The Department of Earth and Planetary Sciences
Strategic Plan (2024–2028)

The Department of Earth and Planetary Science is grateful to be able to conduct research, teach and learn in Tio'tia:ke, which is unceded land that has been cared for by the people of the Kanien'kehá:ka nation for thousands of years. As geoscientists, we honour, recognise and respect the Indigenous knowledge that contributes to our understanding of the natural world, and we strive to support and engage with Indigenous groups in Tio'tia:ke and in all places we travel for our research.

Executive Summary

The field of Earth and planetary sciences is rapidly evolving to address major global challenges around environmental change and sustainable development. At the same time, we have extraordinary new opportunities in developing renewable sources of energy, conducting interdisciplinary research in Earth system science, and employing new technologies in the study of Earth and other planets. It is therefore timely to articulate the Department's strategic plan as we seek to fulfil our mission in educating students while conducting world-class and socially relevant research. We have identified five interdisciplinary themes that bridge our research strengths with fundamental scientific questions and pressing societal needs: i) Environment and Climate Change, ii) Dynamic Earth and Geologic Hazards, iii) Earth and Life Through Time; iv) Earth Materials and Sustainability; and v) Planetary Evolution. Our research in these themes is guided by our core values, which include providing our students with opportunities to gain hands-on learning research experiences while fostering inclusivity and striving to increase diversity in our discipline. We are dedicated to actively involving indigenous and other local communities in Quebec and beyond in our research, ensuring transparency and accessibility in our work, and effectively communicating the outcomes and significance of our scientific pursuits to a broad audience. We also recognize that we have ample room for improvement, and as such, we have identified key goals to guide us in achieving our mission of conducting innovative and impactful research while simultaneously nurturing a new generation of Earth scientists. Central to these objectives is an urgent need to align our curriculum with current scientific and societal needs and attract talented students into our academic program. We will continue to integrate this program with our allied departments, Geography and Atmospheric and Ocean Sciences, while also working with them to develop the new McGill Earth System Science Institute (MESRI). Under the aegis of MESRI, we will seek a Canada Excellence Research Chair in Earth System Science and contribute to the United Nations Sustainable Development Goals. We will optimise our current laboratory and teaching spaces and adopt best practice in storing and archiving research samples, data, and code. These efforts will collectively prepare the Department of Earth and Planetary Sciences to play a central role in the McGill New Vic project, with its focus on transdisciplinary research and teaching in sustainability systems and public policy.

Vision

To be recognized locally, nationally, and internationally for our excellence in research, education, service, and public engagement in Earth system and planetary sciences.

Mission

To pursue innovative, inclusive and impactful approaches to discovery and dissemination of knowledge about Earth systems and planetary sciences while educating the next generation of scholars to tackle the scientific and environmental challenges of the 21st century.

Values

The Department of Earth and Planetary Sciences has long been committed to excellence in research and teaching and to providing a welcoming environment to our students, staff, and faculty. While we celebrate the Department's legacy, we recognize the urgency of fostering diversity, prioritising inclusivity, and pursuing equity in all our activities.

Research-centred and experiential teaching

We believe that early exposure to research enhances the educational experience. Our academic and teaching programs are interwoven, and we strive to involve undergraduate students in research. Hands-on experiences are central to our teaching and in preparing students for a career in the Earth sciences, and we have an obligation to provide affordable and equitable opportunities for our students to learn in field, laboratory, and computational settings.

Diversity and inclusivity within our program and the broader Earth sciences community

We recognize that the Earth sciences suffer from poor representation of women, persons with disabilities, Indigenous peoples, racialized people or visible minorities, ethnic minorities, and 2SLGBTQIA+ individuals. This lack of diversity in our discipline undermines our capacity to perform research and training to its fullest potential. It is our responsibility to address systemic bias and other barriers to equity and diversity at all career stages and in all fields of the Earth sciences. We will continue to consider equity, diversity, and inclusion in both hiring and recruitment. We nurture inclusive practices in the classroom, in our research groups, in the field, and in the laboratory.

Interdisciplinary, transparent, and publicly accessible research

Much of our research into the Earth system is driven by fundamental scientific questions that transcend traditional disciplinary boundaries. We also recognize the importance of science that

addresses societal challenges, including climate change and the transition to a sustainable economy. We emphasise collaboration, open discussion, critical feedback, accountability, and accessibility in conducting and disseminating our research.

Teaching and learning at McGill and beyond

We endeavour to provide an exceptional learning environment both within and beyond the University. This ambition is rooted in thoughtful teaching and learning across undergraduate, graduate, and postdoctoral levels and extends to provocative courses offered to the broader McGill community. We aim to educate students across the University about how the Earth system operates so that they can contextualise contemporary environmental challenges within the broader framework of Earth's history and planetary habitability. Members of the department contribute to a range of outreach efforts to communicate the relevance of our work to a varied public audience.

