

This summary of the UBC Research Strategy (full version available at research.ubc.ca) describes broad themes and clusters of research excellence that support the overall UBC strategy, *Place and Promise*. While even a great university like UBC cannot hope to achieve excellence in all of its research efforts, it should be expected in a large number of areas. And while achieving excellence is always based on the recruitment and support of excellent researchers, there will be areas where the achievement of excellence relies on the work of teams of researchers working within or across disciplines.

The three over-arching themes described herein represent areas of strength and opportunity for future innovation at the Vancouver campus. These three over-arching themes, and the research clusters within each theme, are:

Life and Health Sciences

1. Biotechnology and Genomics
2. Human Health and Genomics
3. Neuroscience and Cognitive Systems
4. Population Health and Human Development

Society, Culture and Globalization

5. Culture and its Representation
6. Society in Global Context

Physical Sciences, Environment, and Entrepreneurship

7. Microelectronics, Information Technology and E-commerce
8. Quantum Structures and Information
9. Nanoscience and Nanotechnology
10. Origins and Mathematical Structure
11. Sustainability/Environment

Research goals, major initiatives, and progress milestones in each of the eleven clusters are summarized in the following sections.

Biotechnology and Genomics

This cluster is linked to growth in products derived from biotechnology, including new drugs; new crop varieties; improved processing enzymes, cultures, human tissues and organs; new polymers; and improved methods for treating environmental contamination.

A significant locus for biotechnology and “-omics” research is the Michael Smith Laboratories (MSL). Located in the heart of the UBC campus, these laboratories are housed in a state-of-the-art CFI-funded facility, a realization of the vision of its founding director and Nobel Laureate, Dr. Michael Smith. MSL houses portions of the CFI-funded Laboratory for Molecular Biophysics and also incorporates the Canadian Genetic Disease Network and the UBC Bioinformatics Centre. The second and third floors of the new building are dedicated to research and provide a home to a number of CRC’s and other researchers representing five faculties who explore organisms ranging from worms and mice to trees.

In addressing challenges in biotechnology and genomics, there is significant benefit in stepping beyond the domain of the genome, proteome, and related “omics” to adopt a systems biology approach. An evolving systems biology initiative to capitalize on existing UBC expertise and infrastructure is the Centre for High-throughput Biology (CHiBi). This group has expertise across the physical/life sciences interface and shares a common interest in the use of high-throughput approaches to interrogate or manipulate biological systems. Capitalizing on the availability of high-throughput genomics, proteomics, and bioinformatics expertise at UBC, this group is well positioned to explore biology using a systems approach. CHiBi researchers and associates are also involved in technology development in areas as diverse as computational biology, cell biology, chemical biology, nucleotide and peptide sequencing, microfluidics, and imaging.

UBC is applying meta-genomic approaches with metabolic and biosynthetic engineering to develop new technologies for producing energy, fuels, chemicals, and materials from renewable sources. This interdisciplinary research effort is motivated by a clear and compelling opportunity to develop the biomass remaining from tree and crop harvesting – one of Canada’s most abundant natural resources – as a feedstock for a diverse and growing bio-refining industry. ■

Human Health and Genomics

This cluster encompasses core research in infection and immunity, cancer, cardiovascular and respiratory, wound healing, pathogenomics, pharmacogenomics, genomic imprinting, anti-microbial drug development, transplant research, stem cell genomics, asthma, gene-based medicine, genetics and behaviour, and blood proteins.

Strong research groups are housed in the new Life Sciences Centre on the UBC Vancouver campus and at hospital-based research institutes (CFRI, VCHRI, Providence, BCCA, BCCDC) in Greater Vancouver. UBC's strength and leadership in the field of genomics is underscored by numerous faculty honours, including the awarding of the 1993 Nobel Prize in Chemistry to the late Dr. Michael Smith for his work in basic molecular genetics.

'Gene-to-society' research efforts engage both multidisciplinary and systems approaches and focus on human biology in health and disease across the lifespan. There is a strong focus on providing children with the best possible start in life, including determining fetal origins of disease and early indicators of disease risk, developing vaccines that protect against infection, and characterizing mechanisms for nutritional and environmental effects on health. World-class research also addresses the prevention of complex and chronic diseases of adulthood faced by our aging population.

