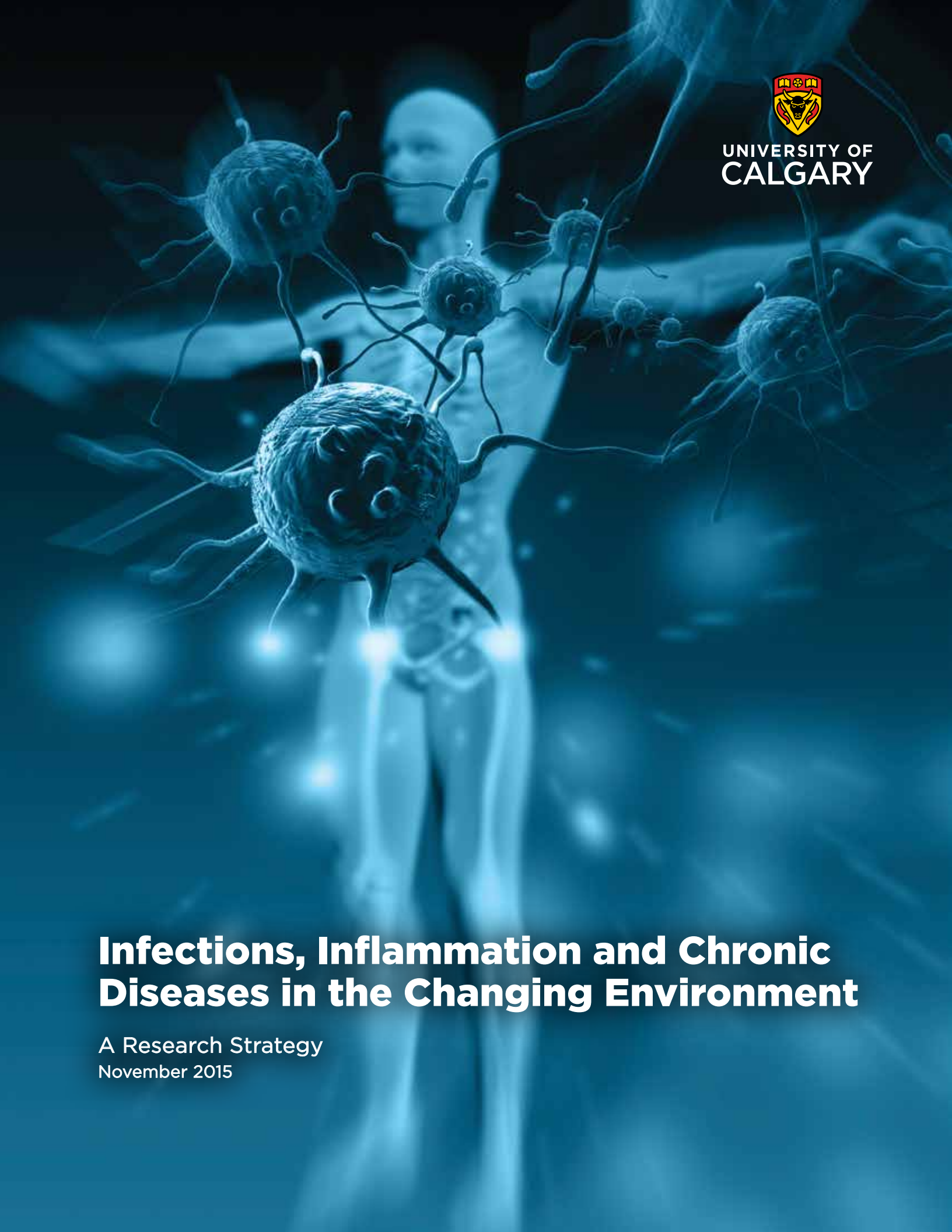


UNIVERSITY OF CALGARY

Infections, Inflammation and Chronic Diseases in the Changing Environment

A Research Strategy

November 2015

Infections, inflammation and chronic diseases create a tremendous burden on human health. The World Health Organization (WHO) ranks chronic diseases (which account for 68 per cent of deaths worldwide) as the greatest challenge to human health, and their impact will continue to increase in parallel with the aging of the global population.

Through cutting-edge research programs and core facilities led by top scientists, the strategic research theme *Infections, Inflammation and Chronic Diseases in the Changing Environment* will drive global initiatives tackling some of the most important challenges for our health and our economy.

Addressing key challenges to our health and the global economy

By 2050, the number of people in the world over the age of 60 will more than double, dramatically increasing the global burden of morbidity and mortality due to chronic disease and its major causes. Growing evidence suggests that many chronic diseases occur as a result of an imbalance between the gut microbiome and its host.

Infections kill more children than any other disease. Infections, whether emerging or re-emerging due to drug resistance, have been deemed more serious than any other societal issue. Microbes can infect humans, as well as livestock and plants. Pathogens have a devastating impact on agricultural production and the health of our ecosystems. It has been suggested that before it can be eaten, as much as 30 per cent of all food is lost to parasites, fungi or bacteria.

To fight these pathogens, antimicrobials are being introduced into almost every aspect of daily life. Antibiotics are given to food-producing animals and a variety of pesticides are used in the agricultural industry, creating environmental pollutants. Dramatic environmental changes, including altered nutrition, climate change, and reduced air, soil and water quality, compound the impact of infections and chronic disease. To address these major impacts, world health in the 21st century will be dependent upon:

- Discovery-based fundamental research with transformative translation and innovation in the areas of host-microbial interactions, infections and chronic disease
- Improved immunotherapies and biologics for infections, inflammation and chronic diseases
- Understanding and optimizing microbiomes in humans, animals and plants
- Managing the threat that chronic diseases pose for the sustainability of the health system and our economy

Recognizing the needs of society to address those impacts and building on the strengths of the University of Calgary, the Infections, Inflammation and Chronic Diseases in the Changing Environment (IICD) research strategy has identified five grand challenges, each with specific and overlapping goals:

1. Adapting to a changing environment
2. Production of safe and healthy food in a changing world
3. Building and battling microbial biofilms
4. Developing immunotherapies: novel approaches to treating infections and chronic disease
5. Managing the growing economic burden of chronic diseases

These grand challenges will be supported through key cross-cutting enabling platforms emanating from the Western Canadian Microbiome Centre (WCMC) to open in 2017. The university secured $9.9 million in 2015 from the federal government to help create this facility. Dedicated to microbiome research, the WCMC leverages platforms including imaging, genomics, bioinformatics, proteomics, metabolomics, cytometry and a germ-free environment.

A **microbiome** is a community of trillions of bacteria, parasites, viruses and fungi that live in and around humans, animals and in our environment. Every person has a unique microbiome, which plays an instrumental role in health and wellness, protecting us from pathogens, cancer, cardiovascular disease and chronic inflammatory disease.

Improving world health in a changing environment

The aging of the population, changes in lifestyle and physical environment, as well as improved life expectancy due to better medical treatments and living standards have led to an epidemic of chronic disease around the world. Today, chronic diseases such as heart disease, stroke, cancer, obesity, chronic respiratory diseases and diabetes kill three of every five people in the world.

Other chronic diseases like asthma, inflammatory bowel disease, arthritis, hepatitis, chronic kidney disease, and skin diseases (such as psoriasis) are responsible for debilitating morbidity and enormous costs. In addition to their direct effects in health, infectious diseases can cause or exacerbate chronic diseases, and infections are also the most important threat to agriculture, food supply and ecosystems — all of which are critical to maintain and improve the health and wellbeing of the global human population, which is predicted to reach 9 billion by 2050.

Health is influenced by genetics, stress, diet, habits and environmental factors. Climate change is altering the environment, as is urbanization. It has been known for thousands of years that diet can cause or exacerbate disease: the global rise of obesity and the tremendous suffering due to malnutrition and food-borne illnesses are clear evidence that the world desperately needs new approaches to providing safe and healthy food.

Many chronic diseases are affected by changes in immune status, and are triggered by an insufficient or excessive immune response. Healthy immunity is dependent upon our microbiome that can be altered by the environment — taking medicine, nutrition, interaction with animals, other humans and local environments. There is growing evidence that the wellbeing of the microbiome is critical to health.

As understanding and treatment of chronic diseases improves, the costs of health care are becoming unsustainable. The Canadian health care system was developed decades ago in response to the fact that most illnesses either resolved quickly with appropriate treatment or were rapidly fatal. However, this is no longer the case. With new, very costly, biologic medications and treatments prolonging life without necessarily curing afflictions, chronic diseases have quickly become a huge burden on society and the health care system. The majority of Canadians over 40 years old have at least one chronic illness (many have three or more). Health information is widely available to the public, patients are increasingly informed about their conditions and many are motivated to take responsibility for improving their own health. Patients now understand the importance of early detection, preventive treatment and managing their own health information. The health system has not kept up with these dramatic changes and new approaches are needed to meet the needs of a 21st century society. There is an urgent need to better understand how the physical environment, food, the immune system and the microbiome interact and contribute to the global burden of infections, inflammation and chronic diseases — and how to update the health system to better address these critical challenges. This knowledge will deliver innovations that will reduce suffering, prevent tens of millions of premature deaths, and save trillions of dollars in lost productivity and health care costs.

