



McGill

Faculty of
Science

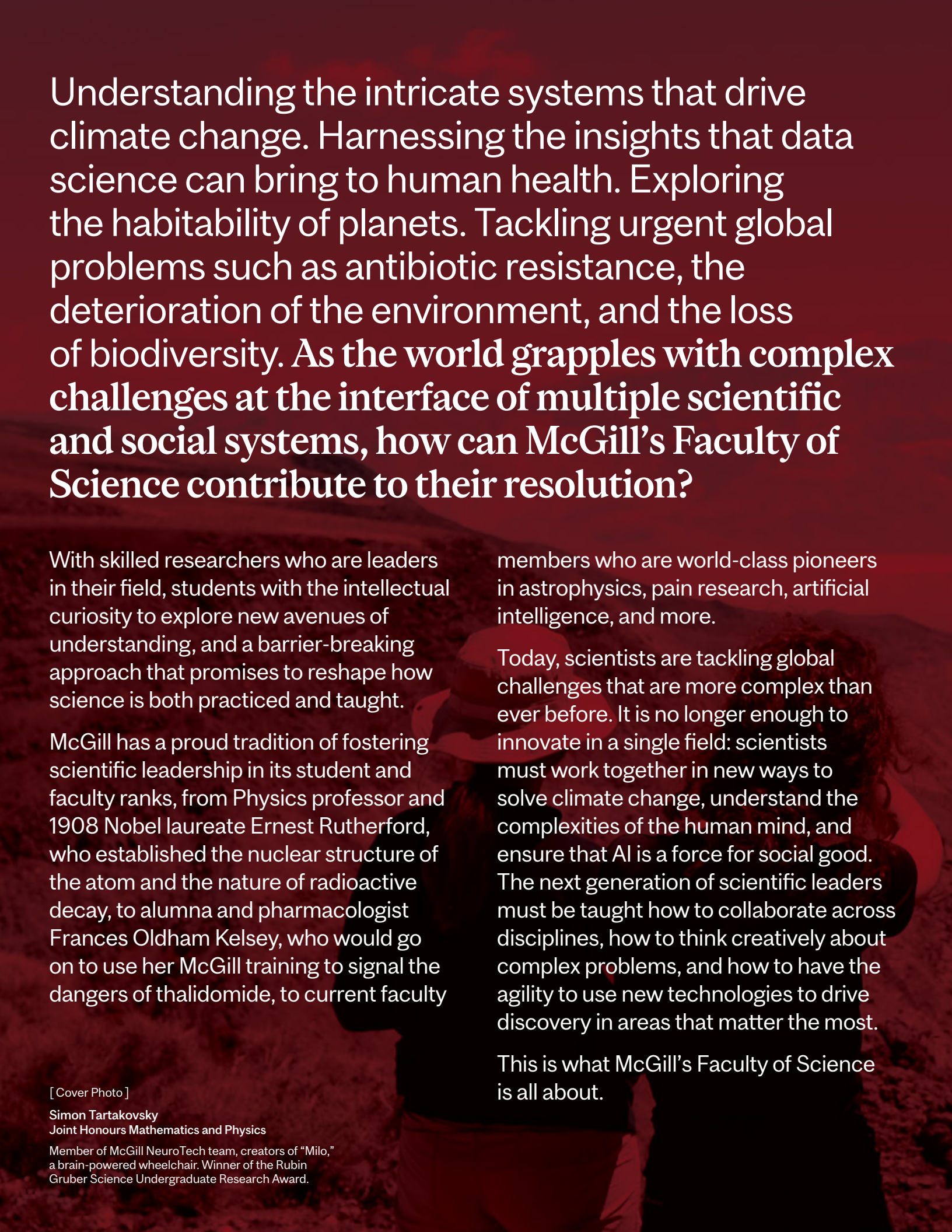


Learning through discovery

MADE

by McGill

Simon Tartakovsky
Mathematics and Physics



Understanding the intricate systems that drive climate change. Harnessing the insights that data science can bring to human health. Exploring the habitability of planets. Tackling urgent global problems such as antibiotic resistance, the deterioration of the environment, and the loss of biodiversity. **As the world grapples with complex challenges at the interface of multiple scientific and social systems, how can McGill's Faculty of Science contribute to their resolution?**

With skilled researchers who are leaders in their field, students with the intellectual curiosity to explore new avenues of understanding, and a barrier-breaking approach that promises to reshape how science is both practiced and taught.