Research in the Human Health and Genomics cluster is supported by major infrastructure funding from CFI, BCKDF and Genome Canada. In particular, investment by CFI and BCKDF through the Laboratory for Molecular Biophysics, Michael Smith Laboratories, the Centre for Integrated Genomics (now the Genome Sequencing Centre), iCAPTURE Centre, the Centre for Research in Childhood Diabetes, the Centre for Blood Research (CBR), the Prostate Centre at VGH, PC-TRIADD, the Centre for Hip Health, and the BC Centre for Disease Modeling (BCCDM).

Over the past decade, The Prostate Centre, a National Centre of Excellence, has become Canada's leading research and treatment centre for prostate cancer and one of the largest in the world. A \$20 million CFI award added core expertise and state-of-the-art infrastructure to augment programs in genomics, proteomics, pharmacology, molecular pathology, and informatics. A developing research initiative will develop DNA-based biomarkers using Ultra High-throughput Sequencing technology to predict the risk of progression of localized disease, to evaluate response to therapy, and to help develop new therapies targeting tumours and pathways to delay the late-stage progression of disease.

The Centre for Disease Modeling (CDM) hosts a state-of-the-art bio-containment facility for the study of viruses including SARS, HIV, influenza, Hepatitis C, and West Nile Virus, each of which presents a substantial threat to

human health. The major aims of research at the CDM are i) to develop vaccines that prevent infection by these viruses and ii) to develop anti-viral drugs to prevent these viruses from spreading in the body and causing disease.

Several recent initiatives enhance prior investment by building on existing CFI-funded infrastructure and expertise. These include the Centre for Drug Research & Development and the Centre for Understanding & Preventing Infection in Children. Each of these initiatives is further supported by major endowments.

The Michael Smith Genome Sciences Centre at the BC Cancer Agency is a leading international centre for genomics and bioinformatics research. Its mandate is to advance knowledge about cancer and other diseases, to improve human health through disease prevention, diagnosis and therapeutic approaches, and to realize the social and economic benefits of genomics research. The Genome Sciences Centre deploys resources and technology of a high-throughput genome mapping and DNA sequencing lab to decrypt the genetic code, specifically to advance cancer research, diagnosis and treatment.

Combining the experience of world-renowned scientists, the Genome Sciences Centre plays a major role in the fields of genomics and bioinformatics as well as various genome projects around the world. The priority of the centre is to find innovative means to automate the sequencing and fingerprinting process, develop cost-effective measures that will make such research financially viable and utilize state-of-the-art computing facilities to collect, mine, analyze and disperse data collected at this and other genome facilities. Experimental genomics is carried out on the latest sequencing and fingerprinting equipment with data collected and analyzed on one of the most innovative and flexible bioinformatics computing facilities in the world. ■

Neuroscience and Cognitive Systems

Research in this cluster seeks to address one of the greatest scientific challenges of this century: unraveling the mystery of the human brain. A central component of this cluster is the UBC Institute of Mental Health, supported by a \$20 million endowment established from private and government sources. Three research chairs in this institute complement the Provincial Leadership Chairs in Depression and in Addictions (\$5 million each). The cluster has also received seven major CFI awards, including: The Brain Research Centre, the MRI Medical and Biological Functional Imaging Centre, High Resolution Functional Imaging in Neurodegenerative Diseases, the Institute of Computing, Information and Cognitive Systems (ICICS), the International Collaboration on Repair

Discoveries (ICORD, an interdisciplinary research center for promoting functional recovery from spinal cord injury that opened in 2008), a Centre for Macular Research (\$1.26 million), which exploits emerging technologies to increase our understanding of the visual system, and a Micro-PET for Functional Imaging Centre.

Examples of leadership in this cluster include a “bench-to-bedside” research approach to early intervention in psychosis, the most disabling disorder of youth and early adulthood, involving faculty and clinical investigators from neuroscience, genomics, radiology, psychology and psychiatry. Other interdisciplinary studies focus on the aging brain, an area of particular societal relevance as Canada’s baby boomers enter the prime ages for stroke, Alzheimer’s, Parkinson’s and similar diseases.

A new research initiative will combine state-of-the-art neuroscience, molecular genetics, functional genomics, and proteomic technologies with bioinformatics to elucidate the molecular mechanisms of neurodegenerative disease processes, identify novel disease proteins and potential drug targets, and develop new drug therapies for patients.

UBC also demonstrates considerable strength in the field of neuroimaging. An emerging research initiative seeks to use molecular and cellular imaging to examine the interaction between genetic and environmental (including prenatal) factors on structural changes in the brain.