Matching our strengths with opportunities

University of Calgary: a global centre for innovative research in infections, inflammation and chronic disease

The University of Calgary is a global leader in discovery, innovation and translation of health and biological research, as well as an innovator in natural resources and the environment. We have the breadth and depth of knowledge to significantly impact worldwide efforts in infections, inflammation and chronic disease. However, economic sustainability is critical as increasing health care costs are untenable. The IICD research strategy will take a leading role in finding new opportunities in treating patients, but doing it in a fiscally responsible manner.

We have the capacity required to utilize, improve and provide a safe environment to promote the health and wellness for those suffering from infections, inflammation and chronic diseases. The IICD research strategy unites more than 200 internationally recognized experts in environmental sciences, biological and nutritional sciences, veterinary sciences, medical sciences, epidemiology, law, population and community health as well as public policy. Together, this group has already secured a large federal grant to fund the Western Canadian Microbiome Centre. Collaborative research efforts are supported through building and sustaining this core research facility and associated activities. Collaborative efforts with industry will be promoted at the local, national and international level. We will work together with our communities to educate as well as learn what really matters to people. With the right combination of research teams and state-of-the-art facilities, the IICD research strategy will provide a platform for innovative discovery and translation to improve the quality of life for individuals affected by infections, inflammation and chronic disease.

On the local, national and international stage

Canada is recognized globally for its collaborative contributions and leadership in the development, implementation, and evaluation of policy related to infectious and chronic disease[1]. Infectious and chronic diseases can have dramatic effects on our quality of life and economy and are the leading cause of mortality both in Canada (89%) and globally (60%). In Canada, the lifetime probability of developing chronic diseases such as diabetes (6.8%), obesity (24%), or childhood asthma (13%) are high and continue to rise. In addition, the mortality in patients with chronic infections such as *C. difficile* has significantly increased over the past two decades, a development that is attributed to an increase in antibiotic resistance. Research at the University of Calgary has increased our understanding of these and other chronic diseases and we have made strides to enhance translation of that knowledge into practice for the benefit of patients around the world.

For example, a member of the IICD team, Dr. Tom Louie, performed the first capsule microbiome transplant from a healthy person to one infected with *C. difficile* demonstrating that, in principle, a healthy microbiome can eradicate this infection. The University of Calgary IICD research strategy will increase this capacity through national and international interdisciplinary collaborations that enable novel and innovative research aimed at eradicating potentially avoidable diseases.

Alberta is a natural laboratory for the study of infections, inflammation and chronic disease in the changing environment. Environmental risk factors in Alberta have an influence on chronic disease, and

[1] Public Health Agency of Canada – Canada's WHO Collaborating Centre on Chronic Non-communicable Disease Policy

The University of Calgary is at the heart of a unique environment strong in societal, population, clinical practice and physical changes that have a direct effect on infections, inflammation and chronic diseases.

chronic disease in turn influences the environment. The Public Health Agency of Canada reports that behavioural, cultural and environmental conditions are major contributors to the development of chronic disease. Unique aspects of the Alberta environment can contribute to the development and exacerbation of chronic disease. Certain chronic inflammatory diseases, such as inflammatory bowel disease, are more prevalent in Alberta than anywhere else on Earth.

Living in cities has changed our dietary intake, physical activity and exposure to pollutants — all of which can directly alter the incidence of chronic diseases such as diabetes, hypertension and obesity. Urbanization and changes in rural economies and communities have also contributed to changes in health care practices and the physical environment.

Extracting natural resources (e.g. oil extraction) and changes in agricultural practices (e.g. antibiotics in feed) also affects Albertans' lives. The Alberta government, industry and Alberta Health Services must work closely with university researchers and communities to promote health, adjust health care practices and decrease the environmental impacts related to socioeconomic changes. The innovative interdisciplinary research of Alberta scientists continues to set international standards for prevention and treatment of infections, inflammation and chronic disease.

Calgary is a major hub for the Alberta economy and the city's success and growth has led to many environmental and social changes. These include pressures on Calgary's infrastructure that impact housing, education and health care access. These environmental conditions have a direct effect on the incidence of infections, inflammation and chronic disease and the related quality of life among Calgary residents. Although there are support programs for Calgarians with chronic disease, the rapid and unique changes in the environment require further advances in prevention of chronic diseases. The University of Calgary IICD research strategy will address these unique environmental pressures as part of the fight against chronic diseases.

University of Calgary researchers in infections, inflammation and chronic diseases are leading studies from basic research to clinical translation of evolving diseases. Some examples include *Cryptococcus gattii* that recently emerged on Vancouver Island and infects healthy individuals; resistant *Clostridium difficile* that mainly infects individuals on anti-microbial therapies; and resistant *Staphylococcus* aureus and other microbes that can infect those with a breach in primary immune protection. Each of these has the potential to cause debilitation and death. Our researchers are key contributors to the global efforts trying to understand the effects of climate change on the transmission and social consequences of infectious diseases. In addition, they have made key advances in the effects of the microbiome on chronic diseases, including the effects of nutrition on our commensal microbial communities, which in turn alter our susceptibility to chronic diseases such as obesity and diabetes. Anti-microbials alter our gut microbiome, leading to susceptibility to pathogens such as *Clostridium difficile*. Biofilms form physical interactions among bacteria, reducing antibiotic effectiveness and inducing devastating complications in chronic diseases such as cystic fibrosis.

University of Calgary researchers are internationally recognized for expertise in the epidemiology and treatment of chronic diseases including stroke, coronary disease, inflammatory bowel disease and chronic kidney disease — and for developing novel solutions for patients. Many of these conditions are being altered by significant changes within Calgary's population. Changes in migration are influencing the genetic pool of Calgarians, as well as their habits and customs. Environmental changes — such as flooding and climate change — are impacting health. To maximize the impact of the IICD research strategy on the community we serve, we need to respond to these changes in a timely fashion and address the needs of Calgarians. In addition, we need to provide education to the public about the impact of these different changes. High-impact knowledge transfer, through community outreach, publications, presentations at international conferences and other venues will secure our place as global leaders in this arena.

Research centres and research groups

The interdisciplinary approach used by infections, inflammation and chronic disease experts in basic science and clinical research will enhance collaborative efforts not only among IICD team members at the University of Calgary, but also through collaborations with external partners such as Alberta Health Services and industry.

These collaborations will lead to health promotion along with the development and implementation of safe and effective clinical practices. The IICD research strategy will build resources and promote communication among all team members to increase multi-disciplinary approaches to solving pressing issues.

Contributing Faculties

- Cumming School of Medicine
- Faculty of Environmental Design
- Faculty of Science
- Haskayne School of Business
- Faculty of Kinesiology
- Faculty of Law
- Faculty of Nursing
- Schulich School of Engineering
- Faculty of Social Work
- Faculty of Veterinary Medicine
- Faculty of Arts
- Werklund School of Education

Contributing Institutes

- Alberta Children's Hospital Research Institute for Child and Maternal Health
- Calvin, Phoebe and Joan Snyder Institute for Chronic Diseases
- Hotchkiss Brain Institute
- O'Brien Institute for Public Health
- Libin Cardiovascular Institute of Alberta
- McCaig Institute for Bone and Joint Health
- Arnie Charbonneau Cancer Institute
- Arctic Institute of North America
- School of Public Policy

Core Facilities

- Clinical Research Unit
- Calgary Centre for Clinical Research
- Centre for Advanced Technologies in the Life Sciences
- Centre for Health Genomics and Informatics
- Western Canadian Microbiome Centre
- Veterinary Sciences Research Station

Calvin, Phoebe and Joan Snyder Institute for Chronic Diseases

This institute was named in 2008 in honour of Joan Snyder and her parents, whom she credits for teaching her the value of philanthropy. It is a group of more than 104 clinicians, clinician-scientists and basic scientists who are impacting and changing the lives of people suffering from chronic diseases, including sepsis, MRSA, cystic fibrosis, type-1 diabetes, inflammatory bowel disease, and chronic obstructive pulmonary disease. Institute director Dr. Paul Kubes is also the lead for the Infections, Inflammation and Chronic Diseases strategic research theme at the University of Calgary.

snyder.ucalgary.ca

Alberta is a natural laboratory for the study of infections, inflammation and chronic disease in the changing environment.

Grand challenges and directives

The IICD research strategy identifies five grand challenges that speak to our strengths at the University of Calgary. These grand challenges will be undertaken using numerous core platforms available throughout the faculties and institutes.

A deficiency in our ability to study microbiomes in humans, model organisms, livestock, and agriculture will be addressed through the construction of the Western Canadian Microbiome Centre, which will offer imaging, proteomics, metabolomics, genomics and germ-free platforms. This facility will enable microbiome research in the first four grand challenges, while the success of the IICD team in these programs will be managed and delivered through the final grand challenge. We have also designed a plan to ensure the impact of these grand challenges through four directives collectively defined as CONNECT research.