McGill has a proud tradition of fostering scientific leadership in its student and faculty ranks, from Physics professor and 1908 Nobel laureate Ernest Rutherford, who established the nuclear structure of the atom and the nature of radioactive decay, to alumna and pharmacologist Frances Oldham Kelsey, who would go on to use her McGill training to signal the dangers of thalidomide, to current faculty

members who are world-class pioneers in astrophysics, pain research, artificial intelligence, and more.

Today, scientists are tackling global challenges that are more complex than ever before. It is no longer enough to innovate in a single field: scientists must work together in new ways to solve climate change, understand the complexities of the human mind, and ensure that AI is a force for social good. The next generation of scientific leaders must be taught how to collaborate across disciplines, how to think creatively about complex problems, and how to have the agility to use new technologies to drive discovery in areas that matter the most.

This is what McGill's Faculty of Science is all about.

[Cover Photo]

Simon Tartakovsky
Joint Honours Mathematics and Physics

Member of McGill NeuroTech team, creators of "Milo," a brain-powered wheelchair. Winner of the Rubin Gruber Science Undergraduate Research Award.

Through its commitment to an interdisciplinary Systems Science approach, the Faculty is tackling the most complex problems in science and society.



The Faculty is breaking down disciplinary silos to support innovation.



Working in fields as diverse as green chemistry, nanotechnology, robotics, earth systems sciences, and cognitive psychology.





Combining this with facilities that engage the **latest technologies** and a hands-on approach to teaching the next generation of leaders.



So that we are **poised to make an even greater contribution** to our country, our society, and our world.



These are our strengths

One of the early champions of McGill Science was the University's fourth Principal, geologist William Dawson, the first Canadian-born scientist of global renown. During his 38-year tenure at the helm of McGill, Dawson oversaw the transformation of science education from a fixed curriculum of "natural philosophy" to an array of professional disciplines focused on research – paving the way to modern science.



In the century and a half since Dawson launched the Faculty of Science onto the path of excellence, the list of honours has grown to include two Nobel Prizes awarded to faculty members and seven to alumni, plus more than 100 fellowships from the Royal Society of Canada.

The future of McGill's Faculty of Science will be forged on these distinctive strengths:

Breadth and depth of expertise

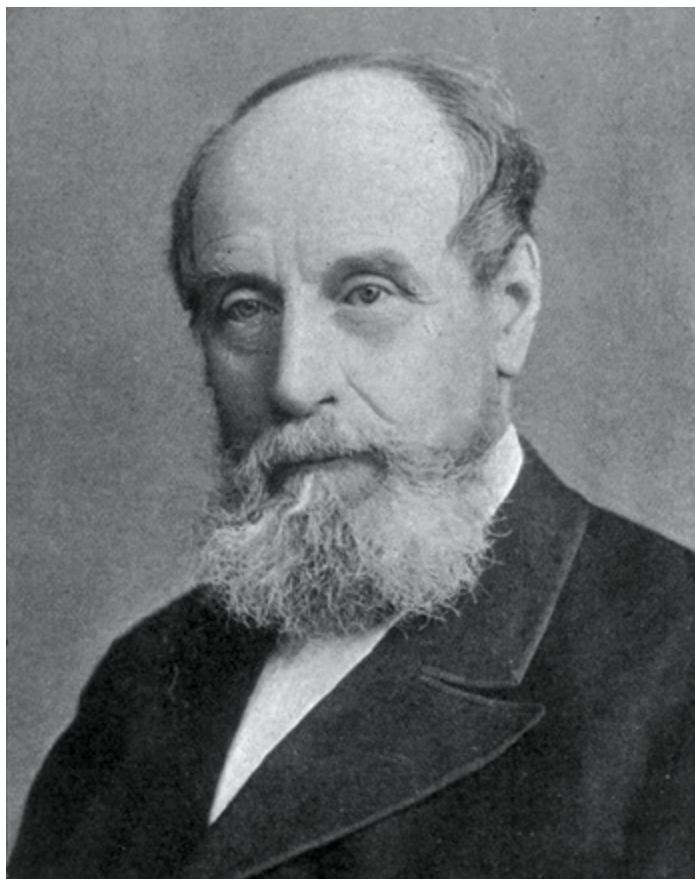
With 285 professors teaching across 10 departments, the Faculty of Science boasts expertise in a diverse range of disciplines. This has helped the Faculty recruit some of the best scientific minds of this generation, who not only perform key research, but teach tomorrow's scientists and prepare them for a lifetime of discovery and impact.

