



NEUROSCIENCE INDUSTRY BRIEFING

A REVIEW OF ONTARIO'S R&D EXCELLENCE WITH A FOCUS ON AGING

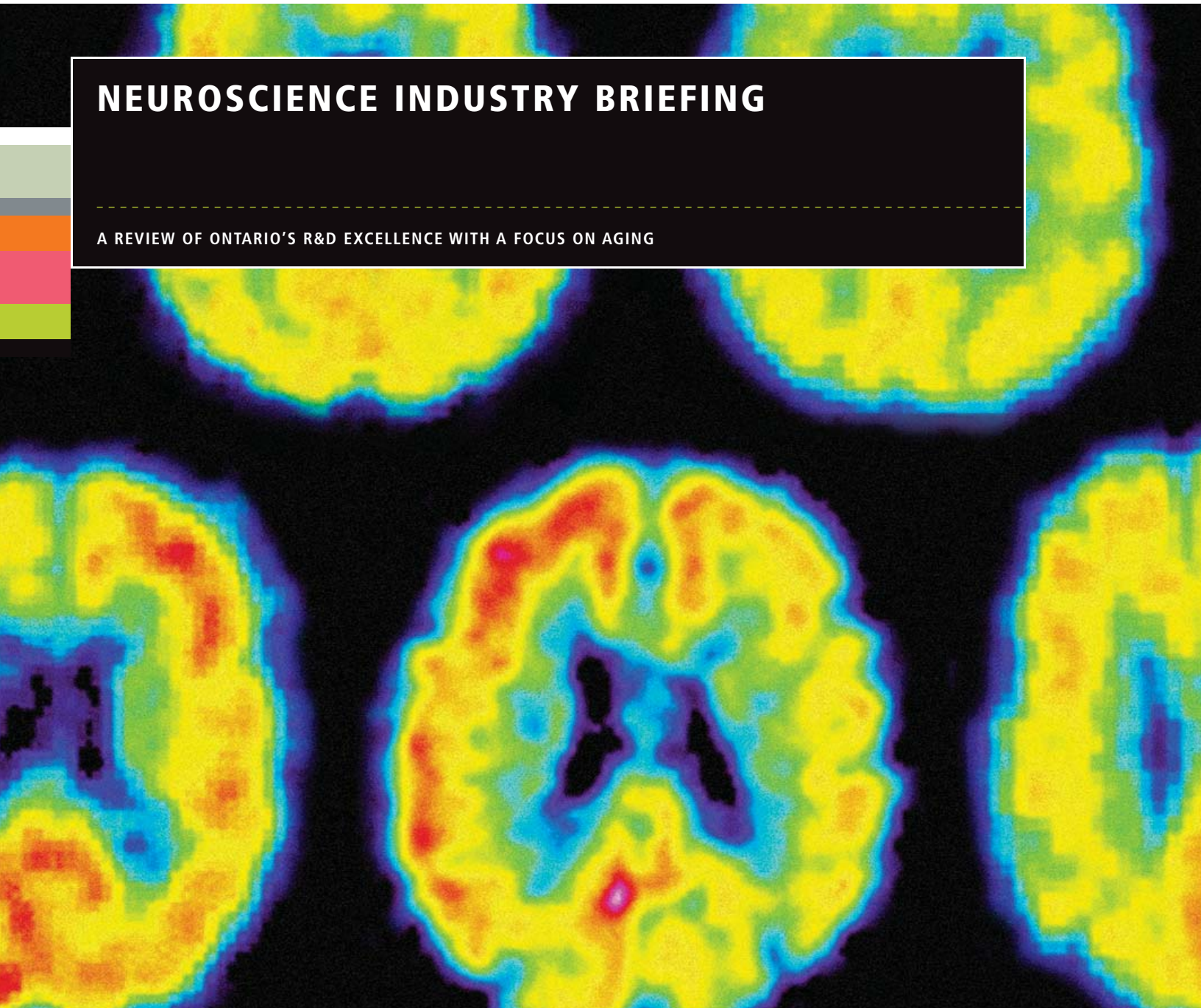
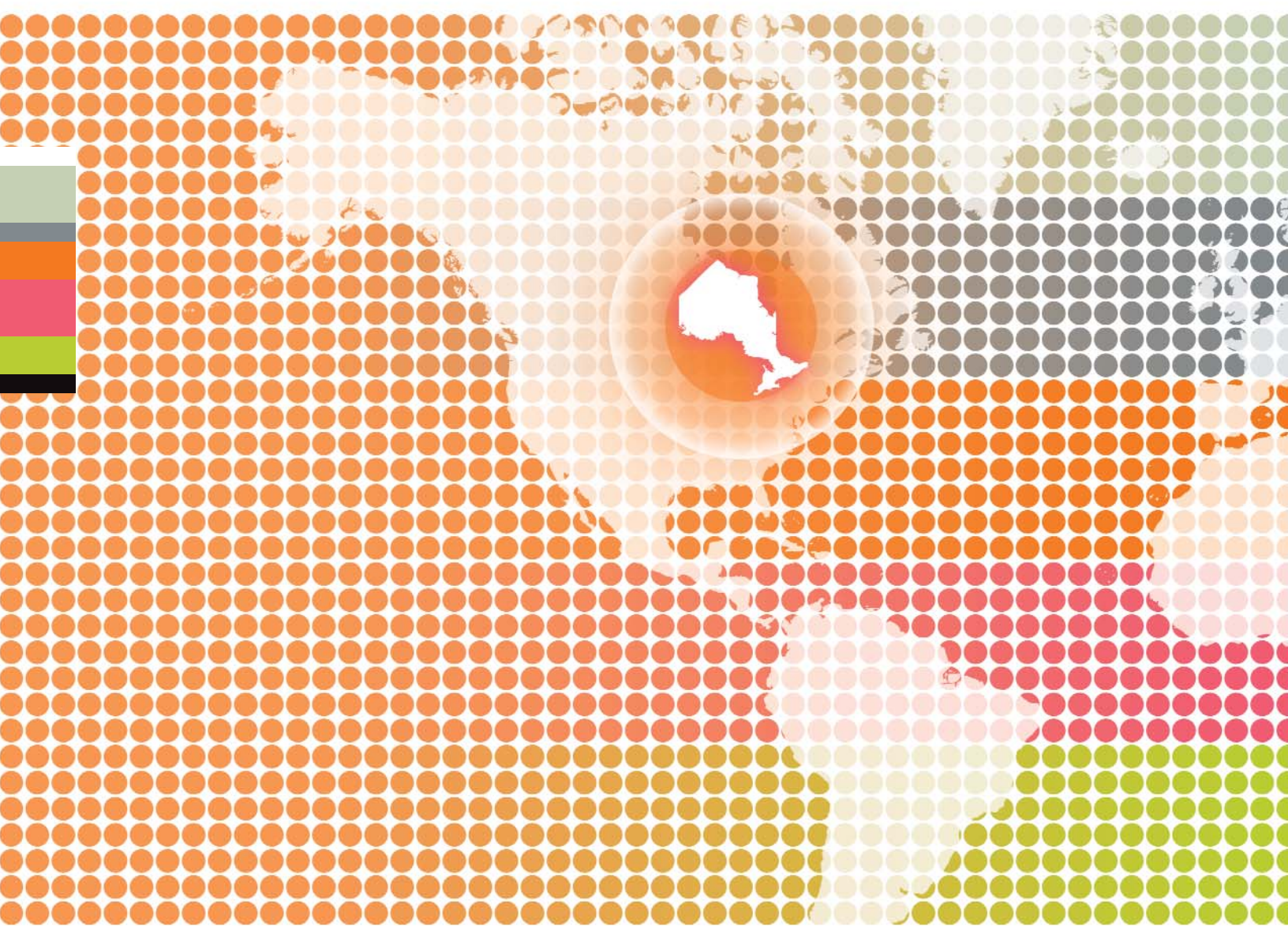


