The Faculty of Science is a community fueled by curiosity and creativity. We are problem-solvers. When we see our city, province, country, and planet face new and existing challenges, our instinct is to investigate and find solutions. Our grand challenges call on all members of our community – from researchers to students to the public – to join forces and help address critical issues. We take pride in our ability to transfer knowledge and contribute to growth through research, innovation, and entrepreneurial thinking.

We have been energized by the grand challenges and research platforms arising from our strategic plan: Curiosity Sparks Discovery 2017-2022. We have identified four grand challenges that harness our current strengths, look to future opportunities, and provide places to explore new discoveries.

Our goal is to understand as much as we can about the world around, above, and below us and to use that knowledge to help build a better future. To this end, we have identified four grand challenges, areas of focus where we are particularly positioned to make a difference.

These include:

- Understanding Earth’s Evolving Systems
- Energy in Transition
- Unlocking our Digital Future
- Personalized Health at the Molecular Level

In pursuing solutions to these grand challenges, we build on the following platforms:

- Fundamental Research
- Major Facilities
- Data Science and Our Sensorized World

As we explore our grand challenges, we will: develop pathways to connect critical science knowledge to stakeholders and decision makers; work collaboratively across disciplines to solve problems of national and international importance; build new capabilities within ourselves and the Faculty; create new ways to educate and train students; and, increase the number of partners engaged with the Faculty of Science.
The Earth consists of the biosphere (the living world), geosphere (the natural physical world), and anthrosphere (the built world). This includes everything: the water we drink, the air we breathe, the land we live on, and the life we interact with as individuals and as a species.

Understanding the interactions between our living, physical and built worlds calls for holistic, multidisciplinary approaches to predict virtually all aspects of global change. Can we alter the course of global warming and climate change? How do we ensure clean and accessible water for all? How are environmental stressors driving a sixth mass extinction, and how do they affect our health?

With advances in sensing technology and space-based observation, we are beginning to understand our Earth as one planet among countless others. What are the physical conditions that make Earth special? How does our interaction with the Sun affect our planetary environment? How does human activity affect the geosphere?

Making significant progress on such questions will have critical implications for our future. In doing so, we use Earth system data from our research facilities both on and off campus, including Advancing Canadian Wastewater Assets (ACWA), a world-class water research station on the banks of the Bow River in the City of Calgary, and from our networks of sensors on the ground, in the air, and in space. We use data science to make sense of the big data that goes hand-in-hand with studying Earth’s systems.

We need energy for everything we do, everything we make, and everywhere we go. All aspects of modern life hinge on access to energy. How do we balance the ever-increasing energy demand sustainably without compromising our environment or our economy? The 21st century will be marked by how our generation manages the transition to a low-carbon economy and society.

By definition, the word “energy” is inherently ‘in transition’ and ‘dynamic’; and the energy of today may not be the energy of tomorrow. As a community and society, how do we address this transition? How do we prepare for the energy of tomorrow, and what does that look like? Can we create energy systems that limit negative local, regional, and global impact?

Finding solutions to problems that surround sustainable energy production, clean water, pollution bioremediation, and efficient energy use is pressing. In the Faculty of Science, we look at this grand challenge from the microscopic and microbial level all the way to the analysis of finance and risk. We are home to world-class research delivering innovative solutions for harnessing, managing, and using energy. We strive to ensure Alberta and Canada achieve breakthroughs and leadership in a rapidly evolving global energy sector. This multidisciplinary effort enables us to lead the way in areas of reservoir exploration and modeling, environmental remediation, and energy capture and storage.
Unlocking Our Digital Future
Security in the digital age, privacy protection, visual computing and quantum information.

The rapid evolution of technology means that how we interact with, and are shaped by, the digital world is constantly changing. The explosive growth in the number of digital devices and the ability to instantly communicate massive amounts of information represents a transformation that rivals the invention of the printing press. However, as this transformation brings staggering cultural and economic benefits, it also presents new, significant challenges.