Grand Challenges

1. Adapting to a changing environment

Change is inevitable and it is through change and progress that humankind has realized unprecedented advances over the past century. It is not change itself that presents a challenge; but rather it is the scale, scope and pace of such change that affects the way in which human beings adapt to their environment. Over millennia, humans have evolved on generational scales to accommodate changing conditions. Recently, however, environmental change — climatic, physical or technological — has outpaced the human adaptive response, presenting novel challenges pertaining to the evolution of illness and disease. We now find ourselves ill-prepared to deal with the pace of disease evolution.

This grand challenge will identify causes of disease to humans, animals and plants in a changing environment, cellular and molecular mechanisms of disease, and translational pathways to design necessary changes in health care policy and delivery as well as novel targets for new therapies and diagnostics.

The human environment can be broadly conceptualized as the set of external factors within which an individual or population functions. Environmental health is a complex web of exposures that interact to impact an individual's wellbeing. It is through a deeper understanding of these complex environmental exposures that medicine can support adaptive responses to the modern changing environment. The global environment has changed substantially over the past century, with infinite potential impacts on human health. For example, exposures to air pollution are well-established risk factors for the development and exacerbation of airway diseases such as asthma and chronic obstructive pulmonary disease. Exposures to airborne particulates are also associated with cardiovascular disease, cardiovascular death and lung cancer. Emerging evidence suggests that air pollution may influence the development of other chronic inflammatory diseases and the mechanism may be secondary to altering the intestinal microbiome. The majority of the world's population now lives in urban environments, influenced by sedentary lifestyles, automobile traffic and reduced air quality, dietary changes and lack of accessible green space. Climate change has the potential to impact all populations, with everything from heat-related illness to altered distributions of endemic infectious diseases.

Western Canada will be uniquely affected by climate change because of the diversity of geoclimatic regions. Generally warmer temperatures and greater variability will have profoundly different effects on the high arctic and the heat of the southern prairies (e.g. Midale, SK where temperatures can reach 45°C). In the arctic, there will be a loss of permafrost and sea ice. Climatic evolution will affect arid regions that receive less than 2.5 cm of rain each year (e.g. Ashcroft, BC), and temperate rain forest that receive over 685 cm of rain each year (e.g. Vancouver Island, BC). In the prairies there will likely be increased severity and duration of droughts with greater flooding. These changes will affect ecosystems, which impacts life on earth in many ways. Climate change in the North completely changes the dynamics of parasitic disease in various animal populations (e.g. caribou), altering the food supply for indigenous people in the arctic. Veterinary investigators at the University of Calgary are exploring the impact this has on that ecosystem.

Altered ecosystems due to climate change will result in changes to health. Many Canadian cities will have an increased number of smog days and intense heat that will affect respiratory and cardiovascular health. The burden of allergens will change, potentially worsening allergic diseases and asthma. A recent report in the *New England Journal of Medicine* indicates that air quality affects

lung function of healthy individuals, not just those with diseases such as asthma, pulmonary fibrosis and lung transplantation. The mountain pine beetle has devastated much of our western forests, which are now prone to forest fires, leading to adverse consequences on respiratory health. The floods in Alberta led to mold in homes and exposed clean-up crews to asbestos. These health hazards are likely to be repeated as the climate continues to evolve.

Climate change will affect where people work and play. Change in population distribution creates societal pressures. An excellent example of how redistribution of populations heightens societal pressures — where further urbanization and stress favour disease development — is the migration of workers from Atlantic Canada to the oil patch in Alberta. Increased temperatures will change ecosystems that affect infectious disease. Moreover, we are just beginning to understand how the collection of microbes that live on and within our bodies — the microbiome — is affected by environmental change and how it affects our bodies' immunity and diseases.

Infectious diseases are evolving with the advent of antibiotic microbial resistance (MRSA), the emergence of virulent viruses (e.g. MERS-CoV and H5N1 influenza) and hospital-acquired infections (e.g. *Clostridium difficile*). The origin of these infectious diseases is directly linked to the changing environment, including the overuse of anti-microbial drugs. With a changing climate we will likely see ongoing impact from infectious diseases, such as the recent outbreak of *Cryptococcus gattii* (a pathogen formerly restricted to Papua New Guinea and Northern Australia) on Vancouver Island. There is real concern that illnesses such as Lyme disease, spread via ticks, will become increasingly common in Canada. An appropriate response to environmental change will require a basic understanding, knowledge of prevention, detection, diagnosis, therapy and management of disease in the Canadian context by both human and veterinary medicine.

WHO reports that the majority of deaths in Canada are caused by chronic diseases. Chronic inflammatory diseases emerged in the Western world following the industrial revolution and some are a product of the last century. For example, in 1932, Beryl Crohn and colleagues described the first few cases of Crohn's disease. Since then, Crohn's disease has grown exponentially — from those few early cases to hundreds of thousands of patients across North America.

Chronic inflammatory diseases predominantly affect individuals at times when they should be focused on school, career development and relationships, but instead are burdened with a potentially debilitating disease. The societal impact of chronic inflammatory diseases over the next decade will be substantial. With costly interventions, suboptimal treatments and low mortality, chronic inflammatory diseases present an unrelenting burden to health care because their prevalence will continue to rise exponentially. With increasing global pervasiveness of chronic inflammatory diseases, differential access to care and the variable quality of that care will be magnified between wealthy and poorer populations, and between individuals with different socioeconomic standing. Health care systems must account for the exponential rise of chronic inflammatory diseases or face the risk of creating an unstable system wherein the volume of patients overwhelms the resources, personnel and infrastructure available to care for them.

Key areas of investigation

An appropriate response to environmental change will require an understanding of disease mechanisms and a focus on prevention, diagnosis, and therapy. In the context of this grand challenge, we will study the environment — broadly defined to include the natural world — as well as cultural and social factors that adversely affect health. The study of how a changing environment affects diseases and the steps needed to restore health is complex, and includes:

- **Population health research.**

  This uses province-wide cohorts derived from administrative databases provided by partners in Alberta Health Services. Surveillance cohorts can track incidence and prevalence of disease, evaluate temporal trends, support predictive modeling for future scenario analyses and identify vulnerable populations including individuals of low socioeconomic status, Aboriginal peoples and rural Albertans.

- **Environmental health research.**

  This includes non-genetic risk factors for disease as a consequence of accumulated environmental exposures. These include Geographic Information Systems (GIS) self-report survey instruments and bio-monitoring from human and animal samples to evaluate the effect of changing landscapes in rural regions (e.g. agriculture practices, oil & gas industry) and urban (e.g. population density, air pollution) and changing climate on human and veterinary health. Environmental determinates can be integrated with genetic susceptibility to evaluate gene-environment interactions.

- **Microbiome research.**

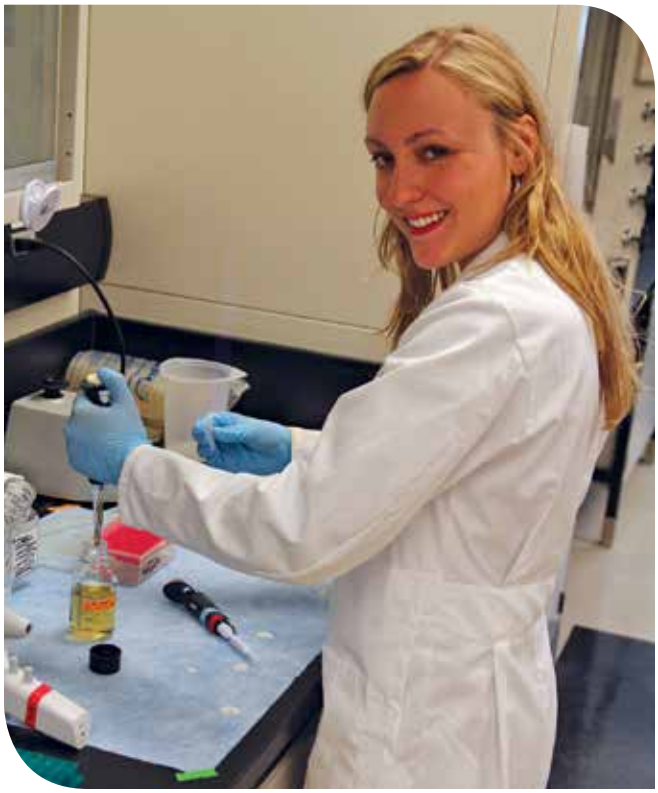
  This includes an understanding of how changes in the population of organisms that live on and within our bodies affect human and animal health and how this might be manipulated in therapeutic approaches.

- **Multidisciplinary team research of infectious diseases in a changing environment.**

  This includes the epidemiology of emerging infectious diseases, host responses to emerging pathogens, the evolution of antimicrobial resistance, the changing human and animal microbiome, zoonotic disease that integrates the ‘one health’ approach (which recognizes that the health of humans is connected to the health of animals and the environment), the transition of disease from community to nosocomial environments, and the influence of microbial exposure on disease.