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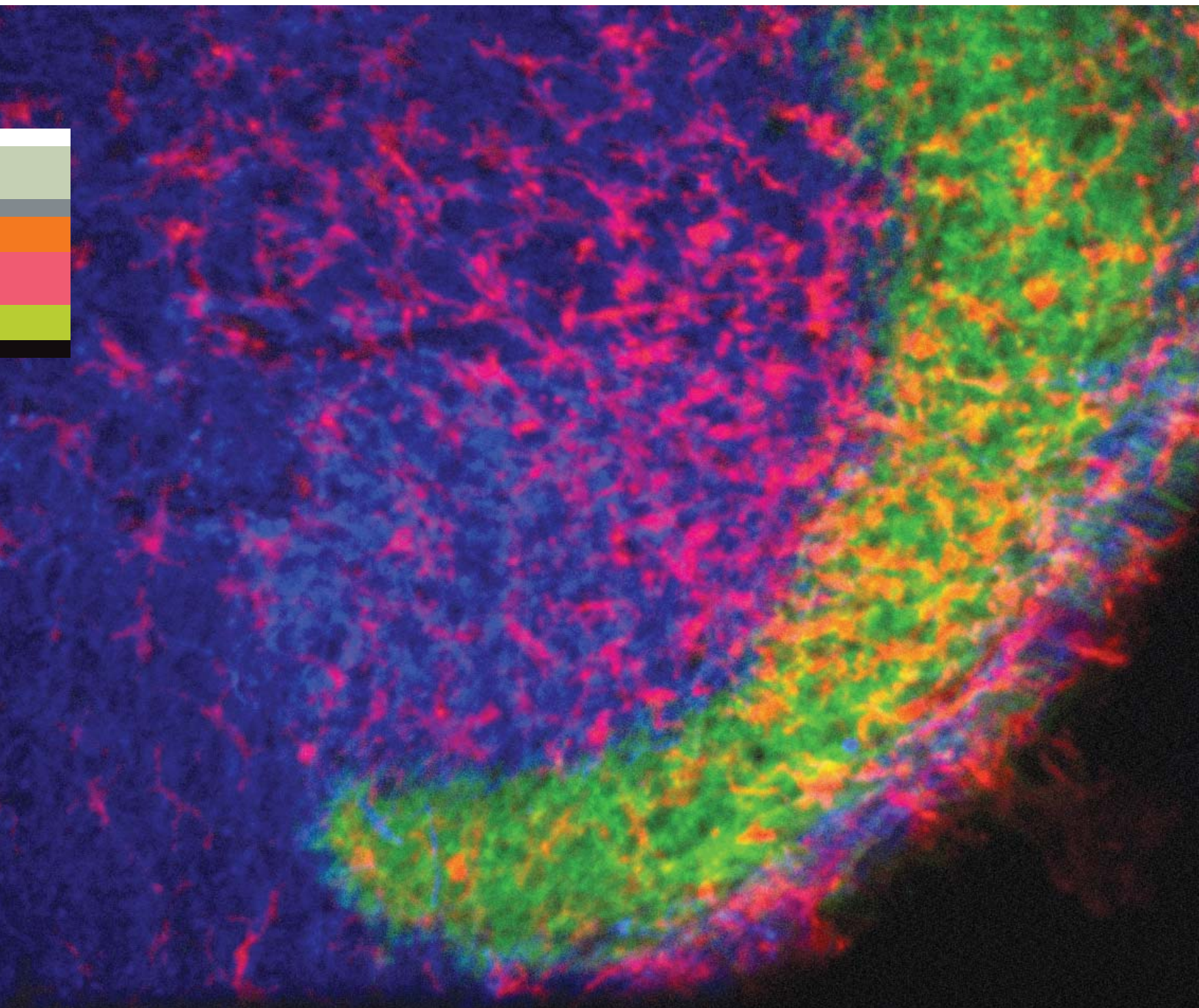


Cover image: The image depicts beta-amyloid binding measured in vivo with PET using $[^{11}\text{C}]\text{SB-13}$, which was higher in mild Alzheimer's disease patients. This radioligand was developed at the Centre for Addiction and Mental Health (CAMH) in collaboration with Baycrest and the University of Toronto. (Image courtesy of Dr. Nicolaas Paul L.G. Verhoeff at the Kunin-Lunenfeld Applied Research Unit, Baycrest)


“Ontario’s vibrant and highly collaborative research community is allowing us to make unprecedented strides forward in understanding the human brain, and this new knowledge has the potential to improve the quality of life for millions.”

– Dr. Michael W. Salter, Head & Senior Scientist, Neurosciences & Mental Health, The Hospital for Sick Children, Toronto





INTRODUCTION



Most industrialized countries of the world are facing aging populations, as the baby boomer generation, born between 1946 and 1964, starts to turn 65 in 2011. In 2005 the percentage of the population aged 65 and older was 12.3% in the U.S., 13.1% in Canada, 16% in the U.K. and 19.7% in Japan. By 2030 the number of people aged 65 and older is projected to be 20% of the total population in the U.S., twice as large as in 2000, growing from 35 million to 71.5 million.

Today, about 13% of Canadians are aged 65 and older. In 2015, for the first time in its history, Canada will have more people aged 65 and older than those under age 15. By 2031 there will be nine million seniors in Canada, accounting for 25% of the total population. This dramatic demographic shift will be a major force driving the neurotechnology industry, with the resulting increase in age-related neurological diseases.

In recent years, the majority of Canadian neuroscience publications have come from Ontario, and much of the nationwide neuroscience research funding has been awarded to Ontario researchers and institutions. With more than 500 senior neuroscientists in Ontario alone, several significant discoveries in the last 20 years have positioned Canada among leading global players in the field.

According to the Neurotechnology Industry Organization (NIO), the non-profit group in San Francisco formed to provide a unified voice for the commercial neuroscience community, more than 500 international companies are involved in the field of neurotechnology. These companies research, develop, manufacture and market pharmaceuticals, biologics, cell-based therapeutics and medical devices, as well as diagnostic and surgical equipment for the treatment of brain and nervous system illnesses.

This briefing discusses Ontario's capabilities in neurotechnology with a focus on applications which are directly influenced by the growing aging population: chronic pain, Alzheimer's disease, stroke, Parkinson's disease and preventative medicine for cognitive health/dementia.

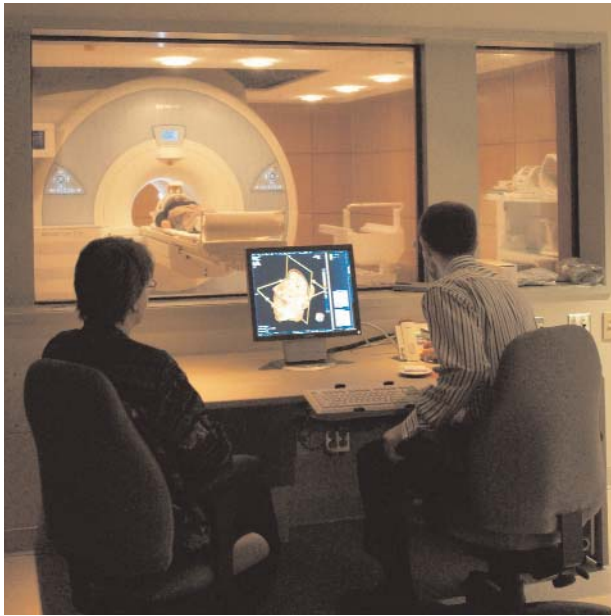


Image courtesy of John Loper/Mount Sinai Hospital

DISCOVERY



DEFINING NEUROTECHNOLOGY



Cognitive scientist Cheryl Grady and MRI physicist Simon Graham collaborate on a brain function study in the fMRI lab at Baycrest. (Image courtesy of Baycrest)

Neuropsychiatric disorders comprise the most significant contributor to disability in the developed world. According to the World Health Organization (WHO), neuropsychiatric disorders account for about one quarter of the total disabled years for populations in economically developed countries. In the neurotechnology market, age-related disorders are the primary drivers of growth, although mental health, attention-deficit hyperactivity disorder (ADHD) and insomnia are among its largest neuropsychiatric indications.

Within the next two decades, five of the ten countries with the largest elderly (age 60-plus) populations will be in the developing world. In China alone, by 2030 one quarter of the population – 400 million people – will be age 65 years or older.

Closer to home, in Ontario the number of seniors is expected to double over the next 20 years. In the development and commercialization of innovative products aimed to improve the brain health of aging adults, Ontario has turned to Baycrest, an academic health sciences centre in Toronto that is internationally renowned for excellence in aging-brain research, clinical interventions and treatments, and cognitive rehabilitation strategies. In January 2009 an international panel led by Dr. Robert Knight, director of the Helen Wills Neuroscience Institute at the University of California, Berkeley, ranked Baycrest among the world's best in the field of aging-brain studies.

But despite attractive growth prospects, successful treatment strategies for neurodegenerative diseases have so far been limited.

Many central nervous system (CNS) disorders are still not well defined, and their underlying etiologies remain poorly understood. In certain areas, however, such as neurodegenerative diseases, a clear genetic component has been established and significant strides have been made in discovering and identifying novel biomarkers to identify and track disease progression and treatment more effectively.