The field of biomedical engineering is of critical importance in understanding spinal cord mechanics and treating neurotrauma, and is contributing innovative solutions to these debilitating disabilities. A new UBC research initiative seeks to combine the latest advances in biological and nanotechnology strategies to develop treatments for the functional repair of the acute and chronically injured spinal cord.

Researchers in this cluster are also exploring the “learning brain” in an effort to enhance human learning and memory and to remedy learning disabilities in brain-injured children. ■

Population Health, Services & Human Development

Research in this cluster seeks to translate basic research in human health into practical outcomes in health delivery and services that benefit all. The cluster is designed to complement two of the four research areas of the Canadian Institutes of Health Research (CIHR): Health Systems and Services, and Population and Public Health.

Current research includes a focus on health and well-being in individuals and in populations, and addresses questions as to how administrative, legal, social and educational systems relate to health and development. Research in this cluster also seeks to examine the delivery

of services that may have a direct or indirect impact on physical and mental well-being, and to develop activities and approaches that improve population health beyond the sphere of the health care system (i.e., in the social and educational systems).

A key strength of this cluster is the BC Linked Health Database maintained by UBC and acknowledged as the world’s largest longitudinal, population-based database on health services utilization and the determinants of health. In addition, the Education Information Data Centre at UBC was awarded CFI funding to link educational data from related fields such as child development, health and economics.

Also affiliated with this cluster is the B. C. Centre for Excellence in HIV/AIDS, which is dedicated to improving the health of people with HIV through comprehensive research-guided treatment programs for HIV and related diseases. The Centre is a key provincial resource, serving all health authorities, regions and citizens of B.C. Research at the Centre places the disease under the microscope and promotes evidence-based social policy that helps protect people from acquiring the virus. ■

Society in Global Context / Culture and its Representation

These two research clusters are designed to foster research and scholarship that addresses social and cultural issues within Canada and beyond. Research within the clusters is focused on improving our understanding of the evolving nature and representation of culture and society from a range of disciplinary perspectives, and facilitates the examination of social and economic policy and practice in both national and international contexts.

UBC Economics is ranked the top economics department in Canada and is in the top 25 in the world, in terms of research. In the last decade, four UBC economists have received the Rae Prize, awarded biennially to the top research economist in Canada. The Department is the administrative home to the Canadian Labour Market and Skills Research Network and manages the British Columbia Inter-University Research Data Centre. Areas of research excellence include data-intensive economics, labour economics, international trade, and industrial organizations.

In other areas within these clusters, UBC has built strength through the recruitment of Canada Research Chairs who have established a number of centres of excellence, including the International Centre for the Study of Historical Consciousness; the Early Childhood & Literacy Research Laboratory; the Centre for Culture, Identity and Education; the Research Facility for Internationalization of Curriculum Studies; the Virtual Global Issues Research Communications Hub; the Asian Urban Laboratory; and

The Political Environment, Cognitive Processes, and Citizen Competence in Policymaking initiative.

With the support of the Canada Foundation for Innovation and the British Columbia Knowledge Development Fund, the Museum of Anthropology (MOA) undertook an \$80 million expansion and renewal that has not only extended its role as a university research institution, but also broke new ground in devising inclusive and collaborative ways for museum work, interdisciplinary research and teaching across local, national, and international borders.

The Multidisciplinary Music Research Institute (MMRI) seeks to link performers, composers, and scholars with researchers in Human Kinetics, Linguistics and Speech Science, Medicine, and Psychology to examine the cognitive, neurological, and physiological dimensions of musical performance and perception and their implications for physical and mental health. ■

Microelectronics and Information Technology

Research in this cluster builds on existing excellence and infrastructure at UBC and seeks to capture exciting opportunities in emerging areas including e-commerce, robotics, intelligent systems, computational biology, entertainment and electronic interaction.

The \$22 million CFI award for the creation of the Institute of Computing, Information and Cognitive Systems (ICICS) has stimulated research both in this cluster and in Neuroscience and Cognitive Systems.

A new research initiative in this cluster focuses on animation and gaming, and is supported by the areas of rendering, human-computer interaction, and intelligent user interfaces. In the past eight years, CFI awards have funded heavy investments in recruitment, infrastructure and space in these areas. ■

Quantum Structures and Information

Quantum mechanics is a powerful tool for describing how the fundamental building blocks of the universe interact to form familiar macroscopic objects. Scientists and engineers at UBC are learning to translate quantum mechanics into technological developments that will help to inform the future of computer power, among other applications. Of particular interest is the ability to exploit phenomena found when materials are controlled at the atomic scale.

