shed light on public policies and decisions made by governments, companies and individuals. The field of socioeconomic statistics, in particular, is based on the development of appropriate data analysis methods (in macroeconomics, finance, econometrics; development of indicators in various fields, etc.) and their development as part of analyses on a range of phenomena: economic conditions, population health, health administration, evaluative research on social transfer, education management, etc.

The *Ethics Research Centre (CREUM)*, created in 2001, brings together the University's driving forces in this field. Several ethical dimensions are addressed by building on this discipline's fundamental knowledge and projecting it into multiple fields of application: bioethics, professional ethics, the ethical use of technology, ethics related to the environment, the ethics of international relations, etc.

Childhood and adolescence development draws on a hub strongly rooted in the network of organizations concerned with the education, health and safety of children and adolescents. Whether in a perspective of analysis, intervention or assessment, the projects take into account the life environments (family, school and community) and the vulnerabilities (poverty, substance abuse, domestic violence and exclusion) that determine the physical and mental health, emotional and cognitive development, and psychosocial adaptation of children and adolescents. Certain initiatives are implementing extensive longitudinal surveys, from conception to adulthood.

In the field of *education and training*, two main axes are developed, namely the pedagogy of higher education and the educational use of technologies. The first relates to university teaching models, the analysis and evaluation of practices and models of guidance and management of educational intervention. The second concerns the integration and impact of information and communication technologies (ICTs) on training and in the field of teaching/learning (including e-learning), provided in both institutional (schools and universities) and non-institutional settings (workplace and community-family).

The *digital society* theme is covered by studies on the use and usage of information and communication technologies (ICTs). Research on the uses of ICTs examines the human-machine relationship (cognitive ergonomics, interface design, etc.), while research on usage dwells on transformations in individual relations and new social phenomena brought about by ICTs. These studies encompass all operations made possible through the opportunities provided by these technologies, such as automatic language and text processing.

B. – Natural sciences and mathematics sector

Nanoscience, nanotechnology and new materials revolves around the synthesis, characterization and integration of materials in industrial, biomedical and environmental devices. With its expertise in polymeric, supramolecular and thin-layer materials, as well as in biomaterials, the University is also developing the soft materials sector. The physical systems resulting from nanoscience and nanotechnology are deployed in a host of application fields, including computing, telecommunications, energy, materials, chemistry, medicine, pharmaceuticals and biotechnology.

The field of *medicinal chemistry and pharmacology* focuses on the chemistry and pharmacology of new therapeutic agents. This area addresses strategies for chemical synthesis, the synthesis of novel drugs, their structural, biochemical and pharmacological characterization, as well as vectorization and controlled release of therapeutic agents.

The *astrophysics and astronomy* field is represented by the vast array of current and developing activities in astrophysics and stellar, galactic and extragalactic astrophysics. For its part, the "particle physics" component regroups forces that are particularly well inserted within large international collaborations. A solid program in advanced instrumentation is conducted, combined with extensive expertise in digital analysis techniques, computer science, information processing, image analysis and communication networks.

The field of *computer science, information and communications science* aggregates, on one hand, research axes in several subfields of pure and applied sciences: theoretical and quantum computing; computerized systems and parallel processing; bioinformatics; computer graphics; imaging and vision; optimization and simulation; adaptive systems computing; artificial intelligence; data mining and telecommunications. On the other hand, it includes institutional expertise in information science, knowledge and digital information management.

Recourse to *simulation and modeling* has become critical, replacing or even preceding experimentation. The methods employed are derived from the latest breakthroughs in mathematical research, and their applications are growing. They are in great demand not only in computer sciences and mathematics, but also in a wide disciplinary range including: pure,

applied and digital analysis; geometry and physical mathematics; probabilities; mathematical finance; cryptology; the formal study of molecules and biological systems; the cellular environment; anatomy; industrial design, etc. New fields of exploration are opening up with the advent of increasingly sophisticated tools, such as virtual and augmented reality, haptic interaction and fast prototyping.