A tradition of innovative teaching

We are committed to offering every undergraduate Science student an opportunity to enrich their classroom education through international experience, internships, exchanges and field studies, research projects and other ways to put theory into practice in a real-world context. The Faculty of Science's renowned field courses bring students to the High Arctic, Panama, Barbados, East Africa, plus a number of sites across Canada, Europe, and Central and South America. A cornerstone of this commitment to experiential learning is the Science Undergraduate Research Awards (SURA) program, which provides fellowships that allow undergraduates to work-hand-in-hand in the laboratories of renowned researchers – something very few institutions offer.

A focus on interdisciplinary research

The Faculty of Science recognizes that an interdisciplinary approach is necessary if we are to make headway in resolving today's complex research challenges. This commitment leads to new discoveries and new technologies, provides a template for training the next generation of scientists, and serves as a catalyst for new ways of thinking, teaching, and discovering, both within McGill and beyond.



This is our vision

Our goal is to strengthen our capacity to address the challenges of the future.



The Faculty of Science is eager to help shape a more inclusive, prosperous and sustainable future. This ambition recognizes our distinctive capabilities and the areas in which we can have the greatest impact.

Our vision is organized around the following priorities:

Transforming teaching to prepare the next generation of scientists

The Faculty counts undergraduate students as one of its key strengths, and for good reason: they boast the highest average entrance grades in Canada. How can we ensure that these talented young individuals have access to the knowledge, the facilities, and the experiences that will help launch them on the path to success?

Creating new ways to advance science

To position the Faculty at the forefront of discovery, we need to advance the technological and methodological foundations of science. How can we innovate by creating new scientific tools and systems that will accelerate discovery across departments and fields?

Driving discovery to solve complex global challenges

The Faculty's commitment to a Systems Science approach will be the engine that drives discovery, as diverse groups of researchers work to resolve some of the most critical issues of our time. It will also provide a template for training the next generation of scientists, public service, and industry leaders. How can we help break down disciplinary barriers and encourage the kind of inclusive thinking that will change the world?

A portrait of a young woman with long, straight brown hair, looking directly at the camera with a slight smile. She is wearing a dark blue t-shirt. The background is a plain, light grey color. The top right corner of the image is cut off by a diagonal line.

Made to talk science.

**Driven to get others
excited about STEM.**

Made by McGill.

Victoria Chui
Biochemistry major

Shares her love of science with kids
through teaching at the Redpath Museum
and with the McGill branch of Let's Talk
Science, a Canada-wide STEM initiative.



Transforming teaching to prepare the next generation of scientists

Science today requires a new model of teaching and learning: one that is collaborative and interactive, in which students have more hands-on opportunities to engage with real-world problems and develop innovative solutions.

Learning Through Discovery – our Faculty theme – reflects the dynamic approach the Faculty of Science takes towards undergraduate education: one that encompasses the complexities of today’s scientific challenges.

To further strengthen this transformation of science education through an experiential approach to undergraduate teaching, the Faculty is seeking support to:

Establish a Science Education Innovations Laboratory

The **Science Education Innovations Laboratory** will create an ecosystem for the incubation of new teaching and learning programming. It recognizes that the learning of Science in the next decades requires innovations in course delivery, assessment methods, and content. Innovations in teaching must also mirror students’ technological sophistication and desire for their teaching/learning experience to be as impactful as the subject matter they are studying. McGill Science has frequently demonstrated that innovations such as “active learning” and “integrated experiential learning” are effective in developing a student’s critical analysis skills while also enabling them to develop as disciplinary experts.

The goal of the **Science Education Innovations Laboratory** is to make McGill Science a leader in the development of novel teaching approaches in an environment that encourages students to identify, define, and address complex scientific problems. It will ensure that students experience meaningful education in the classroom and laboratories by focusing on active and inquiry-guided learning, together with applied research opportunities.

To achieve this, the Faculty will create:

- › **Learning communities** that bring together faculty, students and staff to share their unique perspectives and work together to transform discipline-specific approaches to pedagogy
- › **New spaces that enhance creativity** in the design phase of teaching, incorporate new technologies, and promote mental and physical well-being
- › **Fellowships, awards and initiatives such as retreats** that will reward, recognize and support efforts to increase effective teaching and learning, especially by groups within or across departments

Overseeing the activities of this important new learning hub will be the **Tomlinson Chair in Science Education**. The Faculty seeks additional philanthropic investments to support:

- › An Executive Director position to oversee the Lab’s operations
- › Outreach initiatives, including lectureships, workshops, symposia, and public events
- › New graduate and postdoctoral fellowships in Science Education research



**A deeper understanding
of the cosmos.**

**Made by researchers
like Victoria Kaspi.**

Made by McGill.

BSc'89. Professor, Department of Physics. Lorne Trottier Chair in Astrophysics and Cosmology. Director of the McGill Space Institute. Renowned astrophysicist. Winner of the Gerhard Herzberg Canada Gold Medal for Science and Engineering.