The Centre for Research in Neurodegenerative Diseases (CRND) at the University of Toronto, for example, is at the forefront of research for neurodegenerative diseases, including Alzheimer's, Parkinson's, frontotemporal dementia, amyotrophic lateral sclerosis (ALS) and prion diseases. Under the leadership of neurologist and molecular geneticist Dr. Peter St George-Hyslop, CRND has made important breakthroughs in research that have substantially advanced the understanding of neurodegenerative diseases and have been a catalyst in attempts to generate new treatments and diagnostics.

Many common CNS disorders targeted for drug treatment are chronic processes manifested by highly subjective and context-dependent symptoms. Thus, samples selected for treatment trials using clinical criteria are inevitably heterogeneous, and dependence on traditional endpoint results in early proof-of-concept trials being long and large in scope, with very poor signal-to-noise ratios. As a result, the average length of time to develop a CNS drug is 12–16 years versus 10–12 years for non-CNS drugs. It is no wonder that pharmaceutical companies are looking to biomarkers as an integral part of the decision-making process in rationalizing CNS drug development.

Much of the current CNS biomarker research is aimed at the discovery and identification of biomarker signatures through the application of gene expression profiling, protein profiling and/or metabolomics, as well as the use of imaging and electrophysiological surrogate biomarkers. Studies of complex diseases would greatly benefit from a complementary approach of "omics" and imaging technologies.

Productive collaboration between industry, clinicians and academia is critical in realizing the potential of CNS biomarkers. A good example of Ontario's investment in facilitating such partnerships is the Centre for Functional and Metabolic Mapping (CFMM) at the Robarts Research Institute in London, Ontario. CFMM conducts in vivo studies of brain structure and function by utilizing state-of-the-art magnetic resonance imaging (MRI) systems such as the Varian 7T, which was installed at CFMM in 2008. The most powerful magnet of its kind in Canada, the Varian 7T was developed specifically to study human brain function.



The Centre for Addiction and Mental Health is home to Canada's only positron emission tomography (PET) facility fully dedicated to mental health and addictions research and is one of a few in the world. (Image courtesy of Rick Chard)

Ontario is also home to the Centre for Addiction and Mental Health (CAMH) and its renowned positron emission tomography (PET) Centre. CAMH scientists use PET methods to identify diagnostic markers for disease and to encourage innovative approaches to drug development by using the technology in the early stages of evaluating new drugs. Led by Dr. Alan Wilson, the CAMH radiochemistry team developed the first dopamine D2 agonist radiotracer used in humans, which is now used by most of the world's leading PET centres.

Dr. Jeffrey Meyer, head of the CAMH mood neurochemistry program, led the development of the advanced monoamine model of depression, which represents a big step forward in the disease frontier. It brings the study of mental illness closer to the advancements in research into physical illnesses such as cardiac disease, and provides one of the most comprehensive disease models in mental illness.

Still, reliable clinical biomarkers remain elusive. Such predictive markers could make a significant difference for patients in the following examples: progression of mild cognitive impairment (MCI) to Alzheimer's disease (AD); progression of clinically isolated syndrome (CIS) to multiple sclerosis (MS); and prediction of outbreak of psychosis. In order to better understand the disease and the treatments, it's imperative to gain feedback from the bedside to the basic research.

Changes in the metabolism, disposition and impact of medications in elderly individuals require geriatric-specific development strategies.

Recognizing this need, Ontario researchers have developed close cross-institutional collaborations in the field of cognitive neurosciences, in particular, memory research and the ability of the aging brain to compensate for these changes in aging. Studies are being carried out in patients with Alzheimer's disease, using neuroimaging as an aid to the design of cognitive rehabilitation procedures.

Global healthcare challenges necessitate a more complex collaborative environment involving multidisciplinary teams from academia and industry.

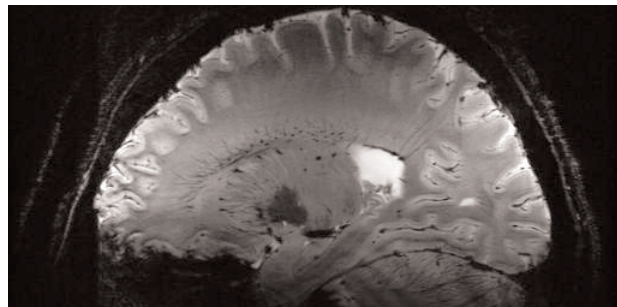
Such "large-scale science" is not new in Canada. Cross-disciplinary research programs have been a hallmark of Canadian science for decades. Recent initiatives such as the Canadian Action and Perception Network (CAPnet) and the Heart and Stroke Foundation Centre for Stroke Recovery (HSFCSR) reinforce Canada's international leadership and close-knit community in neuroscience and further illustrate the unique research ecosystem of this region.

The sophistication of today's R&D technologies makes pooling resources and leveraging public infrastructure investment an attractive solution for improving innovation productivity, reducing commercial costs and speeding time to market.



↑ Arriving on a crane is the 27.5-tonne Varian/Siemens 7 Tesla (7T) functional magnetic resonance imaging system – the most powerful clinical magnet of its kind in Canada – at the Centre for Functional and Metabolic Mapping, in the A.M. Cuddy Wing at Robarts Research Institute in London, Ontario.

↓ Captured using the 7T, the image below is of a brain that depicts many fine structures not visible on low magnetic fields.



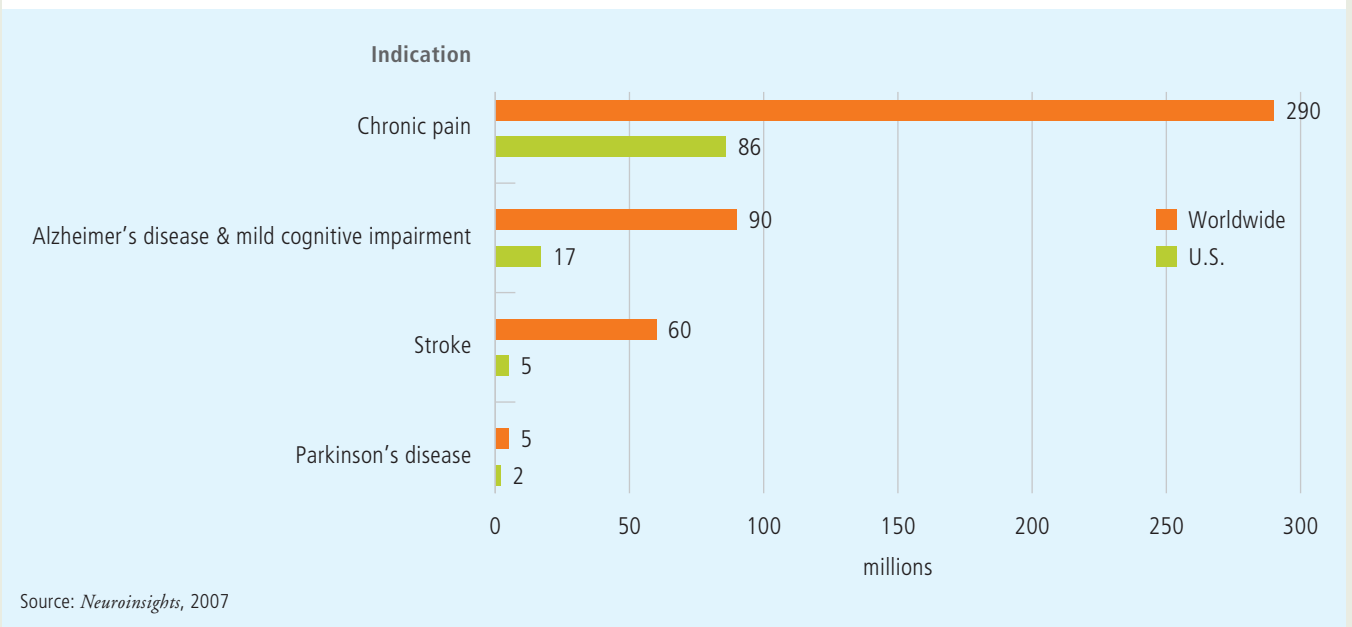
MARKET OPPORTUNITIES

Although mental health, ADHD, obesity and insomnia are among the most significant neurological/psychiatric indications, growth in the neurotechnology market in 2007 has increased primarily due to the increase in age-related disorders.