The theme of *environment and sustainable development* combines fundamental and applied research activities over a broad range of issues linked to the natural and built environment: the ecology of freshwater and forests; plant biology; the dynamics of river environments; adaptation to environmental change; the study of biohazards; urban and suburban environments; transportation and energy; the relations between landscape and environment; environmental design; conservation and heritage preservation; the connection to health; the legal framework; risk management; and sustainable economic development. There is a new emphasis on biodiversity, with implementation underway of the Consortium of Canadian Universities on Biodiversity led by the University.

Projects in the field of *agri-food biotechnology* target the production of high quality, healthy and nutritional food at competitive costs, and from a sustainable development perspective. The objectives relate essentially to the development of tools derived from biotechnology (vaccines, active molecules, enzymes, diagnostic methods, vectorization of active molecules, etc.), making it possible to control diseases and improve livestock and plant production, as well as resulting processed products.

C. - Biomedical and health sciences sector

The field of *genomics and integrative genetics* addresses developments in functional and evolutionary genomics, descriptive and functional proteomics, pharmacogenetics and bioinformatics. It includes many innovative sectors in several axes: community genetics; pharmacogenomics; molecular genetics of stem cells; cell therapy; predictive medicine; custom medicine; drug response; immunomonitoring; mechanisms of action of pathogens; protein-protein interactions; interactions of genetic factors; and environmental and psychosocial determinants influencing the course of complex human diseases, along with the legal, social and ethical aspects of developments in genetics. The thematic range extends into the animal and plant realms.

The area related to *cancer* covers a broad spectrum, from biological foundations to epidemiology and through to screening, therapeutic research and toxicology. Issues are approached from three angles: endogenous (basic biology, genetics and markers, diagnosis, prevention and therapeutics); exogenous (environment, nutrition, epidemiology and therapy); and organizational (therapeutic assessment). Involvement in major North American basic research projects (including vaccines and stem cells) and clinical research projects should lead to major benefits on the care level. Immuno-oncology, in particular, is experiencing rapid progress, which has revived interest in anti-cancer immunotherapies.

The theme of *immunity and infection* refers to research on the body's inflammatory, cellular and immunological reactions to viral, bacterial and traumatic attacks. It addresses preventive and curative interventions as well as specific strategies (e.g., vaccines and treatment protocols) aiming to maintain and restore the body's integrity. A major effort is underway in

virology. Considerable expertise in biological models, infectious animal diseases, zoonosis agents and the safety of the food chain is also being deployed.

The field of *drug development* covers a wide range of themes related to drug design, synthesis, development and evaluation. Several themes are part of this continuum: identification and development of new therapeutic targets through molecular, cellular and animal models approaches; combinatorial chemistry and high-speed screening to identify new molecules that can interact with these targets; characterization of the new molecules' pharmacological profile; development of new pharmaceutical forms; assessment of these agents' therapeutic potential through clinical studies; assessment of the optimal use of drugs through pharmacoepidemiological, pharmaco-economic and social studies.

At the core of cell biology, research in the field of *internal environment, cellular environment and biomarkers* deals with all the normal and pathological conditions of the major physiological systems (cardiovascular, nervous, renal, pulmonary, nutritional and reproductive). Found here are such fundamental themes as: membrane signalling; membrane transport and protein-ligand interactions at the basis of the biology of receptors; intracellular cascades in response to external stimuli (attack of an environmental or pathological nature, or attack linked to a therapeutic intervention), and the metabolism and biology of cellular interactions.

The *cardiovascular and metabolic* field integrates, on one hand, the study of cardiac functions (mechanical, electrical, and hormonal) and projects on circulating blood cells (differentiation and functional characteristics) and, on the other hand, the study of genetic and behavioural determinants, the study of blood regulatory mechanisms and the epidemiological and nutritional aspects of all the anomalies that make up the metabolic syndrome, with a focus on innovative treatments. Various chronic or acute diseases (type 2 diabetes, atherosclerosis, cardiovascular disease [myocardial] and strokes) are targeted as well as their common risk factors (e.g., hypertension, hypercholesterolemia, physical inactivity and diet). The field includes a pharmacocardiocardiovascular dimension as well as a public health dimension, taking into account individuals and populations (genetic, epidemiological and prevention components).