Creating new ways to invent and advance science

Measurement Innovations Laboratory

McGill Science is committed to the invention, development, and use of new scientific tools, where tools are defined as measurement and methods platforms or systems (including new software and analysis methods) which have the potential to advance scientific knowledge and understanding. New tools have been driving scientific discovery for centuries. Examples such as van Leeuwenhoek's pioneering microscope that revealed the existence of microorganisms, Galileo's use of the telescope to observe the celestial bodies of the night sky, and Sanger's methods of sequencing DNA that enabled today's biotechnology revolution have changed our understanding of the nature of our world.

Building on the legacy of nearly two centuries of McGill's own scientists, more than 75 Science professors and their research groups are currently focusing their efforts on groundbreaking instrument/method design, invention, and use.

From tools that enable the search for dark energy, to devices for imaging molecule-level detail of living cells and DNA, to new instruments that create 'molecular movies' of the properties of solids - McGill Science is committed to developing research tools that push the boundaries of spatial resolution (nanometres to billions of kilometres) and temporal resolution (from femtoseconds to billions of years). The **Measurement Innovations Laboratory** will enhance the Faculty's capacity for scientific discovery in a multitude of fields by inventing, designing, and implementing new instrumentation and tools for measurement, data analysis, and fabrication. Among the new devices currently being developed are detectors applied to high-energy physics and astrophysics; molecular biology markers of genetic diseases; ultra-high resolution microscopes using optical, probe, and physical properties; computational platforms for materials design; and ultra-fast spectroscopy to probe structure and property relationships in quantum materials.



In order to create and sustain the Measurement Innovations Laboratory, the Faculty of Science seeks funding for:

- › An endowed Chair, occupied by a globally-recognized scholar in this field, to serve as the Laboratory Director
- › New postdoctoral fellowships to enhance research capacity
- › New graduate fellowships to attract top young scholars
- › An Innovation Development Fund to support high-impact research initiatives
- › A Visiting Professor of Innovation to inspire and mentor faculty and students in their drive to have their new tools be widely used in both academic and commercial terms

Driving discovery to solve complex global challenges



From the search for sustainable energy solutions, to the revolution in gene editing techniques, to the transformative impact of artificial intelligence on our societies, today's highly complex scientific problems are often intertwined with other significant challenges. Resolving them requires sustained collaboration across multiple scientific disciplines and sectors, including government and industry.

Through a **Systems Science** approach, the Faculty of Science is able to harness the power of its innovative and multidisciplinary research capabilities. Such a strategy creates opportunities for new and creative tactics that lead to new discoveries and advanced technologies, providing a template for training the next generation of scientists, public leaders, and business leaders.

Among the successful collaborations spawned by Systems Science is the **McGill Sustainability Systems Initiative**, which brings together experts from across McGill's faculties to build a vibrant community of sustainability researchers that will transform knowledge into solutions for our complex ecosystems.

The Faculty of Science is eager to build on the success of this research model through the creation or expansion of the following institutes:

- › **Computational and Data Sciences Institute**
- › **Cognitive Systems Institute**
- › **McGill Space Institute**
- › **Earth Systems Institute**
- › **BioSystems Institute**
- › **Molecular Systems Institute**

In order to create and sustain each of the institutes described below, the Faculty of Science seeks funding for:

- › An endowed Chair, occupied by a globally-recognized scholar in this field, to serve as the Institute Director
- › New postdoctoral fellowships to enhance research capacity
- › New graduate fellowships to attract top young scholars
- › An Innovation Development Fund to support high-impact research initiatives
- › Visiting Professors of Innovation to inspire and mentor faculty and students in the translation of their research successes to the commercial and policy worlds



Computational and Data Sciences Institute

Shedding light on the dynamic systems that underlie climate science. Monitoring the health data of individual patients across whole populations to improve the provision of targeted health interventions. Understanding the implications and ethical issues associated with a data-driven society. Data has become the universal currency of the 21st century and computational/data sciences are integral to all aspects of personal and public enterprise.

McGill Science researchers are at the forefront in the development of data analyses methods and algorithm innovations, and their application to complex physical, biological, and social sciences problems.

The establishment of a **Computational and Data Sciences Institute** will enable the Faculty of Science to harness its expertise in pure and applied mathematics, statistics, and computer science and to lead in innovative approaches to data analyses and interpretation.

Cognitive Systems Institute

What thought processes underlie the maladaptive decision-making seen in compulsive gambling, eating disorders, and substance abuse? In multilingual individuals, how are different languages represented in the brain, and what does this reveal about the essence of language itself? These are just some of the important questions that McGill's cognitive scientists are examining.