The following areas present major age-related opportunities within the neurotechnology market:

- chronic pain
- Alzheimer's disease
- stroke
- Parkinson's disease
- preventative medicine for cognitive health/dementia

Figure 1: NUMBER OF AFFLICTED INDIVIDUALS BY INDICATION



The lack of clear-cut efficacy for many neurotechnology treatments means new and better treatments face little competition in a market already large enough to accommodate several blockbusters. Cognitive therapeutics could also potentially be used in the broader healthy population for memory improvement, creating enormous opportunity for companies that can successfully navigate the R&D and commercialization path.



LEADERS IN NEUROSCIENCE

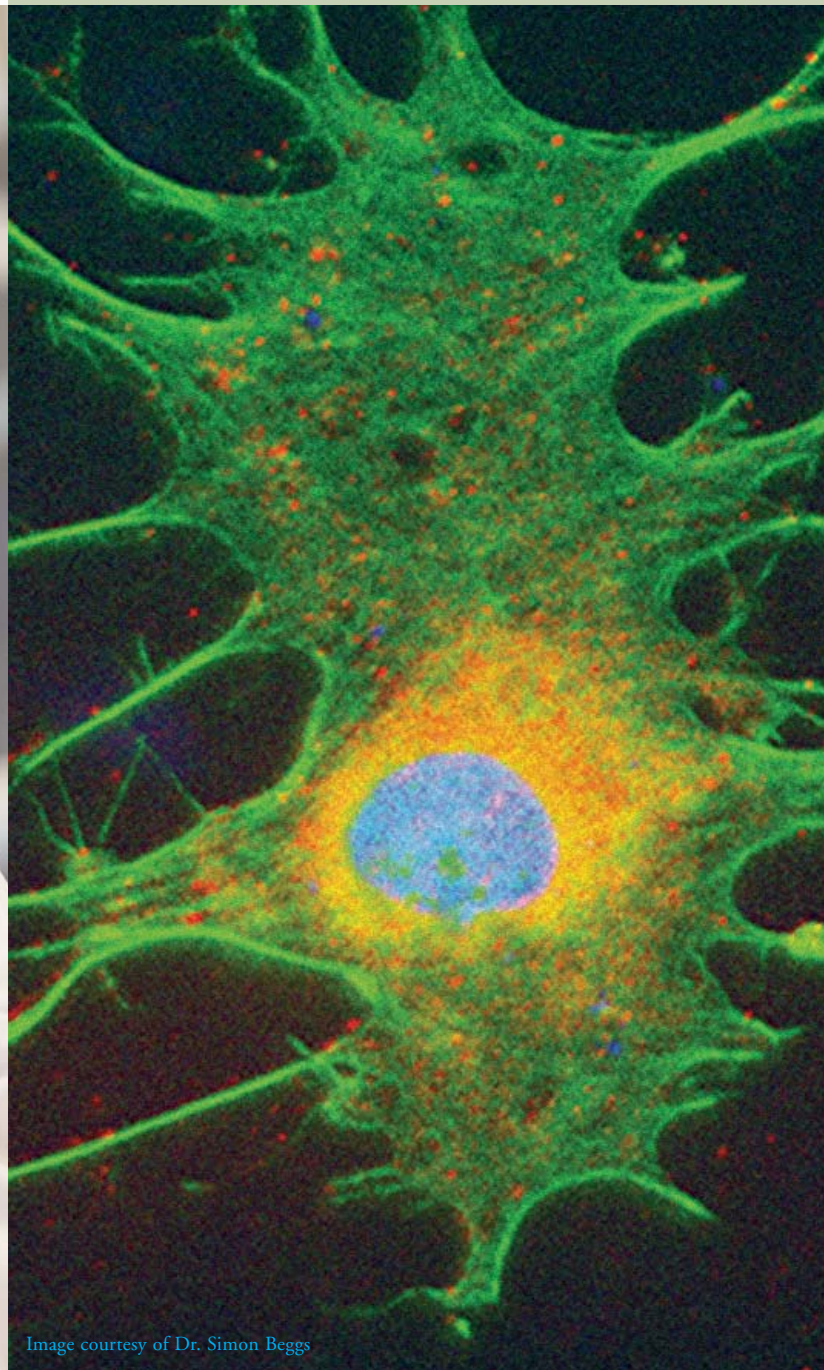


Image courtesy of Dr. Simon Beggs

Canadian Achievements in Neuroscience

1957 – FIRST MAP OF THE BRAIN

Dr. Wilder Penfield, a pioneering brain surgeon in Montreal, maps out the brain's functional areas.

1965 – UNIVERSAL PAIN THEORY

A joint report by McGill University's Dr. Ronald Melzack and Massachusetts Institute of Technology's Dr. Patrick D. Wall proposes the gate control theory of pain, which has been the basis of pain theory for the past 40 years.

1970 – CANADIAN ASPIRIN TRIAL

Dr. Henry Barnett at the University of Western Ontario establishes for the first time that any antiplatelet drug could prevent stroke and other diseases due to thrombosis.

1974 – TREATMENT FOR PARKINSON'S DISEASE DISCOVERED

Dr. Donald Calne at the University of British Columbia introduces the use of synthetic dopamine to treat patients with Parkinson's.

1990 – DOPAMINE D2 RECEPTOR DISCOVERED

The University of Toronto's Dr. Philip Seeman clones three dopamine receptors, which are currently being tested to determine their role in abnormalities seen in patients with psychotic disorders.

1992 – BRAIN STEM CELLS IDENTIFIED

Dr. Samuel Weiss at the University of Calgary identifies natural stem cells in the brains of adult mammals, proving for the first time that stem cells exist in all stages of development.

2000 – ALZHEIMER'S GENE DISCOVERED

Dr. Peter St George-Hyslop, director of the University of Toronto's Centre for Research in Neurodegenerative Diseases, identifies the key protein involved in the degeneration of nerve cells in Alzheimer's patients.

2003 – PAIN GENE DISCOVERED

Dr. Michael Salter at The Hospital for Sick Children in Toronto identifies a gene that causes neuropathic pain, a sharp and chronic pain associated with nerve injury and diseases affecting the nervous system.

2004 – BRAIN CANCER STEM CELLS ISOLATED IN HUMANS

Dr. Peter Dirks at The Hospital for Sick Children confirms that childhood and adult brain tumours originate from cancer stem cells.

2005 – DISCOVERY OF PROTEIN RESPONSIBLE FOR DEATH OF CELLS IN NERVOUS SYSTEM

Dr. David Kaplan at The Hospital for Sick Children discovers a major death-promoting protein that affects nerve cells during fetal and post-natal development.

2006 – POSSIBLE TREATMENT FOR HUNTINGTON DISEASE

A team of researchers at the University of British Columbia's Centre for Molecular Medicine and Therapeutics provides groundbreaking evidence of a possible treatment in a mouse model.

2007 – DISCOVERY OF ALZHEIMER'S DISEASE GENE

A team of researchers at the University of Toronto, led by Dr. Peter St George-Hyslop, isolates another gene responsible for Alzheimer's disease.

CANADA'S GLOBAL COMPETITIVENESS IN NEUROSCIENCE

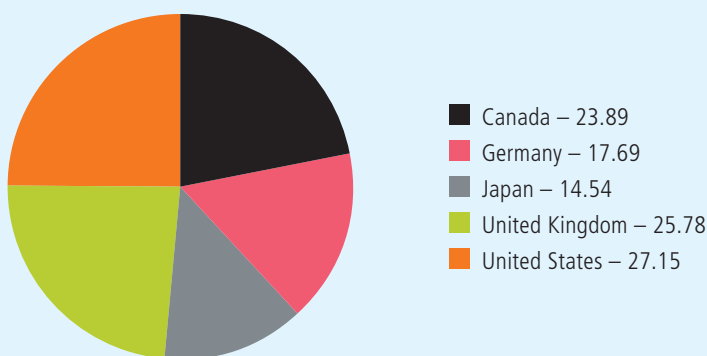
Canada ranks fifth out of 20 most-cited countries in the field of neuroscience and behaviour.

Rank	Country	Papers	Citations
1	United States	115,940	2,518,999
2	England	22,609	476,316
3	Germany	25,934	446,065
4	Japan	24,963	308,852
5	Canada	17,299	308,657

Source: *Essential Science Indicators*, January 1997–April 2007.

In a separate analysis of seven neuroscience categories (behavioural sciences, clinical neurology, neuroimaging, neurosciences, biological psychology, psychiatry and substance abuse), Canadian neuroscientists rank third in terms of citation impact.