Engaging local communities

Our educational and research activities actively engage and impact the communities around us. Therefore, we are committed to collaborating with local communities to articulate and develop research and teaching objectives and strategies. This commitment extends to partnering with indigenous and other local communities both in the Montreal area and in our field areas to ensure that our research methods and outcomes are respectful and inclusive and incorporate local knowledge, practice, and customs. We value Québec's rich heritage and seek to make our educational, outreach, and research activities accessible in both French and English.

Research Themes

Our students, faculty, and staff are united in their passion for exploring and understanding the world around us. This collective quest for knowledge about how the Earth and other planets originated and evolved encompasses five research themes, each of which is driven by questions that span from fundamental inquiry into the Earth system to critical societal challenges.

Environment and Climate Change: *Understanding the causes and impacts of past, ongoing and future environmental changes in response to natural and human-induced drivers*

We study Earth system processes and quantify anthropogenic perturbations to climate, the water cycle, soils, vegetation, organisms, land ice, oceans, sea level, coastal processes, and human societies. Research in this theme spans a range of spatial and temporal scales, from understanding global change over glacial-interglacial cycles, through studying phenomena such as volcanism, ocean acidification, and melting of permafrost. We conduct fieldwork in diverse settings, from the Montreal region to the Arctic and the tropics. Geological and biological

archives are used to reconstruct past environmental change, while ground-based sample and data collection, sensors, and remote sensing are used to collect contemporary environmental information on topics as diverse as wetland contamination and the dynamics of ice sheets. Field specimens are analysed for heavy metal and other elemental concentrations, DNA, isotopes, and organic compounds. Numerical modelling tools are developed to simulate Earth systems. The results of our research provide historical context and current evidence for the accelerating environmental change of the Anthropocene to inform solutions for adaptation and resiliency in a rapidly changing world.

Dynamic Earth and Geologic Hazards: *Understanding earthquakes, volcanoes, ice sheets and the feedbacks between Earth's surface and interior*

The movement and deformation of the solid Earth drives geologic hazards such as earthquakes, volcanoes, and sea level change. Our researchers contribute to hazard mitigation and understanding the Earth resources that arise from tectonic processes and tectonic-climate interactions. These efforts are supported by a focus on Earth observation, including geodesy, seismology, field geological studies, high-resolution microscopy, geochemistry, and geochronology. We study earthquake source processes in active seismic zones of both natural and anthropogenic origins. Using experimental, field, geochemical and modelling approaches, we study magmatic-hydrothermal processes from bubble dynamics and controls on the violence of volcanic eruptions to crystal-melt interactions. Studies of rock fractures and faults, both in the field and through experiments, contribute to mechanistic understanding and mitigation of current and future geologic hazards.

Earth and Life Through Time: *Understanding the complex and interconnected relationships between Earth and the diverse forms of life that have inhabited our planet over the last 4 billion years*

Since its origin, life on Earth has impacted biogeochemical cycles, from the sequestration of organic carbon and oxygenation of the atmosphere to the generation of natural resources. Similarly, geologic processes strongly influence the biosphere through the availability and global cycling of nutrients and regulation of climate. We explore the dynamic interplay between Earth and life to unravel the evolution of our planet's surface environment by examining feedback loops between them. We employ a combination of field, analytical, and computational techniques spanning the disciplines of microbiology, geochemistry, paleontology, and sedimentary geology. Research topics include reconstructing the geochemical composition and evolution of past Earth environments, understanding the causes of catastrophic perturbations to the global environment, quantifying changes in the global carbon cycle and the processes that control it, and documenting the timing and causes of major evolutionary steps in the history of life. The results of these investigations inform our understanding of how the modern Earth and the life that inhabits it came to be and how the Earth system will respond to increasing environmental pressures, as well as the potential for life on other planets.

Earth Materials and Sustainability: *The cycling of elements in the Earth by igneous, metamorphic and hydrothermal processes.*

We study the processes that control the cycling of elements in the Earth, including their mobilisation, fractionation, and deposition. Elements are distributed systematically among phases, which allows us to extract information on the physical and chemical conditions in the Earth from minerals, melts and fluids. We combine data acquisition with experiments, thermodynamic modelling and numerical simulations to build predictive models for the mobility of elements in the crust. This research generates fundamental knowledge about elemental behaviour in the Earth and the rocky planets, which is essential to understanding elemental cycling in subduction zones, across the magmatic-hydrothermal transition, and during ore formation. This knowledge is applied to exploring and utilising the critical metals and geothermal energy needed for the transition to a sustainable society.