The *neuroscience* field covers research on a range of phenomena relating to the nervous system at various stages of life. The themes include the biology of neuronal development, neuropharmacology, cognition, structure-function relationships, the sleep-wake cycle, human communication (audiology and speech therapy), neuropsychology, interactions between environment and development, functional brain imaging and neuronal regeneration. The underlying field of *motor skills and musculoskeletal system* refers to the study of musculoskeletal support, motor innervations, and central and peripheral nervous control, as well as physical rehabilitation in the event of injury. This area also includes the genetic and genomic determinants of neurological development and brain disorders (neurogenomics). Lastly, *mental health* is part of this field given the continuity between biological considerations and environmental influences (physical and cultural).

Vision science and vision health finds a fruitful environment at the Université de Montréal, the only institution in Canada with both a School of Optometry and a Department of Ophthalmology. The University will continue to nurture the development of an integrated team of high-level researchers who specialize in these fields. The eye-vision complex is a

unique field of study where converge basic, applied and clinical research dimensions on the development, maturation and normal aging of the visual system as well as the function it underpins.

The *rehabilitation and adaptation* theme includes the neurological, neurosensory, locomotor, organizational, behavioural and social determinants of physical rehabilitation and social reintegration of individuals suffering from various disabilities, in a framework of strongly integrated biomedical and social research. New niches have developed out of this theme, such as technological aids or home automation for adaptation of the living environment. Top-notch infrastructures, notably in virtual reality and prototyping laboratory, are put to full use. This theme, which affects pediatric and adult fields alike, includes trauma research.

The *human development* field covers virtually all stages of life, from fetus to adult, and integrates various aspects (genetic, biological, functional, psychosocial and behavioural) of a person's evolution through the transitions and circumstances of his/her life. Research on perinatology, neonatology, fetal diagnosis, the prevention of adverse effects of therapies, and on pharmacology applied to the mother and child requires multidimensional approaches that reach communities (outreach and remote case management). Also found in this field are the various dimensions of aging (biological, psychological, social, organizational and public health). Studies on the development of *in vivo* and *in vitro* organs are also included in this field.

Research related to *public health and populations* has many facets, embracing: health determinants (socioeconomic, biological, physical and lifestyle); epidemiology; promotion and prevention relating to both lifestyle and environment (physical, social and economic); the analysis of policies and health services, including research on the performance of health care systems and decision-making; the assessment of technologies and modes of intervention in health care; evaluative research; and infectious or chronic diseases. With the recent establishment of the School of Public Health, which brings together several sectors of activity (global health, environmental health, occupational health, health administration, veterinary medicine, biostatistics and epidemiology, social sciences and behavioural sciences, bioethics, biotechnology law, etc.), the synergy between training, research and practice, along with links to clinical and practical settings, public health institutions, the health network and citizens, is expected to grow even stronger.

Clinical research addresses the causes, diagnostic methods and tools, along with the various treatments of diseases and their actual effectiveness in populations. This field includes the innovative technological developments applicable to human health and health care: biomedical materials; robotics applied to medicine and innovative surgery; imaging; and modeling. Telemedicine is an active part of this field.

Diagnostic, functional, interventional and guidance imaging is a field with high clinical impact, having greatly benefited from IT developments. Thanks to the establishment of multi-user platforms in diverse environments and the regrouping of forces within an integrated research program, scientific breakthroughs of great significance were made in the diagnosis and treatment of certain pathologies (notably neurocirculatory) as well as in the development of surgical guidance systems. Many diagnostic and therapeutic areas directly benefit from advances in imaging, to name but a few: assisted surgery; the cardiovascular and circulatory field; the brain and spine; and the treatment of certain cancers.