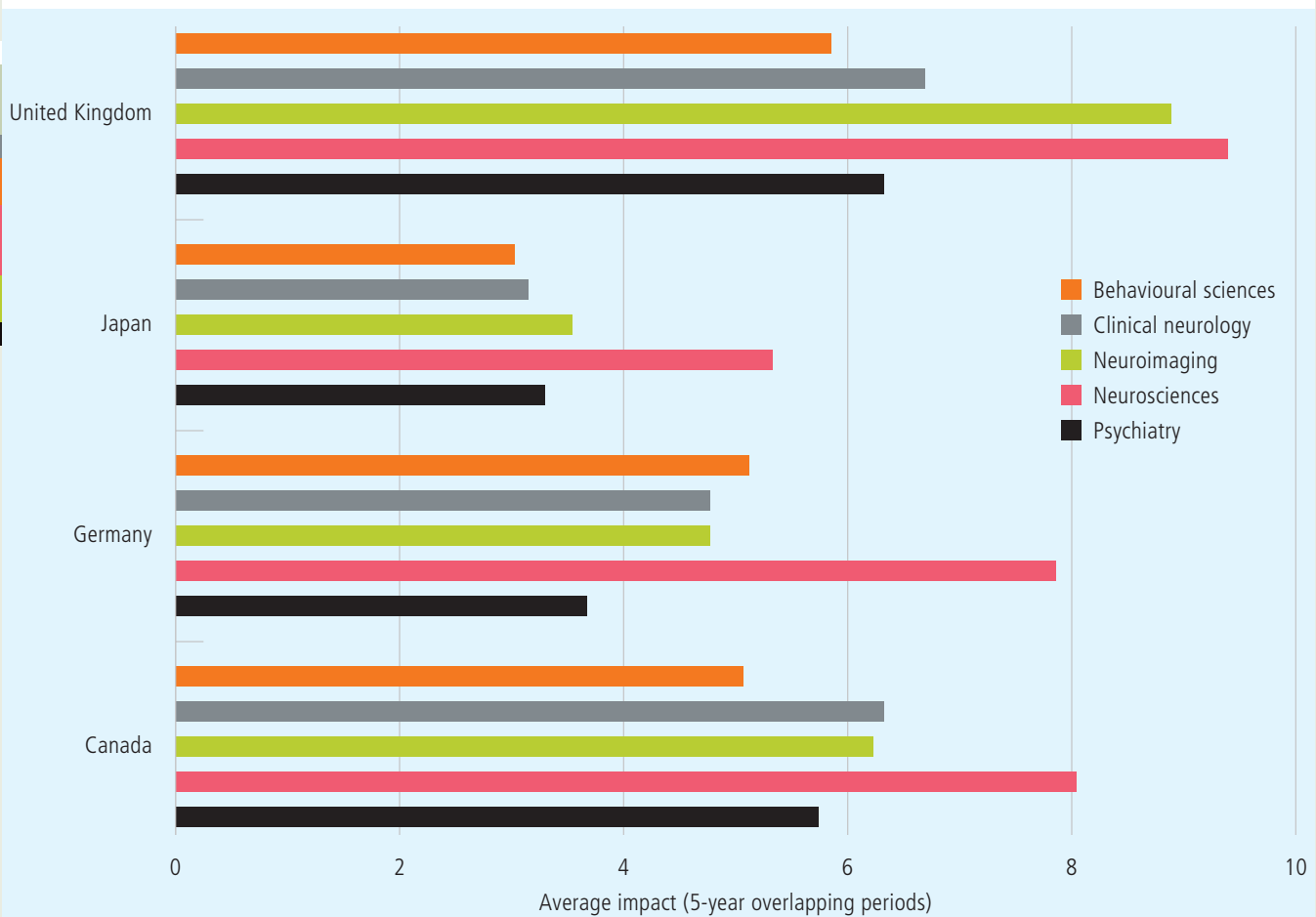
Figure 2: CITATION IMPACT (1981–2007)



Source: Thomson Reuters, 2008. Citation impact is the number of citations received per paper indexed in Thomson's Web of Science database.

In an analysis of selected neuroscience categories, the impact of Canada's scientists is on par with those in the U.K., Japan and Germany.

Figure 3: AVERAGE CITATION IMPACT BY COUNTRY (1997–2007)



Source: Thomson Reuters, 2008. Citation impact is the number of citations received per paper indexed in Thomson's Web of Science database. Average impact from 1997 to 2007 was calculated from five-year overlapping periods (1997–2002, 1998–2003, ... 2003–2007).

ONTARIO'S GLOBAL COMPETITIVENESS IN NEUROSCIENCE

Commercial and Research Strengths

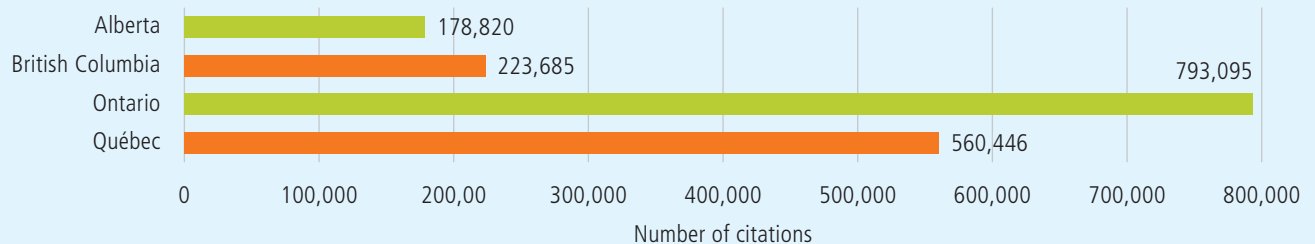
Translating neuroscience into neurotechnology products is an attractive global investment opportunity and Ontario is well positioned to deliver.

Ontario's concentration of well-funded scientists produces world-class research, spinning off companies that develop innovative therapeutic treatments for neurological disorders. In Canada, approximately 70% of start-up companies are created from science developed at universities. Ontario is Canada's largest biotechnology cluster and the third-largest in North America, behind only California and Massachusetts. According to the Toronto Financial Services Alliance, Toronto is the third-largest financial services hub in North America (measured by employment), after New York and Chicago. AstraZeneca, Bayer, Eli Lilly, GlaxoSmithKline, Takeda, Purdue, Pfizer and sanofi pasteur have an Ontario presence, and multinationals MDS, Apotex and TLC Vision had their start in Ontario. (See page 32, for a summary of Ontario neuroscience companies.)

Ontario's concentration of top research institutes, hospitals and universities position the province as a major Canadian centre for neuroscience research. Six medical schools and 13 universities provide a steady output of science graduates contributing to its strong scientific base. Ontario is home to more than 500 neuroscientists and has the most Canada research chairs in neuroscience out of all the Canadian provinces. Hospitals in Ontario were successful at winning Canada Foundation for Innovation (CFI) awards from the Large-Scale Institutional Endeavours component of CFI's Research Hospital Fund. Out of the eight institutions across Canada awarded funding totaling \$554 million, six were based in Ontario. These infrastructure investments will modernize existing facilities and build on the province's medical research strengths.

In an analysis of seven neuroscience categories (behavioural sciences, clinical neurology, neuroimaging, neurosciences, biological psychology, psychiatry and substance abuse), Ontario is first in number of citations.

Figure 4: NUMBER OF CITATIONS BY PROVINCE (1981-2007)



Source: Thomson Reuters, 2008.

In a comparison of major neuroscience centres in North America, the Toronto region is competitive with centres in California and Massachusetts.

Figure 5: AVERAGE CITATION IMPACT IN MAJOR NORTH AMERICAN NEUROSCIENCE HUBS (1997–2007)



Source: Thomson Reuters, 2008. Citation impact is the number of citations received per paper indexed. Average impact from 1997 to 2007 was calculated from five-year overlapping periods (1997–2002, 1998–2003, ... 2003–2007).

UNIQUE OPPORTUNITIES

1. CHRONIC PAIN

The University of Toronto Centre for the Study of Pain – a world leader in the molecular, genomic and human (basic and clinical) aspects of pain research – is developing a new model of pain, which is increasingly accepted by the research community. New therapies in development have already led to the creation of six start-up companies in Ontario. NoNO, a spinoff from the University of Toronto, has discovered a new pain platform based on glial cells (supporting cells surrounding nerves). NeurAxon, whose research operations are based at the MaRS Centre, is developing novel pain therapeutics targeting neuronal nitric oxide synthase (nNOS), and NXN-188, its lead candidate for acute migraines, is currently in phase II clinical trials. With a more efficient commercialization infrastructure and a stronger drug development pipeline in Ontario, world-class technologies can be brought to the market.