The creation of a **Cognitive Systems Institute** will allow scientists to take an integrated and interdisciplinary approach to their research, while actively engaging in exciting new developments related to the creation and study of artificial minds, using sophisticated computational modelling to examine hypotheses about the processes and structures that create intelligence. This new institute will also benefit from close connections to related institutions, including The Neuro and Mila, the Montreal-based centre for artificial intelligence that is a partnership between McGill, Université de Montréal, École Polytechnique and HEC Montréal.

McGill Space Institute

How did structure in the universe form and evolve following the Big Bang? What is the nature of dark energy? What is the origin of fast radio bursts, and can they be used as novel cosmic probes? Are there habitable planets we can observe? Can we find biosignatures of extraterrestrial life? These are just a few of the questions being explored by the world-class team of investigators at the **McGill Space Institute (MSI)**.

The MSI has made significant advances at the frontier of space-related science. Its scientists conduct research and training in the fields of cosmology and early universe physics, the contents and processes of the universe, compact object physics including black holes and neutron stars, solar system and extrasolar planets, planetary habitability, and life in extreme environments.

The MSI faculty are well connected with the global research community, and have developed a powerful research infrastructure of telescopes, satellites and robotic landers, all driven by computing and digital communications innovations.

Earth Systems Institute

As global economies and populations continue to grow, their demand for energy is outpacing society's efforts to transition away from fossil fuels. This has put tremendous pressure on the operating limits of our planet's energy, water, chemical and biological systems.

Scientists are in a race against time to resolve this hugely complex problem. A failure to take action – and the consequences of inaction – have prompted some experts to suggest that the term “climate change” should be changed to “climate crisis”.

Drawing on the Faculty's many disciplinary research strengths, the **Earth Systems Institute** will focus on improving forecasts of environmental conditions and their human consequences, determining how to anticipate and manage disruptive environmental events, and establishing the societal changes that will lead to environmental stability.

BioSystems Institute

At the core of modern biology is the challenge of determining how living systems function across all levels of biological organization, from biomolecules in cells, to the environment in which they are embedded, to entire organisms. This knowledge will allow scientists to unravel the complexities underlying genetic, molecular and cellular systems, populations of organisms, disease interactions and the health of ecosystems on a global scale.





The establishment of a **BioSystems Institute** will bring together an interdisciplinary group of theoretical, computational, laboratory and field researchers from many disciplines – biophysicists, biochemists, bioengineers, and ecologists, as well as cell, neuro- and evolutionary biologists – working in partnership with the Computational and Data Sciences Institute.

Molecular Systems Institute

An understanding of the properties of matter, from the sub-atomic to the macro-scale, is vital for the development and use of virtually all modern scientific processes and technologies.

The **Molecular Systems Institute** will integrate physical, biological, and computational research capabilities to shed light on the relationships between atoms, molecules, and materials – and the resulting function(s) that they have. Molecular Systems encompass the study of isolated atoms subjected to intense magnetic or electro-optical fields, to molecules that organize in specific manners to create biological function. From designing and synthesizing new antibiotics and longer-lasting rechargeable batteries, to using crustacean shells and insects to create a biodegradable plastic, molecular sciences impact our lives and the world around us in myriad ways.

A new home for sustainability research

The ultimate realization of the Faculty's Systems Science approach will see many of these institutes and labs located at the site previously occupied by the Royal Victoria Hospital, which will house a groundbreaking collaboration across disciplines – including Atmospheric and Oceanic Sciences, Chemistry, Physics, Geography, and Earth and Planetary Sciences, as well as Chemical, Materials, Mechanical, and Mining Engineering – designed to address the greatest problem of our time: sustainability and sustainable development.

Complex global problems call for new multidisciplinary approaches, and the overcoming of traditional academic barriers that will create dynamic new synergies. The transformation of the Royal Vic site into one of the world's leading teaching, research and innovation centres devoted to sustainability will provide a high-tech home for world-leading researchers and students to explore how to improve and expand a sustainable relationship with our planet.



**A Faculty of Science for
McGill's third century.**

**Made by donors like
Rubin Gruber.**

Made by McGill.

BSc'65, DSc'14. Serial entrepreneur in telecommunications. Alumni Student Engagement Award recipient. Established the Rubin Gruber Scholarships, Science Undergraduate Research Awards, and Summer Undergraduate Research Awards in Engineering.

The Faculty of Science:
Leading discovery, invention and learning.

Made by McGill: THE CAMPAIGN FOR OUR THIRD CENTURY.



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