- **Basic and translational research that explains the pathogenesis of chronic inflammatory diseases in order to foster strategies to prevent disease development.**

  Clinical research for environmental modification strategies can also prospectively evaluate the effect of altering environmental exposures on human health. At the patient level, clinical studies can focus on reducing disease burden on the health care system. At the population level, clinical studies can focus on disease prevention.



2. Production of safe and healthy food in a changing world

Secure provision of safe and healthy food is one of the major challenges of the 21st century. With the human population predicted to reach 9 billion by 2050, pressures on global food supplies are growing in the face of climate and societal change. Many technological advances made in the last century have, both intentionally and unintentionally, changed the physical and social environment in which we live, contributing to a worldwide increase in chronic disease. The entrenchment of chronic disease in industrialized nations and the paradox of coexisting malnutrition and obesity in the developing world present huge challenges for science, medicine, agriculture and public health. All parts of the production chain — from farm to fork — need to be considered. The way food is produced, processed, and manipulated contributes to both nutritional imbalance and chronic disease but, with innovation, it can be a means of widespread delivery of health-promoting nutrients.

The University of Calgary's strategic location with respect to Canada's agriculture and food industries — together with its particular community of multidisciplinary scientists and well developed infrastructure — place it in an outstanding position to lead global research at the interface of food, health and chronic disease.

Key areas of investigation

- **Combatting the impact of infectious disease on livestock health, sustainable food production and food safety.**

  Infectious disease has major impacts on livestock heath, productivity and food safety. This area is particularly relevant for Alberta given its central role in the multi-billion dollar Canadian livestock and food-production industries. For example, with 48 per cent of Canada's beef herd raised in Alberta, the industry employs 19,000 people and generated $3.5 billion in farm cash receipts alone in 2012 (with the total contribution of the beef sector to the Canadian economy estimated at over $20 billion/year). Our proximity to the Alberta beef industry, the synergies provided by the co-location of the Faculty of Veterinary Medicine and the Cumming School of Medicine, and the established interdisciplinary collaborations across other faculties (such as Science) all provide a unique environment for global leadership in this area.

- **Infectious disease and pathogen genomics research (bacteria, parasites, viruses and prions).**

  The University of Calgary has growing capacity in this area, with both established and emerging research programs on endemic and emerging infections that limit livestock production and on food/waterborne pathogens that threaten human health. The research ranges from fundamental investigations of host-pathogen interactions to translational research on diagnosis, control and prevention. A critical mass of researchers is undertaking a 'one health' approach to investigate the interplay between infectious disease and animal-human-environment interactions and how these are impacted by changes in climate, land use, production practices, pharmaceutical use and other anthropogenic/sociological factors. These basic and applied research programs will create new knowledge about how to reduce the impact of infectious disease on livestock health and food production – increasing the sustainability, profitability and safety of our food supply.

- **Food, microbiome and advances in preventing and treating nutrition-linked chronic disease.**

  Obesity, once considered a disease of the Western world, now affects nearly 30 per cent of the world's population. The global economic costs of obesity now exceed $2 trillion/year. Obesity is a leading risk factor in the development of Type 2 diabetes, heart disease, stroke, high blood pressure, arthritis and certain cancers. In addition, obesity and Type 2 diabetes make people more susceptible to infection, as illustrated in the dramatic increase in obesity in South Asian populations in Calgary – leading directly to the re-activation of tuberculosis.

A disrupted gut microbiome is now known to play a key role in most lifestyle-mediated obesity. Foods that have a positive effect on health beyond basic nutrition play a key role in the prevention and management of obesity and its associated chronic diseases. Alberta's strong agricultural base is a rich source of bioactive food ingredients that have the potential to improve health and treat disease. Alberta's strengths in grain, oilseed and pulse crops, as well as dairy and beef production, provide researchers with a unique opportunity to identify and commercialize bioactive ingredients targeted at the most pressing nutritional concerns of today. Ninety-six per cent of Canada's pulses (lentils, peas, beans) are grown in the Prairie provinces, and Alberta canola crops contribute over $6 billion per year to the Canadian economy.

There is growing capacity at the University of Calgary to develop and test novel 'functional foods' and ingredients for primary prevention and management of chronic disease. Given rising consumer concerns over food additives, we are also building capacity for identifying how these chemicals can impact human health.

Our research in these three areas brings together scientists in veterinary medicine, agriculture, food and nutrition, microbiology, medicine and policy development. In addition to documenting the impact of dietary components on chronic disease, research over the last decade has revealed a critical role of the microbiome in how humans and animals respond to food and the susceptibility or resistance to disease. For example, disturbances in the profile of microorganisms that colonize the gastrointestinal tract have been linked to the development of food-related inflammatory and autoimmune diseases. This ecological community of microorganisms can inhabit the human, the animal or the plant host.

There is a strong critical mass of researchers working on understanding how microbe and host interact in our changing environment as well as understanding how dietary (prebiotics and probiotics) and pharmaceutical (antibiotics, medications) agents alter the microbiota. With the global functional food market projected to double between 2010 and 2015 to $245 billion, there is a strong commitment by researchers to address the challenges and leverage opportunities to increase the availability of nutritious value-added foods to consumers domestically and internationally.

- **Developing new plant foods and crops to feed people in the future.**

  Based on population growth estimates, there will be a doubling of world food demand by 2050. Plant-derived foods such as cereals, oilseeds, fruits and vegetables account for 70-95 per cent of the calories and essential nutrients in the human diet. Given this, plant-derived foods will play a key role in ensuring global food security over the coming decades. However, traditional plant-breeding approaches to improving the yield, nutritional value, and consumer/producer-desired qualities of plant foods are not sufficient to address the doubled demand from population growth. A comprehensive approach is necessary – using proteomics, genomics, transcriptomics and metabolomics to enable improved food-crop breeding, management and marketing decisions. This requires deeper knowledge about the genes or metabolites responsible for controlling the yield, nutrient content, flavour attributes, positive (or adverse) health effects, pest resistance or stress tolerance of many plant-derived foods.

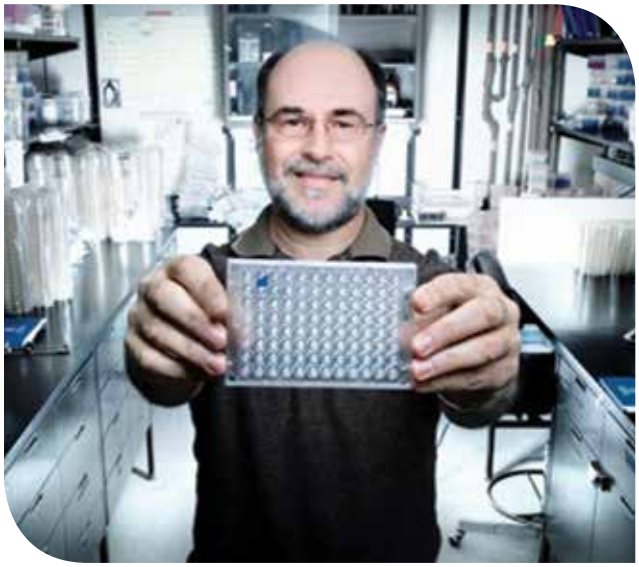
  University of Calgary researchers will use 'omics' platforms to characterize comprehensively a carefully selected collection of high-value Canadian plant food crops thereby creating a comprehensive map of food crop metabolism and biochemistry. Using molecular approaches, we have the capacity to develop nitrogen-efficient crops and drought-tolerant crop plants. Understanding how crops cope with stress and enabling farmers to use less nitrogen fertilizer – which costs $1 billion annually in the Prairie provinces alone – has tremendous potential for decreasing production costs and reducing the impact of nitrogen in the environment. Working with key end-users and stakeholders will ensure this knowledge is translated to yield significant socioeconomic benefits for all Canadians.

- **Understanding food marketing and policy to improve personal and governmental decision-making.**

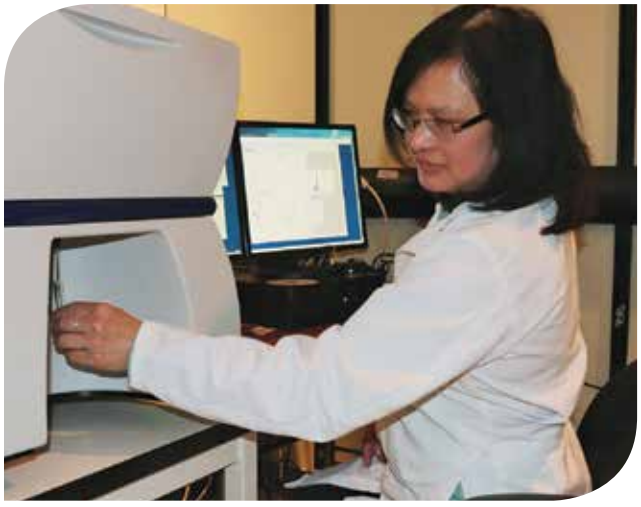
  Consumer and retailer awareness and perceptions of the various elements of the entire food value chain and the impact that it can have on health are critical drivers of government policy, domestic consumption and export markets. Consumers are strongly influenced by marketing campaigns that hint at health benefits but offer little, if any, science-based evidence. Similarly, federal policy on food marketing and food safety can be vague enough that manufacturers and retailers are able to make claims that come close to outright misrepresentation, potentially jeopardizing both the health of domestic consumers and competitiveness of Canadian goods in the international marketplace. Food marketing to children, specifically, is increasingly scrutinized because of the rising obesity epidemic amongst children and youth in Canada, not to mention the moral and ethical debate over the cognitive ability of young people to evaluate advertising and their level of media literacy. Conflicting provincial and federal guidelines on other elements of food safety (e.g. regulation of pharmaceuticals and what constitutes a notifiable animal disease) further muddy the waters, leaving consumers vulnerable to the effects of sluggish health policy decision-making. There are well established and emerging research programs at the University of Calgary seeking to understand and improve food marketing and policy in Canada to mitigate diet-related illness.