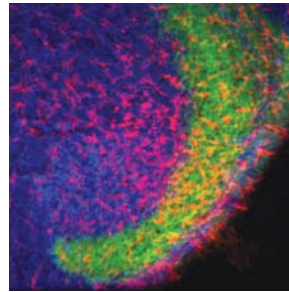
2. ALZHEIMER'S DISEASE

Several companies in Ontario are developing therapies for Alzheimer's disease – Amorfix Life Sciences, Cita Neuropharmaceuticals, GeneNews, Vasogen and Transition Therapeutics, whose lead Alzheimer's product, ELND005 (AZD-103), is currently in phase II trials.

3. STROKE

The Canadian Stroke Network (CSN), established in 1999 with \$4.7 million in federal funding, is comprised of 62 institutions in the academic research field, industry and government. These include Astrazeneca, Boehringer Ingelheim, Eli Lilly, Pfizer and Merck Frosst. Research is focused on four themes: preventing stroke, optimizing acute stroke care, minimizing stroke damage, and post-stroke repair and recovery. The Heart and Stroke Foundation of Canada, a CSN partner, invested nearly \$59 million in research in 2007, providing funding to more than 900 Canadian researchers and is increasing its investment in cardio- and cerebrovascular disease research. In its fiscal year ending August 2008, it invested \$52.3 million in research in Ontario.

Established in 2002, the Heart and Stroke Foundation Centre for Stroke Recovery (HSFCSR) combines expertise from four Centres



This image depicts the dorsal horn of the spinal cord, an area that receives input from nerves carrying sensory information from the periphery. The terminals of two populations of these nerves are shown in blue and green. If the peripheral nerve is damaged, microglial cells in the spinal cord (shown in red) respond by proliferating around the central terminals of those fibres that have been damaged. Factors released by these proliferating microglia contribute to the generation and maintenance of neuropathic pain states. (Image courtesy of Dr. Simon Beggs with the Program in Neurosciences & Mental Health at The Hospital for Sick Children)

of Excellence: Ottawa Health Research Institute (OHRI), University of Ottawa, Sunnybrook Health Sciences Centre and Baycrest's Rotman Research Institute. The HSFCRS successfully raised more than \$23 million in funds. Scientists at OHRI are investigating molecular and cellular mechanisms involved in brain repair and the effects of manipulating these mechanisms for therapeutic intervention. Clinical researchers at Sunnybrook are designing specialized sensorimotor physical therapies, evaluating pharmaceuticals and studying the influence of small-vessel/white-matter disease. Research at Baycrest is focused on the development and validation of cognitive behavioural and psychosocial therapies, as well as advanced brain-imaging techniques and technologies to assist in developing rehabilitation strategies.

4. PARKINSON'S DISEASE

The University Health Network (UHN) Toronto Western Hospital (TWH) has research units dedicated to determining the mechanisms and treatment of Parkinson's disease. With its world-class research in deep brain stimulation, transcranial magnetic stimulation for Parkinson's and the recent development of the epilepsy chip, TWH is well positioned to take advantage of this emerging market.

The Parkinson Research Consortium (PRC) in Ottawa was established in 2004 to bring together scientists with the common goal of understanding how and why Parkinson's patients' brain cells die and then applying this knowledge to treat the disease. PRC scientists are from the OHRI, National Research Council and the University of Ottawa, with expertise in genetics, molecular biology, neuroscience and patient care. PRC has a mandate to be an incubator for innovative ideas in Parkinson's disease research and to generate novel findings leading to a cure.

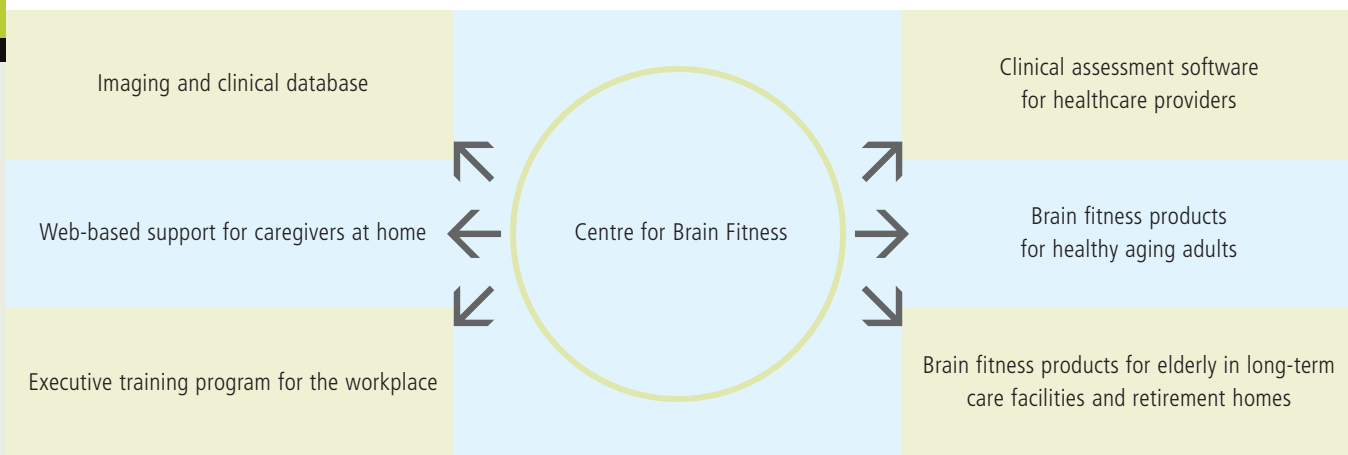
5. PREVENTATIVE MEDICINE FOR COGNITIVE HEALTH/DEMENTIA

Baycrest

Internationally renowned for its care, research and educational programs on aging, Baycrest currently serves more than 2,500 patients daily and provides seniors with supportive residential care and community services, short-term specialized medical care and long-term and complex continuing care. Baycrest, which is an

affiliate of the University of Toronto, has two research units: one focused on interdisciplinary basic cognitive research, the other on clinical application of innovative therapies. It offers an integrative multidisciplinary, multimodal and multilevel research program to study and facilitate repair mechanisms for successful aging and to assist the response of central and peripheral nervous systems to injury. In March 2008, Baycrest received \$10 million from the Government of Ontario to create the Centre for Brain Fitness, which is currently developing and commercializing products aimed to improve the brain health of the aging population of Ontario.

PRODUCTS IN THE DEVELOPMENT PIPELINE FROM BAYCREST'S CENTRE FOR BRAIN FITNESS



A. Ontario Research Institutions

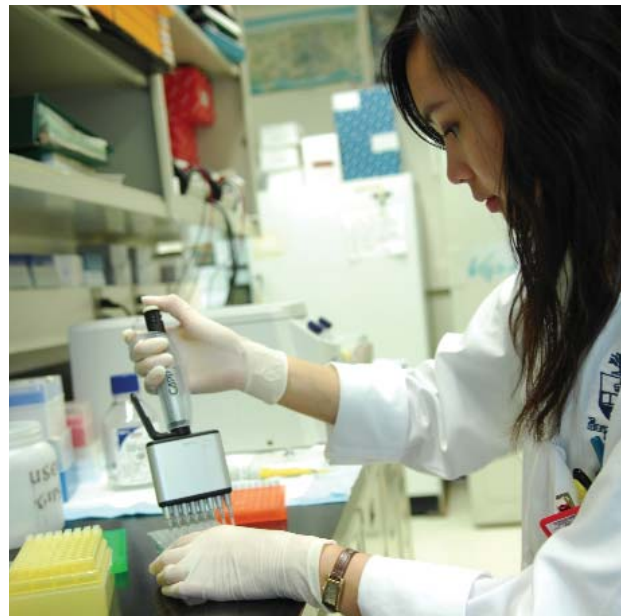
THE CENTRE FOR RESEARCH IN NEURODEGENERATIVE DISEASES (CRND)

CRND at the University of Toronto's Faculty of Medicine is a research powerhouse that brings together scientific expertise in genetics, molecular and cell biology, protein chemistry, transgenic animal modeling, neuropathology, neurobiology, neuropharmacology and neuroimmunology.

Under the directorship of neurologist and molecular geneticist Dr. Peter St George-Hyslop, CRND is a world leader in the field of basic research studies in neurodegenerative diseases. Its mandate is to discover, apply and disseminate knowledge that will lead to the prevention of neurodegenerative diseases, diagnosis and cure of individuals afflicted with these disorders, as well as easing the burden for their caregivers and families. These neurodegenerative diseases include Alzheimer's disease (AD), Parkinson's disease (PD), frontotemporal dementia (FTD) and related tauopathies, amyotrophic lateral sclerosis (ALS) or motor neuron disease (MND), ataxia-telangiectasia (AT) and prion diseases such as Creutzfeldt-Jakob disease (CJD), spongiform bovine encephalopathy (mad-cow disease) and scrapie.