Planetary Evolution: *Understanding how planets in the solar system and beyond evolve, from the atmosphere to the core*

We study the long-term evolution of the interior, surface and atmosphere of planets. These investigations help us to understand the feedbacks that regulate planetary evolution and habitability. To interrogate processes on Earth, we rely on a combination of satellite measurements, experiments, numerical and analogue simulations, chemical analyses, and field work. Other Solar System worlds are studied via remote sensing, rovers, and chemical analyses of rocks from other terrestrial planets. We observe extrasolar planets with telescopes and compare these data to computer simulations of exoplanetary interiors and atmospheres.

Goals

While the Department of Earth and Planetary Sciences prides itself on a long history of academic achievement, we also recognize the importance of critical evaluation and adaptation; we have room for growth and improvement. Here we articulate a list of strategic goals aimed at adapting our research, education, and outreach activities and practices to ensure the long-term viability of Earth system and planetary sciences at McGill.

To design a curriculum that addresses emerging scientific and societal demands in a rapidly changing world

We recognize the importance of Earth sciences in mitigating, predicting, and adapting to environmental change and transitioning to a sustainable economy. We will streamline our existing academic program, nurture the Earth System Science program, and provide our students the educational foundation and flexibility to pursue diverse careers in Earth system science and sustainable resource development. We will seek best practices in creating an inclusive and accessible learning environment and adapt our educational delivery to meet new challenges and opportunities.

To expand our undergraduate program

The number of incoming undergraduate students in Earth science programs is at a historic low across Canada. Through a revised curriculum and vigorous outreach and recruitment efforts, we will steadily increase our undergraduate enrollment with a goal of accepting 20 new undergraduate students per year into majors in Earth and Planetary Sciences by 2028. We will recruit students from diverse backgrounds that reflect the population of Quebec and Canada, while also valuing international perspectives in our department. Recognizing that prospective students increasingly seek interdisciplinary programs, we will attract students into EPS that have wide-ranging scientific interests. We will expand our recruitment efforts among high school and CEGEP (junior college) students and demonstrate the relevance and employability of students trained in our programs with their emphasis on heuristic learning.

To strengthen our linkages with the Departments of Geography and Atmospheric and Oceanic Sciences (AOS)

Earth system science serves as a natural bridge between our three departments, presenting unique opportunities to collaborate and train students in impactful, interdisciplinary fields. We will pursue deeper integration with Geography and AOS through our academic program and by helping to develop the McGill Earth Systems Research Institute (MESRI). This institute will foster research collaboration among our three departments while raising the stature of Earth system science at McGill and positioning it at the forefront of the New Vic project, with its core focus on sustainability.

To attract a Canada Excellence Research Chair (CERC) in Earth System Science

We will use MESRI as a springboard for writing a successful CERC proposal to attract a cadre of leading scientists to McGill. The primary CERC hire and the associated hires will span EPS, Geography, and AOS, build alliances with other departments and faculties, and play a central role in the success of MESRI and its eventual move to the New Vic site.

To improve our teaching and research facilities

The poor state of infrastructure in the Frank Dawson Adams (FDA) building limits our capacity to build and maintain cutting edge laboratories and adequately educate and train our students. While recognising the constraints posed by budgetary and structural challenges, it is imperative that we improve our current facilities while concurrently developing a plan for moving to the New Vic in five years. We will improve the teaching and research infrastructure in a way that increases their viability while decreasing their environmental impact. We will declutter and optimise existing space for current and future students and faculty, update classrooms and common spaces, prioritise shared analytical facilities, and seek CFI funding for major instrumentation upgrades and renovations both in FDA and at the New Vic.

To make a meaningful and impactful contribution to the UN Sustainable Development Goals

We aim to deliver data, tools and models to investigate and develop mitigation strategies for the grand challenges that we face as a society. These challenges include the need to protect our natural environment (SDGs 14 and 15) while providing the critical resources for the transition to a carbon-neutral economy (SDG 7), the importance of combating climate change, ocean acidification and sea level rise (SDG 13), and the urgency of transitioning to a sustainable society (SDG 12). We commit to disseminating the results of our research widely to inform society so that it can make and support the policy decisions and teach the skills needed to address these development goals. We will incorporate this vision into our teaching such that our students become future leaders in the effort to realise the UN Sustainable Development Goals.

To streamline accessibility of our research methods and output

As publicly supported scientists, we have an obligation to make our research results freely accessible to other researchers and the public at large. This duty extends beyond open access publication to include archiving our data and computer code in accessible and searchable public databases. Furthermore, much of our data derive from samples collected in the field or generated through experiments, commonly obtained at a high cost. We are committed to implement best practice protocols (FAIR) for sustainably archiving and storing these samples such that they are linked to open access databases and can be accessed by other researchers, therefore enhancing transparency and reducing feature costs and environmental impact associated with collecting and generating samples.