Synergies and platforms

The proposed University of Calgary microbiome/pathogen genomics and germ-free facilities will facilitate research in many of the areas listed above. In addition, although the focus of this grand challenge is on food, there are clear synergies and overlaps with water safety, treatment and resource protection, as well as with social sciences. As a result, this challenge would involve collaboration with the Advancing Canadian Wastewater Assets (ACWA) initiative at the University of Calgary.



The University of Calgary is a world leader in biofilm microbiology — and the only biofilm research centre of its size and scale in Canada.



3. Building and battling microbial biofilms

The field of biofilm microbiology was pioneered by University of Calgary researchers in the 1970s. An understanding of these microbial communities has driven a revolution that has transformed the science of microbiology. Biofilms — aggregates of microorganisms in which cells are stuck to a surface and surrounded by a self-produced layer of slime — are integral components of microbial ecosystems. Biofilms are the natural mode of growth for most bacteria, some fungi, and algae, and are a key factor for microbial survival in diverse and changing environments. In this grand challenge, University of Calgary researchers will develop technology and basic knowledge about biofilms that can be applied to control and harness biofilm processes and solve problems relevant to medicine, agriculture and industry.

Biofilms are:

- a vital part of human, animal and plant microbiomes, both in health and disease;
- responsible for a substantial number of persistent and chronic infections, ranging from gum disease to life-threatening infections of the heart, lungs and medical devices such as pacemakers and joint prostheses;
- able to shelter microorganisms from their environment, protecting them not only from host immunity and predation, but also from antibiotics, antimicrobial agents, and physical forces;
- able to cause significant problems relevant to agriculture and industry, including contamination of drinking-water systems, food and seed spoilage, and corrosion of oil pipelines; and
- able to be engineered and harnessed for bioremediation, cleaning up pollution that is hazardous to the environment and human health.

With nearly 20 faculty members investigating biofilms, the University of Calgary is a world leader in biofilm microbiology — and the only biofilm research centre of its size and scale in Canada. This grand challenge brings together multidisciplinary teams of experts from medicine, veterinary medicine, biology, geology and engineering to work on problems of strategic importance to multiple research themes and platforms.

Key areas of investigation

- **Develop anti-biofilm agents and engineer materials that thwart microbial adhesion.**

  Biofilms are difficult or impossible to eradicate using conventional antimicrobial agents. There are very few current antibiotic therapies or disinfectants developed or approved specifically for use against biofilms. Research teams are striving to understand how biofilms resist antibiotics and disinfectants, and how we might inhibit bacterial adhesion, with the aim of devising strategies to disrupt and destroy biofilm communities.

- **Charting conflict and cooperation across biofilm microbiota, the host immune system, and the intestinal environment.**

  Because biofilm infections are rarely resolved by the host immune system, many of these infections are chronic or relapsing and may cause irreparable tissue damage. This can make seemingly routine infections potentially deadly. Also, gut commensal microbiota live as multispecies biofilms. Exposing the interactions between multiple microbial species in biofilms and their hosts will provide key insights into microbiome functioning, disease pathogenesis, and immunity – leading to new therapies that target biofilm pathogens.

- **Develop design principles for biofilm engineering.**

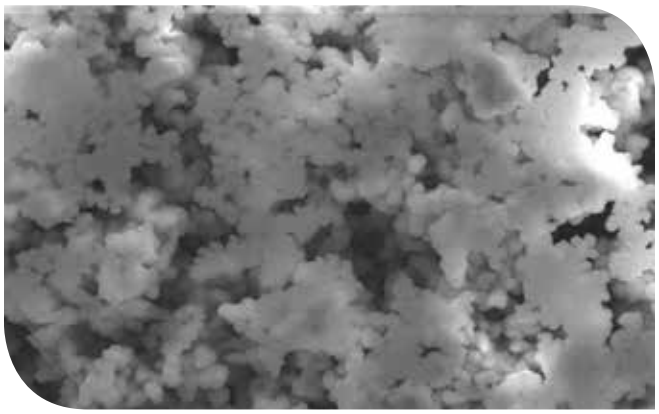
  Researchers seek to develop beneficial uses for biofilms, which may be engineered to degrade contaminants and toxins and used to reclaim polluted environments. Bioremediation will protect Canadian ecosystems and the health of Canadians.

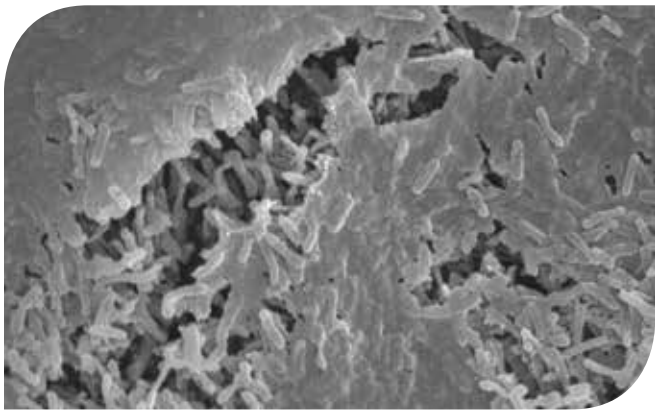
- **Creating policy for biofilm control and regulating anti-biofilm claims.**

  There is currently no policy in Canada or the United States for making anti-biofilm claims on product labels. Engaging stakeholders and regulatory agencies, such as Health Canada, matches our strengths to an opportunity to create policy for making regulatory claims.

Synergies and platforms

Our biofilm researchers work in specialized, dedicated biofilm research laboratories, are key stakeholders in the Western Canadian Microbiome Centre, and seek to build the Optical Imaging Synergy (OPTIS) Research Initiative. Biofilm researchers support multidisciplinary teams at the Advancing Canadian Wastewater Assets (ACWA) initiative. Finally, key objectives of this challenge have important synergies with the University of Calgary Biomedical Engineering Research Strategy.





University of Calgary researchers are leading the country in chronic inflammatory disease research in animal models of human disease and translating these discoveries into improved human health using precision immunotherapy.

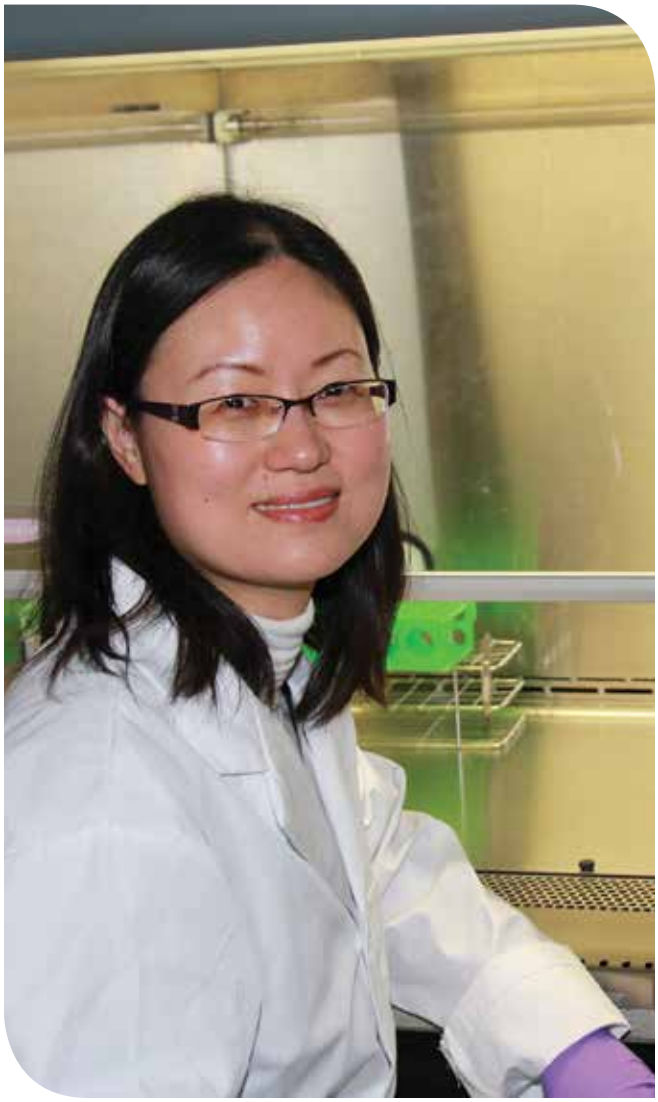
4. Developing immunotherapies: novel approaches to treating chronic disease

Immunotherapy of cancer, deemed the discovery of the year by Science in 2013, highlights the benefit of understanding the immune system's response to foreign cancer cells and then modifying this response to target those cells using novel biologic therapies. This approach has been successfully used to treat melanoma by blocking two checkpoint immunosuppressive molecules (PD-1 and CTLA4), leading to a targeted increase in the immune response against malignant cells. Chronic inflammation was also found to play a critical role in the development of cancer.