Groundbreaking Alzheimer research

Research into the biology of Alzheimer's disease first began at the CRND in the late 1980s. From those beginnings, CRND has been able to make world-leading contributions to the understanding and possible treatment of AD. Since 1989, CRND researchers have made a series of fundamental discoveries that have shaped current understanding of the disease. They have also developed several of the first generation of new treatments, including vaccines and drugs that may help to prevent and treat the disabling memory loss and impairment associated with AD. As a major international research centre, CRND continues to be productive, publishing numerous papers and achieving significant citations for its work even though its base budget is smaller than those of similar centres elsewhere.



Danielle Moreno, a laboratory technician at the Centre for Research in Neurodegenerative Diseases at the University of Toronto, prepares a PCR experiment for analysis of DNA taken from a human patient with Parkinson's disease. (Photo by R. Lautens)

Major research projects

- identifying new genes, in which mutations confer susceptibility to AD, PD, FTD, ALS, CHD and other neurodegenerative diseases;
- understanding age-related factors that contribute to the development of neurodegenerative disorders;
- determining how genetic and non-genetic factors alter normal biological processes and cause neurodegeneration;
- developing novel diagnostic and therapeutic agents to combat these biological processes; and
- generating and characterizing models of neurodegenerative diseases as research platforms that will help understand these diseases and can also be used for pre-clinical validation of new diagnostics and therapies.

Institution	Centres and institutes	Research strengths
Baycrest	Kunen-Lunenfeld Applied Research Unit; Rotman Research Institute; Centre for Brain Fitness; Centre for Stroke Recovery	Alzheimer's disease, Parkinson's disease, clinical trials, imaging, stroke
Bloorview Kids Rehab	Bloorview Research Institute; Brain Injury Rehab Program	Advanced mind/brain machine, interfaces for voiceless communications
Centre for Addiction and Mental Health	PET (positron emission tomography) Centre; University of Toronto Functional Imaging Research Network	Addictions, mood disorders, schizophrenia, imaging
McMaster University	Michael G. DeGroote Institute for Pain Research and Care; McMaster Institute for Neuroscience Discovery and Study; The Brain-Body Institute; Henderson Research Centre	Stroke, pain
Mount Sinai Hospital	Samuel Lunenfeld Research Institute; Wasser Pain Management Centre; Centre for Neurodevelopment and Cognitive Function; Advanced Bioimaging Centre	Transgenic-mouse and embryonic stem cell technologies
The Hospital for Sick Children Research Institute	Brain Tumour Research Centre; Functional Neuroimaging Centre	Imaging, stem cells
Sunnybrook Research Institute	Centre for Stroke Recovery Regional Stroke Program; Dorothy Macham Home	Imaging, stroke, dementia, mood disorders
Toronto Rehabilitation Institute	Ontario Rehabilitation Technology Consortium	Brain injury, stroke, spinal cord rehabilitation
Toronto Western Hospital – University Health Network	Toronto Western Research Institute; Krembil Neuroscience Centre; Comprehensive Pain Program	Parkinson's disease, Alzheimer's disease, neuro-oncology, epilepsy, ophthalmic and visual science, deep brain stimulation, stroke
University of Ottawa	Ottawa Health Research Institute; Ottawa Hospital; Parkinson Research Consortium; Centre for Stroke Recovery	Vision science, stroke, Parkinson's disease
University of Toronto	University of Toronto Centre for the Study of Pain; Centre for Research in Neurodegenerative Diseases	Pain, Alzheimer's disease, Parkinson's disease, stroke
University of Western Ontario	Robarts Research Institute; Lawson Health Research Institute Centre for Brain and Mind; Centre for Functional and Metabolic Mapping; Stroke Prevention and Atherosclerosis Research Centre; University of Western Ontario Interdisciplinary Pain Program; Ontario Neuroimaging Consortium	Clinical trials, advanced medical imaging

B. Notable Ontario Neuroscientists



Dr. Sandra Black

DR. SANDRA BLACK, MD, FRCP(C)

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Sunnybrook Research Institute
Brill Chair in Neurology, Department of Medicine,
University of Toronto and Sunnybrook Health Sciences Centre
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Dr. Black completed her medical degree and neurological training at the University of Toronto and her internship in medicine at St. Michael's Hospital. She has also completed residencies in medicine and neurology at Sunnybrook & Women's College Health Sciences Centre, as well as a residency in clinical neurophysiology at Toronto Western Hospital. Besides completing postdoctoral research at the University of Western Ontario in behavioural neurology and stroke, she had previously pursued graduate work in the history and philosophy of science at Oxford University.

Dr. Black has published more than 200 papers and has been actively engaged in treatment trials for stroke, Alzheimer's disease and vascular dementia. Her research has been published in numerous peer-reviewed journals, such as the *Journal of Neurological Sciences*, *Stroke*, *Cognitive and Behavioural Neurology*, *Archives of Neurology* and *International Journal of Geriatric Psychiatry*. In 2001 she received the Mel Silverman Award for Outstanding Mentorship from the University of Toronto's Institute of Medical Science.

She is a member of several professional organizations, including the American Academy of Neurology, American Stroke Association, American Neurological Association, International Neuropsychological Society and the International Society for Vascular Behavioural and Cognitive Disorders.

Dr. Black's research has focused on the cognitive sequelae of stroke and stroke recovery, the differential diagnosis of dementia, and the use of neuroimaging techniques to elucidate brain-behaviour relationships in stroke and dementia. She is currently conducting a prospective study on the utility of quantitative structural and functional imaging in diagnosis and monitoring of mild cognitive impairment, Alzheimer's disease, as well as vascular and other dementias. She also conducts collaborative research on sensorimotor recovery after stroke using functional magnetic resonance imaging (fMRI) and on praxis and attention in stroke and dementia. As well, she is currently completing a clinical trial of the efficacy of amphetamines in facilitating sensorimotor stroke recovery using fMRI to monitor brain reorganization.

DR. PETER ST GEORGE-HYSLOP, MD, FRCP(C)

*Professor, Department of Medicine, Division of Neurology;
Director, Centre for Research in Neurodegenerative Diseases
University of Toronto*

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416-978-7460

Dr. St George-Hyslop received his MD from the University of Ottawa's faculty of medicine and an FRCP(C) in internal medicine and neurology from the Royal College of Physicians of Canada, and conducted his postdoctoral research at the University of Toronto and at Harvard Medical School. He was appointed as an instructor in neurology and genetics at Harvard University and was assistant physician in the department of neurology and the department of genetics at Massachusetts General Hospital before assuming his current position at the University of Toronto, where, since 2003, he has held the rank of university professor. Among the numerous honours he has garnered are the Francis A. McNaughton Prize from the Canadian Neurological Society and the Award for Medical

Research from the Metropolitan Life Foundation. He was selected as a Medical Research Council of Canada (Canadian Institutes of Health Research) Scholar in 1991 and as Distinguished Scientist in 2000. He received the Gold Medal in Medicine from the Royal College of Physicians of Canada in 1994 and the Michael Smith Award from the Canadian Institutes of Health Research in 1997. In 1995 he became a member of the American Society for Clinical Investigation and is a Fellow of the Royal Society in the U.K. and the Royal Society of Canada. In 2004 he was awarded the Oon Prize in Medicine from the University of Cambridge; in 2007 he was elected as a Foreign Member of the Institute of Medicine of the National Academies of Sciences (NAC) in Washington, D.C.

Dr. St George-Hyslop's research focuses on the molecular mechanisms that cause neurodegeneration in Alzheimer's and, in particular, the mechanisms by which the presenilin protein complex generates a neurotoxic peptide that plays a central role in this disease. This knowledge has utility both in the design of potential therapeutics and in understanding the mechanism of neurodegeneration in other neurodegenerative diseases.



Dr. Andres Lozano

**DR. ANDRES LOZANO, MD, PhD,
FRCSC, FACS**

*Senior Scientist, Division of Brain Imaging & Behaviour-Systems
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A graduate of the University of Ottawa's Faculty of Medicine in 1983, Dr. Lozano underwent neurosurgical training at McGill University. During his residency in Montreal, Dr. Lozano earned his PhD in experimental medicine in 1989. In 1990 he became a Fellow of the Royal College of Physicians and Surgeons of Canada and joined the neurosurgical staff at the Toronto Western Hospital the following year. He is currently a professor in the department of surgery and holds the Ron Tasker inaugural chair in stereotactic and functional neurosurgery at the University Health Network. He also holds a tier I Canada research chair in neuroscience. His main research and clinical interests are in the field of the neurosurgical treatment of movement disorders and micro-electrode recordings of the human brain.