Our individual security, freedom, and privacy depend on secure national and corporate digital systems – think health care, banking, military, and infrastructure. Digital devices have become so abundant that privacy and security must be scrutinized in new ways and at new levels. As a society, we need to respect people’s need for privacy and desire for convenience, while still supporting the electronic marketplace.

So how can we interact effectively with this evolving digital world? We must move around the vast ocean of data, and extract information that we want and need from it. For this, we need innovations in how people and computers interact.

We have experts in our faculty who research how people interact with computers and explore alternatives to defensive information security through cryptography and quantum information science. Our researchers investigate challenges in several areas such as health-care, finance, environment, and government.

Personalized Health at the Molecular Level
Drug synthesis, delivery and diagnostics, minimizing antibiotic bacterial resistance, and understanding the role molecules play in our health.

We explore treatments, diagnostics, and pathways towards affecting personalized health on a molecular and individual level. Molecular details help us understand how chronic and infectious diseases work, and broaden our approach to medicine through exploring drug synthesis, delivery and diagnostics. We are exposed to diverse molecules through our food, water, and even our environment. These interactions range from atoms to complex bacterial communities and, while critical to our survival, they can be detrimental.

We combine bioinformatics, chemical synthesis, molecular characterization and imaging to understand the role that molecules play in our health.

The widespread use of antibiotics is driving a worldwide increase in the prevalence of drug-resistant bacteria. According to the World Health Organization, this problem is so serious that it “threatens the achievements of modern medicine.”

Our faculty is uniquely positioned to reduce this growing global health problem with advanced diagnostics to detect and differentiate pathogens, the use of novel approaches for point-of-care devices, research into evolution-based approaches, and therapies that include a mixture of fundamental microbiology, biochemistry, and molecular modeling.
In pursuing solutions to these grand challenges, we build on the following platforms:

- **Fundamental Research**
- **Major Facilities**
- **Data Science and Our Sensorized World**

In the Faculty of Science we discover, explore, and seek to learn new things. Our fundamental research fuels innovation, helps us deliver on our grand challenges, and pushes the boundaries of knowledge. It also plays a central role in how we deliver our educational mission.

Fundamental research means we use basic principles of science to advance understanding of natural, human-made, and social systems.

In our faculty, undergraduate and graduate students, and staff including faculty members, postdoctoral fellows, research associates, and technicians get their feet wet and hands dirty doing fundamental research. Our students get involved with research, often early in their programs, and explore how the skills they learn enable scientific advancement.

Our current research initiatives include studying the biology and behavior of dinosaurs, quantum entanglement, the effects of climate change on bees, photosynthesis, anti-matter, differential geometry, how to catalyze the splitting of water by sunlight, the theory of algorithms, extremophiles, subduction zone hydrogeology, and much more!

Fundamental research is an engine that supports the work on our grand challenges - and everything else we do.
Scientists today have access to more data than at any point in history. How do we make sense of the unprecedented amount of information available to us? This platform focuses on the process fundamental to addressing Canada's greatest challenges: collecting and producing unique data sets, and turning this data into new insights, policies, and inventions.

With The Internet of Things, data is available on just about anything at just about any time, and with just about any level of resolution. Globally, data is generated, transmitted, and stored from satellites, sensor networks, and biosensor chips that observe our planet, solar system, oceans, landmasses, atmosphere, and humans in real time. Can we take this information and translate it into results, discoveries, and advancements?

Through our research, we aim to empower individuals and governments at all levels, to make decisions based on accurate and predictable data. This can range from acute financial decisions to escaping hazardous weather. The insights we seek are often hidden and encoded. Using sophisticated statistics, pattern recognition, and state of the art experiments, we can work on finding these insights with increasing predictability. Visualization helps us understand this complex data, while analytics and statistics extract relationships and trends. Modelling helps us understand and predict the behaviours that will shape the world around us.

Research in this platform crosscuts all disciplines from human-computer interaction to geospatial intelligence.