Because many inflammatory diseases are driven by overactivity of the immune system, immunotherapy can also be used to treat these conditions. More than 100 investigators across six different faculties are studying the importance of inflammation in disease. Of the nine team grants awarded across the country by the Canadian Institutes of Health Research (CIHR) in the signature area of chronic inflammatory diseases, nearly half came to the University of Calgary. Studies range from blocking cytokines such as tumor necrosis factor (TNF), which has led to a spectacular decrease in morbidity and pain, delivering improvements in quality of life for patients with rheumatoid arthritis and inflammatory bowel disease. Other molecules that block the recruitment of certain immune cell types have been used to successfully treat multiple sclerosis, inflammatory bowel disease and psoriasis.

Cytokines that stimulate aspects of the immune response — such as interferons — play an important role in the treatment of certain forms of chronic hepatitis and chronic granulomatous disease. Administration of G-CSF and GM-CSF is critical for stimulating the bone marrow of patients following chemotherapy or hematologic malignancies, allowing them to more effectively fight infection. IICD researchers are studying immunotherapy in all its forms and its tremendous potential to improve the lives of chronic disease sufferers. The potential benefits of immunomodulatory therapy may also extend to diseases that are not traditionally thought of as inflammatory. For example, the potential benefits of anti-IL-1 therapy are being tested in people with Type 2 diabetes.

University of Calgary researchers are leading the country in chronic inflammatory disease research in animal models of human disease and translating these discoveries into improved human health using precision immunotherapy. In addition to benefits for treating human disease, new small-molecule immunotherapeutics could be developed and applied to the treatment of infectious disease in livestock, which could have major benefits for the agricultural industry. Similarly, tweaking plant anti-microbial defences could help promote resistance to pathogens without affecting the genome. This would be important for the agriculture industry, as society desires increased yields from crops and food-producing animals without genetic alterations.



Key areas of investigation

- **Discovery of novel pathways for the treatment of chronic diseases in humans and animals.**

  Although significant numbers of immune pathways have been identified, many remain unexplored. Detailed study of these pathways will be critical for identifying promising therapeutic targets for the drugs of the future.

- **Repurposing of existing medications.**

  Given the ubiquity of inflammatory and immunomodulatory pathways, drugs developed for one disease may prove more useful in another. Anti-TNF treatments proved ineffective for reducing mortality in patients with overwhelming infection (sepsis). However, they have proved to have tremendous impact on patients with rheumatoid arthritis and inflammatory bowel disease — two other conditions where excessive inflammation causes considerable morbidity. Thoughtful application of existing drugs to new diseases will be critical for improving health.

- **Using novel technologies to identify targeted therapies for inflammatory diseases.**

  It is becoming better understood that there are subsets of various inflammatory diseases. Examples include anti-TNF responsive inflammatory bowel disease and eosinophilic (versus neutrophilic) asthma. New technologies could be used to identify biomarkers that would direct therapies. Cytokine profiling, auto-antibody profiling, microbiome profiling and genomics will lead to a better understanding of individual patients and the opportunity for precision medicine. In addition, this type of information can be incorporated into future trials. This is not restricted to humans but could be applied to animals and plants.

- **Phase I trials of immunotherapy in humans and animals.**

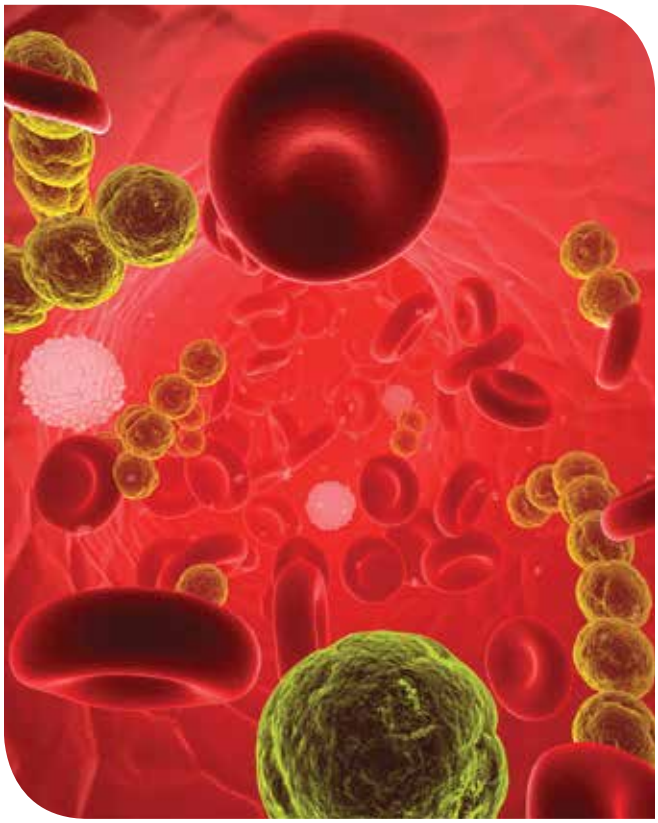
  University of Calgary researchers will bring their discoveries from the bench to the bedside — doing the first-in-human studies of newly discovered molecules that have shown promise in experimental models. Similar approaches will be used to test novel treatments for diseases that affect animals and plants.

- **Links between immunotherapy and the microbiome.**

  IICD researchers will explore whether the change of a microbiome can improve immune health.

- **Imaging immunotherapy.**

  IICD researchers will explore novel imaging modalities that provide mechanistic insight into immunotherapy.



5. Managing the growing economic burden of chronic diseases

Health systems face a common threat: the exploding burden of patients with chronic diseases. Our population is aging, with significant expansion in recent years of the population aged 50 years or older. Recent estimates suggest that more than 60 per cent of Canadians live with a chronic disease, and that many live with multiple chronic diseases. These include coronary artery disease, diabetes, chronic kidney disease, asthma and other chronic lung diseases, inflammatory bowel disease, arthritis of various types, other connective tissue diseases, and depression.

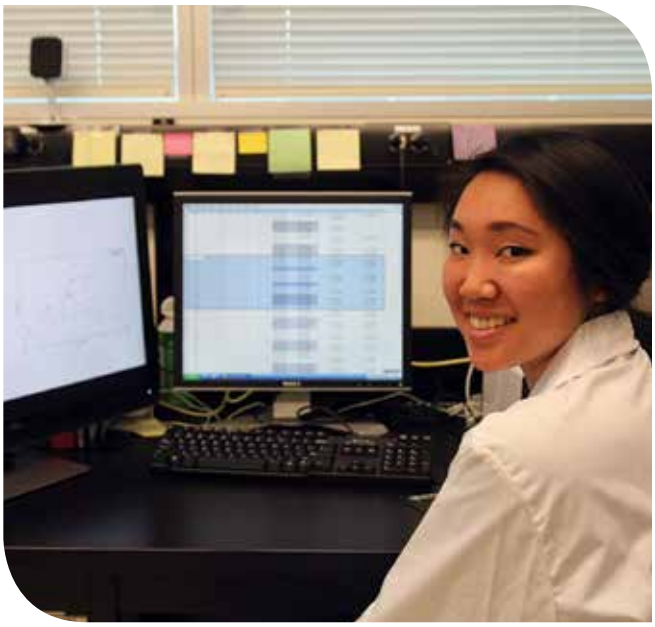
The combination of an aging population and prevalent chronic diseases is producing an exponential rise in health spending around the world. Aging and chronic diseases are driving demand for medical services and prescription drugs, and with this, health care costs are escalating to unsustainable levels. Almost 50 per cent of every tax dollar in Canada is spent on health care, and there are growing concerns that the drain on public and personal finances will jeopardize the economic, social, and psychological well-being of citizens for generations to come.

Many describe this as possibly the single greatest threat to human well-being. Indisputably, we are all affected by chronic diseases through their direct effects on human health, and perhaps even more significantly through their indirect far-reaching micro- and macro-economic effects. Simply put: societies will decline in all sectors if they cannot be sustained economically. There is a pressing need to address this threat.