Research is focusing on the development of new materials and structures assembled with atomic-level control, for example using metal oxide layers to provide a technology for 21st-century information processing.

Another initiative, the Canadian Center for Research on Ultra-Cold Systems, combines the research programs and infrastructure of nine UBC faculty members to study the creation, properties and technological applications of ultracold atoms, molecules, plasmas and condensed matter. ■

Nanoscience and Nanotechnology

Research in this cluster seeks to understand structures on the nano-scale and to develop devices and applications that operate on the molecular scale. The development of such applications – and the proliferation of nanoscience in recent years – is fuelled by new instrumentation that probes materials at the atomic scale. A core group of UBC researchers comprises one of the strongest Canadian efforts in this area, and an \$8.1 million CFI award to UBC and Simon Fraser University for nanostructures-related equipment is boosting efforts in this field in B.C.

UBC is a Canadian leader in composite materials research, and a \$9.8 million investment by Western Economic Development has supported the launch of the UBC-based Composites Research Network, which will establish nodes in British Columbia, Alberta, Saskatchewan and Manitoba where composites experts in academia will work with manufacturers to address industry-specific concerns.

A major research initiative in this cluster involves the fabrication as well as the theoretical and spectroscopic study of novel complex systems and nanostructured materials. The goal is to develop new approaches and understanding in the quantum theory of solids, and to define new pathways for the fabrication of materials and structures with innovative physical properties. This initiative is strongly coupled to a \$9M CFI-funded beamline for atomic-scale microscopy with applications in environmental science and advanced materials led by George Sawatzky and a \$16M CFI-funded Quantum Materials Spectroscopy Centre, led by Andrea Damascelli, which will push Canada into the forefront of research into the electronic properties of novel materials, with applications including high-performance computing and energy storage technologies. ■

Origins and Mathematical Structure

Research in this cluster seeks to address the basic questions of existence, offering exciting challenges to UBC astronomers, mathematicians and physicists: *What is the universe made of? How did it begin and how will it end? How did our own solar system form? Is there life elsewhere?* Seeking the answers to these and similar questions serves to pique public interest, to enhance students' appreciation of science, and to elevate Canada's international status in science and technology.

UBC has considerable strength in this cluster. It is an important participant in several collaborative experiments to decipher the large-scale structure of the universe by measuring the cosmic microwave background. Strength in stellar astrophysics will also blend well with the proposed initiative in planetary astrophysics. UBC also excels in core mathematics research; the probability research group is considered among the top three in the world.

In 2003, UBC established the Pacific Institute for Theoretical Physics (PITP) to support research in three related clusters (Origins and Mathematical Structure, Nanoscience and Nanotechnology, and Quantum Structures and Information). This international research institute is based at UBC but it sponsors research networks and international research collaborations. ■

Sustainability / Environment

UBC's institutional commitment to sustainability, outlined in the strategic plan *Place & Promise*, broadly influences and combines activities in research, teaching and learning, and campus operations. Answering critical research questions in sustainability requires bridging the traditional university disciplines. Research in this cluster seeks to (i) investigate human impacts upon the physical environment and develop sensitive indicators of environmental change (ii) create technological innovations and shape policies to reduce environmental deterioration and its impacts on humans and (iii) integrate knowledge in order to better understand, and address, environmental issues.

Seven UBC faculties (Agricultural Science, Applied Science, Arts, Forestry, Graduate Studies, Law and Science) participate in this cluster. This diverse research cluster has benefited from a number of CFI-funded infrastructure facilities including the Aquatic Ecosystems Research Laboratory, the Earthquake Engineering Research Facility, the Clean Energy Research Centre, the Centre for Higher Order Structure Elucidation, and the Geophysical Disaster Computational Fluid Dynamics Centre. In 2011, UBC unveiled the new \$36 million Center for Integrated Research in Sustainability and the \$41 million Beaty Biodiversity Centre, which includes the Biodiversity Research Centre and the Beaty Biodiversity Museum.

A new research initiative in water and sustainability seeks to pair UBC's globally renowned water scientists with policy experts to establish sound water governance and policies that manage and steward the planet's most important natural resource. Building on UBC's demonstrated excellence in fuel cell technologies, another new research initiative seeks to improve the commercial viability of fuel cell technology. ■

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