Health systems are not dealing well with the burden of chronic disease, and the *status quo* will not suffice. Canada is one of the highest-spending countries in the domain of health care, both in *per capita* spending and in percent of gross domestic product. The returns from substantial Canadian investments in health care are known to be suboptimal, with many demonstrated problems:

- fragmented and disconnected care – across time, providers, and care sectors;
- frequent evidence-care gaps, where proven diagnostic and treatment approaches are adopted sluggishly or not at all;
- insufficient attention to the patient and family experience of care;
- inequitable care, with factors such as ethnicity, geography, and socioeconomic status influencing care received;
- lack of timely care, compromising the patient experience and sometimes patient outcomes;
- inefficient care, with duplication of services, and excessive use of clinic- and hospital-based care; and
- inappropriate care, often with insufficiently-regulated use of new diagnostic tests, therapies, and devices

University of Calgary researchers have internationally renowned expertise in population health; assessing, improving and innovating health systems quality; health policy and finance; health technology assessment; patient engagement; clinical trials; and knowledge translation. We will leverage this local expertise with our national and international collaborations to address the critical challenges that chronic diseases and an aging population pose to our health system.



Key areas of investigation

- **Enabling and empowering patients and families for community- and home-based chronic disease care.**

  Moving health care outside hospitals and clinics has tremendous potential for improving the patient experience while improving health system efficiency and optimizing health. However, much remains to be learned about how to do this safely while meeting the medical needs of patients and their families. New models of citizen and patient engagement in research will be critical to achieving this important objective.

- **Integration of chronic disease care across the care continuum.**

  Family physicians once provided nearly all of Canadians' medical care. Today, many Canadians with chronic diseases also see multiple specialists, each with their own treatment goals and approaches. These differing and often conflicting objectives can lead to fragmented care, an unsatisfactory patient experience, suboptimal care and wasted resources. There is a pressing need to better connect care in hospitals and by specialists with care that is delivered in the community and family physician offices. University of Calgary expertise from the Ward of the 21st Century (W21C) will help to achieve this goal.

- **Development and testing of eHealth systems for enhanced communication and care integration for chronic disease.**

  Technologies such as the internet, cloud computing and mobile phones have revolutionized the daily lives of billions of people. They have obvious and extraordinary potential to facilitate health-related communication, self-management and medical treatments. Equally promising are decision-support systems that deliver evidence and information to the care setting to improve patient and provider decision-making at crucial moments. However, little is known about the best way to use these technologies to achieve these objectives.

- **Priority-setting frameworks in challenging economic times.**

  Health resources are scarce and even affluent places like Alberta cannot afford to provide all possible health services and treatments. New methods for economic research and health technology assessment are needed to allow fair and transparent priority-setting for resource allocation as well as innovative approaches to health system financing.

- **Harnessing the potential of big data and smart analytic tools for enhanced chronic disease surveillance and measurement of health system performance.**

  All industries use data to identify potential new markets, keep track of competitors and other potential threats, and monitor their own performance. Despite the enormous quantities of health-related data available, the health care industry lags far behind in routinely using these data to improve the health of populations. New approaches are needed to make big data available and useful to health care professionals and policy-makers. Such data could help them identify areas and populations where the risk of disease is rapidly growing, monitor health system performance (and rapidly intervene when outcomes are poor) and invent new approaches to treatment.

CONNECT research

The IICD team has developed four research directives to ensure maximal impact of the grand challenges. Each directive will assist in guiding scholars in developing and implementing research pertinent to their communities, thus having highly impactful translational significance. Together, the research directives are called CONNECT, as the focus of the research under the grand challenges is to connect our communities with research scholars, government and industry to better enable translation against infections, inflammation and chronic diseases and our environments.

Infections, Inflammation and Chronic Diseases

CONNECT Research

Identifying and understanding our local, national and international community challenges:

University of Calgary scholars provide innovative research for pertinent problems within our communities. IICD scholars will continue to do so and to actively build strong internal and external partnerships with a variety of institutions to further these relationships. The IICD team will host events to engage the community, enhance public knowledge of our research focus, and ensure that our goals appropriately address public concerns.

Public concerns pertinent to the IICD strategy include everything from public health, veterinary medicine and agricultural issues to ensuring a safe and viable environment. This requires working in a multi-disciplinary fashion and among our internal and external communities to understand and address our grand challenges. Medicine and nursing are directly involved in the study and treatment of diseases, but translation of truly innovative discoveries can be greatly enhanced through collaboration with experts in policy, engineering, environmental design, geology, sociology, psychology, biological and nutritional sciences, law, population health and epidemiology.

Use our natural resources and agriculture sectors to promote health and combat disease:

Alberta is world-renowned for its natural resources in energy and agriculture. Agricultural productivity and human health influence each other. With a multi-disciplinary approach, the IICD research team will tackle high-impact issues in these areas. Environmental issues of the Alberta oil sands may be studied in innovative fashion through collaborations with biological scientists, including experts in bacterial biofilms (communities of bacteria), medical scientists and experts in health-related microbial communities including biofilms (microbiomes); geologists with expertise in environmental microbiomes; and engineers with expertise in the physical extraction of energy.

University of Calgary scholars have researched microbial communities that can capture carbon dioxide from energy production that pollutes the atmosphere, causes death and debilitation in patients with chronic diseases such as cystic fibrosis, and then convert biomass into energy. The IICD team's collaborative efforts will enable the discovery of translatable techniques as a solution to multiple problems.

Create innovative ideas through academic/industry collaborations and partnerships:

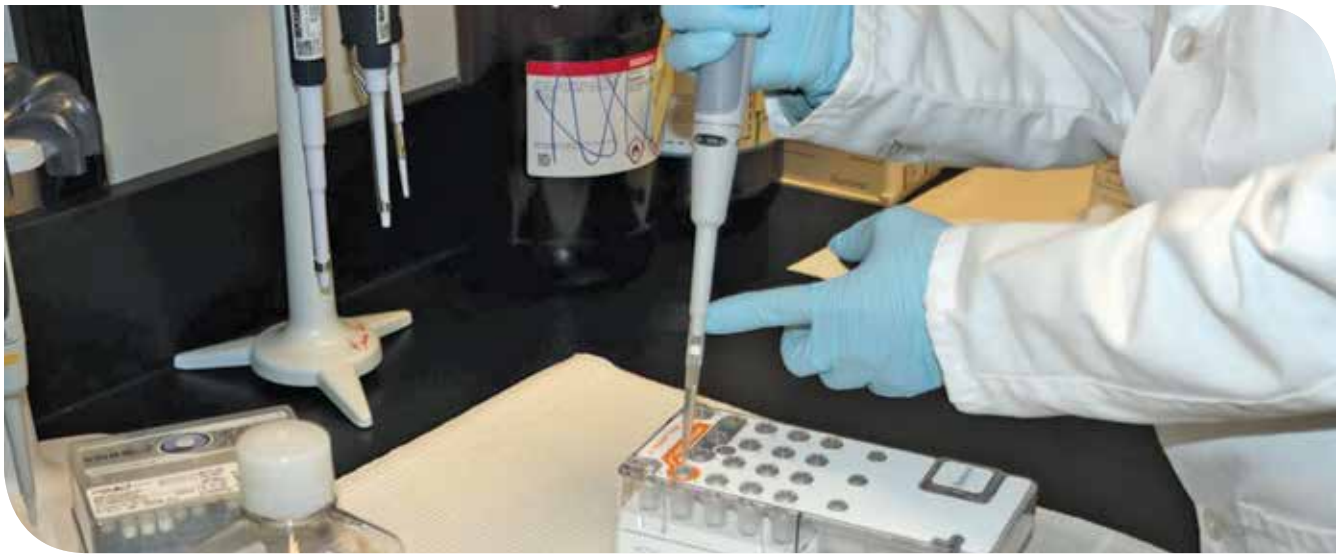
Economic development and sustainment not only requires recognition of marketable goods, but is also driven by highly trained research experts in both academic and industrial settings. Historically, academic-driven discoveries are recognized by industry only after the discoveries have been made. For example, investigators at the University of Calgary recently discovered a live bio-therapeutic based on gut microbiota that can combat major infectious diseases such as C. difficile. This, in turn, has led to partnerships with industry that will accelerate the translation of this innovation from the lab to the bedside.

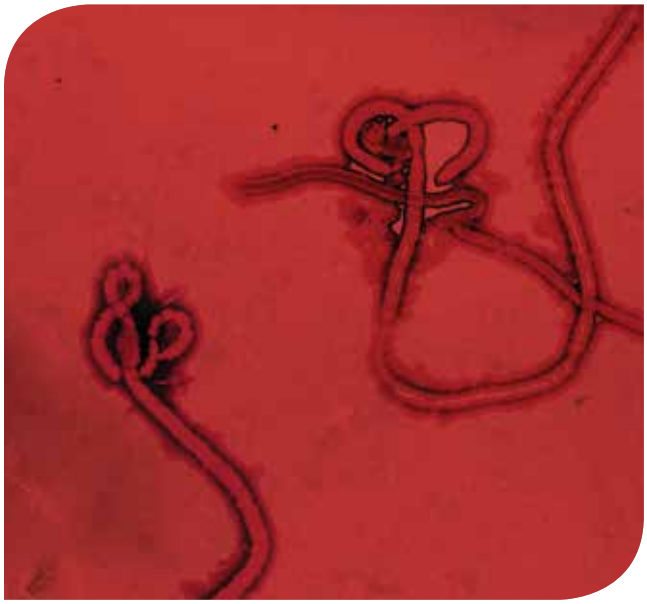
These are important relationships that the IICD team will continue to develop. IICD scholars will also work directly with industry to determine important vital community issues related to chronic diseases and how to develop innovative and translatable research ideas that will address these important issues, be highly marketable and enhance both our local and international economies.

Enable clinical translation in a changing physical, social and economic environment:

Alberta has a number of important relationships that can contribute to enhancing clinical translation of research. The University of Calgary has unique strengths in its collaborations between clinician scientists with basic scientists and Alberta Health Services in the discovery of new techniques and therapeutics.

As well, industrial partners, such as Mitogen Advanced Diagnostics Laboratory, work with researchers at the university and Alberta Health Services to develop and implement new bio-diagnostics for improved patient diagnosis and care. The IICD team is building on these relationships and creating additional opportunities for environmental experts to contribute to clinical translation. For example, experts in geological microbiomes are working with medical scientists, clinician scientists and Alberta Health Services to develop pipelines for clinical genomics.





Increasing research capacity

Creating a Confederation of Scholars

The IICD strategy has brought together specialists from across the academy to build a 'confederation of scholars'. This strong network of interdisciplinary researchers will leverage individual and collective knowledge and contacts to advance exploration into the questions behind infections, inflammation and chronic diseases.

The University of Calgary will support the IICD confederation of scholars by investing in collaborations among interdisciplinary members and with external academic, economic, governmental, and community partners. This support is vital to the success of the IICD strategy as it involves local, national and international granting, prizes and award opportunities that will develop and sustain the team's multi-disciplinary approach to research. The university will also invest in networking activities to enable IICD scholar interactions. Each of these investments will advance specific IICD research and provide a means for individual scholar success through knowledge translation opportunities and enhanced access to state-of-the-art technologies.

Building on our research platforms

Our research on infections, inflammation, chronic disease and the environment will draw on, and contribute to, all of the seven platforms in the University of Calgary Strategic Research Plan:

- **Synthesis and visualization**

  The multi-disciplinary approach to IICD research is driven by innovative ways to synthesize and visualize qualitative and quantitative data, not only among our university academics, but also with external collaborators and partners including industry, government and other academic institutions. The IICD team will utilize this platform to address the grand challenges in a number of ways, including inventing and improving data capture technologies (e.g. optical imaging, sequencing and mass spectrometry) and high-performance computing (e.g. bioinformatics and live cell imaging).

- **Analytics and simulation**

  Through innovative ideas and research enablers, IICD scholars — together with their cross-disciplinary and external partners – will make sense of integrated data through analytical processes such as bioinformatics approaches to 'omics' technologies. IICD scholars will work among such experts as clinician scientists and industry experts to enable simulation of high-level technologies and solutions to problems that impact our societies, such as live-biologics, immunotherapies and antibiotics against chronic diseases.

- **Research stations**

  The IICD team will integrate with current and future research stations that will provide platforms for research conducted by global scholars from multi-disciplinary academic and industrial institutions and for student education. For example, the Kluane Lake Research Station and the Geoscience Field Research Site (GFRS), which enable studies of our northern communities' environments and energy-related research — including carbon capture.

- **Research enablers**

  The IICD team will work with the university to build on and maintain related research enablers. As a core facility, the Western Canadian Microbiome Centre will have state-of-the-art germ-free and gnotobiotic capacity, imaging, 'omic' technologies and bioinformatics.

Innovate Calgary

Innovate Calgary is a liaison between academic and industrial partners, government and university-funded agencies with the goal of promoting technology-transfer and business expertise for:

- Intellectual property management/licensing
- Company creation and incubation
- Analysis of commercial potential for technologies
- Mitigation of financial and resource risks relative to commercialization
- Leasing/tenancy opportunities (Alastair Ross Technology Centre and the Research Transition Facility
- Entrepreneur development services and programs

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INNOVATE CALGARY

- **Commercialization**

  The IICD team is developing strategies for commercialization of technologies developed from collaborations and partnerships. This includes partnering with Innovate Calgary to implement some of these innovative strategies and will seek similar partnerships.

- **Knowledge translation**

  The internal and external multi-disciplinary approach used by the IICD team will help to streamline the high-level research into practical applications. For example, IICD clinical scientists will collaborate with basic scientists in medicine, science and engineering, along with industrial partners, to move new discoveries in technologies and therapeutics against infections, inflammation and chronic diseases to clinical applications.

- **Policy creation**

  Championed by the School of Public Policy, select IICD projects will inform public policy development in the areas of health and wellness, veterinary care, agriculture and the environment, allowing for new opportunities to drive policy research.

Engaging our communities, commercialization and knowledge transfer

IICD scholars will work with communities at the local, national and international levels to ensure that research driven by the grand challenges addresses vital community concerns. Our communities are our greatest resource and we will strive to ensure direct communication. The IICD team will develop external partnerships with industry, government and other academic institutions, along with community stakeholders. The group will also develop internal multi-disciplinary collaborations to develop innovative research ideas through the grand challenges. Together, these partnerships and collaborations will enable essential innovative and translatable research.

Through the Office of the Vice-President (Research), in partnership with Innovate Calgary, the University of Calgary has provided opportunities for industry engagement that have led to knowledge transfer in the form of patent developments, licensing and development of start-up companies. The university will continue to provide such support in promoting knowledge translation related to the IICD grand challenges.

Transformational opportunities

The grand challenges will provide a framework by which IICD scholars and their partners can develop joint research initiatives. Working together in multi-disciplinary teams and with internal and external partners will open the door for further support by the University of Calgary and provincial, national and international sources. The University of Calgary, through the Office of the Vice-President (Research), will invest in the development of these teams. It will also provide support for the development of research initiatives and for targeting major external funding opportunities. These opportunities will be the seeds for future development of the IICD research program.

Multi-disciplinary cross-cutting enabling platform: Western Canadian Microbiome Centre (WCMC)

Through successful federal government opportunities and matching support from the University of Calgary, the IICD team has secured funding to build the Western Canadian Microbiome Centre. The centre will open in April 2017 and consist of four research platforms that include a high-capacity germ-free core, systems for live-imaging that are unique worldwide, and high-level 'omics' including proteomics, metabolomics and genomics and powerful bioinformatics. Together, the WCMC infrastructure, the scientific expertise of its members, and direct access to environmental factors unique to Western Canada, will result in high-impact microbiome research that will improve health and wellness for people and animals around the world.

We now know that our constant interactions with internal and external microbiomes can alter our immune system. However, we do not yet fully understand how this occurs. For example, alterations in microbiomes through antibiotic use in early life can cause obesity, and alter susceptibility to other chronic diseases (for example asthma, inflammatory bowel diseases, and allergies). Development of the WCMC will provide University of Calgary researchers and industry partners with the opportunity to make significant advances in how microbiomes can alter the immune system leading to infections, inflammation and chronic disease; the results of which will provide the basis for prevention and treatment.

WCMC platforms: The germ-free platform with gnotobiotic capacity will provide an environment to study the effects of microbiomes on the immune system and chronic diseases within living organisms. Few core facilities of this calibre exist anywhere. World-renowned investigators in *in vivo* imaging with capacity to watch the immune response to microbiomes in real time will revolutionize the microbiome field. 'Omics' and live-imaging platforms with state-of-the-art infrastructure and expertise will allow for the discovery of new diagnostics and therapeutics, including immunotherapies, biologics and anti-microbials. This will be attractive to industry partners that want to explore advanced technologies for testing specific variables in the development of effective therapeutics, vaccines and diagnostics.

The unique ecosystems of Alberta, such as the oil sands, also enable harvesting of potential natural anti-microbials or biologics. In addition, WCMC will have considerable expertise in biofilms that have the potential to absorb carbon emissions and for more efficient production of energy. The facility will also have capacity for the research of plant and animal microbiomes for food production, thereby ensuring nutritional value as well as diagnosing, controlling and altering the production and quality of food sources.

The University of Calgary is a leading Canadian university located in the nation's most enterprising city. The university has a clear strategic direction to become one of Canada's top five research universities by 2016, where research and innovative teaching go hand in hand, and where we fully engage the communities we both serve and lead.

This strategy is called *Eyes High*, inspired by the university's Gaelic motto, which translates as 'I will lift up my eyes.' As part of the roadmap to achieve these goals, the university's Strategic Research Plan identifies six research themes that will leverage our distinct capabilities while addressing the unmet needs and challenges of our society as a whole:

- Energy innovations for today and tomorrow
- Engineering solutions for health: biomedical engineering
- Brain and mental health
- Infections, inflammation and chronic diseases in the changing environment
- New Earth-space technologies
- Human dynamics in a changing world: smart and secure cities, societies, and cultures

Learn more about the University of Calgary's Strategic Research Plan and the Infections, inflammation and Chronic Diseases in the Changing Environment Research Strategy. Contact the Office of the Vice-President (Research) at vpr@ucalgary.ca

ucalgary.ca/research

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