Dr. Michael W. Salter

DR. MICHAEL W. SALTER, MD, PhD

*Head & Senior Scientist, Neurosciences & Mental Health,
The Hospital for Sick Children
Professor, Department of Physiology, University of Toronto
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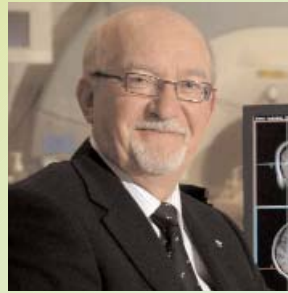
Dr. Salter received his MD from the University of Western Ontario in 1982 and his PhD in physiology from McGill University in 1987. After post-doctoral training at Toronto Western and Mt. Sinai hospitals, he joined the Research Institute of SickKids in 1990. He currently heads the Program in Neurosciences & Mental Health

at SickKids and is a professor of physiology at the University of Toronto.

His primary research and clinical interest are in pain mechanisms and management. Another main research focus of Dr. Salter's is synaptic physiology, a field where he has produced groundbreaking work that has led to new paradigms about neuroplasticity and how synaptic transmission in the central nervous system is regulated by biochemical processes within neurons and by glial-neuronal interactions. Besides his extensive work on the molecular/cellular aspects of pain, he has also published papers on the pain experience, including clinical studies on the bio-behavioural aspects of chronic pain in patients. In addition, he has a broad interest in neuroscience and has done pioneering work relevant to learning and memory, stroke-induced neuron death, epilepsy and schizophrenia.

Dr. Salter is actively involved in several start-up biotech companies. He is the founding scientist and vice-president of NoNO Inc., which is developing novel therapeutic agents for the treatment of stroke, neurodegeneration, neurotrauma and pain. Afference Therapeutics, where he is chair of the scientific advisory board and a founding member, is developing novel methods of treating diabetes. He was also a member of the scientific advisory board of Chlorion Pharma, which develops novel therapeutic agents that lower intracellular chloride ion concentration for the treatment of neuropathic pain and epilepsy.

Among the numerous honours he has garnered are the E.B. Eastburn Award, John Charles Polanyi Prize in Physiology or Medicine, and the Canadian Pain Society's Early Career Investigator Award and the Distinguished Career Investigator Award. Dr. Salter is a Fellow of the Royal Society of Canada and an International Research Scholar of the Howard Hughes Medical Institute.



Dr. Donald Stuss

**DR. DONALD T. STUSS, PhD, C. PSYCH,
ABPP-CN, ORDER OF ONTARIO,
FRSC, FCAHS**

*Vice President of Research, Baycrest Centre for Geriatric Care
Senior Scientist, Rotman Research Institute
Reva James Leeds Chair in Neuroscience and Research Leadership,
Baycrest Centre for Geriatric Care
University Professor, University of Toronto – Department of
Psychology, Faculty of Arts and Science; Department of Medicine
(Neurology), Faculty of Medicine; Centre for Studies of Aging
Adjunct Professor, Centre for Studies in Aging,
Faculty of Medicine, McGill University
Associate Scientist, Discipline of Imaging in the Program
of Neuroscience, Sunnybrook Health Sciences Centre
Professor, Graduate Department of Rehabilitation Science,
Faculty of Medicine, University of Toronto*

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Dr. Stuss has garnered many honours over the years, including the following: Fellow of CPA, APA (Divisions 3, 6, 40), APS, American Heart and Stroke Association, AAAS; University of Toronto Faculty Award (2004); APA/APF FJ McGuigan Lecture on Understanding the Human Mind (2007); Michener Institute Honorary Diploma (2008). His research focuses on understanding and treating the cognitive functions and personality changes associated with the frontal lobes as they occur after stroke, normal elderly, and in those with traumatic brain injury or dementia. Dr. Stuss has published four books and more than 200 papers, and has conducted approximately 250 scientific lectures and workshops. His publications have been cited approximately 10,000 times.

Alzheimer's disease		Parkinson's disease	
Paul Fraser	Biochemistry and biophysics of amyloid plaques	David Grimes	Genetics of Parkinson's and movement disorders
Nathan Herrmann	Clinical pharmacology of dementia	Stephen Kish	Neurochemical basis of dopamine excess and deficiency
Andrew Kertesz	Classification localization and recovery in aphasia	Anthony Lang	Clinical trials, development of rating scales for movement disorders
Joanne McLaurin	Role of aging in neurodegeneration	Andres Lozano	Functional neurosurgery
Peter St George-Hyslop	Discovery of first Alzheimer's gene	David Park	Signaling pathways which control neuronal death
Pain		Stroke	
Jonathan Dostrovsky	Perception of touch, pain and temperature	Henry Barnett	Discovery of Aspirin as a preventative therapy for cardiovascular disease
Gillian Hawker	Osteoporosis and osteoarthritis	Sandra Black	Stroke and dementia
Michael Salter	Identification of molecule that causes neuropathic pain	Vladimir Hachinski	Coining of the term "brain attack"; clinical and experimental studies in the prevention and delay of stroke
Bonnie Stevens	Pain in infants and children	David Spence	Stroke prevention
Min Zhuo	Mechanisms of pain and analgesia	Salim Yusuf	Population health
Cognitive Health			
Morris Moscovitch	Memory, attention and recognition of faces and objects		
Bruce Pollock	Geriatric clinical psychopharmacology		
John Roder	Mechanisms which govern learning and memory in mammals		
Donald Stuss	Dementia, memory, aging		
Endel Tulving	Development of episodic memory concept		

C. Ontario Neuroscience Infrastructure

Ontario neuroscientists are involved in many collaborative research programs at the national and international levels. The depth of research talent in the province is evident in the number of networks among its institutions. These research groups utilize state-of-the-art facilities supporting neuroscience research through top-quality services such as imaging, genomics, proteomics and microarray.

I. ONTARIO NEUROSCIENCE RESEARCH NETWORKS

Network	Description
Behavioural Research and Imaging Network http://www.brainimaging.ca/	Involves 12 major Ontario imaging institutes studying neuroscience of perception and cognition, stroke and rehabilitation, and psychiatry and neuroendocrinology
Brain Network Recovery Group http://www.brainnrg.org/	Brings together nine international research institutes to examine the ability of brain networks to rewire after damage caused by stroke, Alzheimer's or other dementias
Centre for Stroke Recovery http://www.heartandstroke-centrestrokerecovery.ca/	Established by the Heart and Stroke Foundation of Ontario and three Centres of Excellence
CIHR New Emerging Team: Integrative Computational Neuroscience Program http://www.rotman-baycrest.on.ca	Consortium of cognitive neuroscientists, imaging physicists and computer scientists developing a research program that merges human and animal neuroscience studies through computational models
Lifecycle Research Network http://www.schulich.uwo.ca/research/	Coalition of the major health research organizations in Guelph, London, Waterloo and Windsor focused on chronic-disease prevention and maintenance, including neurodegeneration
Neuroscience Alliance http://www.rotman-baycrest.on.ca	Collaboration of three healthcare centres to create a complete continuum of care for individuals suffering from neurological diseases and disorders
Parkinson Research Consortium http://www.ohri.ca/prc/	Partnership formed in 2004 involving scientists at the Ottawa Health Research Institute, the National Research Council and the University of Ottawa
Research-Clinical Program in Geriatric Neuropsychiatry http://www.rotman-baycrest.on.ca	Collaborative effort to identify the most effective and safest treatments for seniors with mental health disorders
University of Toronto Functional Imaging Research Network http://www.rotman-baycrest.on.ca	Network of five research institutes affiliated with the University of Toronto

II. RESEARCH SUPPORT FACILITIES IN TORONTO

Facilities	Services
Advanced Bioimaging Centre (a joint facility of SickKids and Mount Sinai Hospital)	Electron microscopy
Analytical Genetics Technology Centre – University Health Network	Sequencing, genotyping and analysis
McLaughlin Centre for Molecular Medicine	S.M.A.R.T laboratory for biological screening
Microarray Centre – University Health Network	Microarrays
NMR Services	Equipment for performing high-resolution liquid- and solid-state NMR (nuclear magnetic resonance)
Shanghai-Toronto Institute for Health Research – University Health Network	Collaborative programs in drug development and biomarker discovery
Toronto Western Hospital Functional Brain Imaging Centre	Functional magnetic resonance imaging
Vivian M Rakooff PET (positron emission tomography) Centre	Equipment includes a 17 MeV dual particle cyclotron (Scanditronix MC-17) and a brain PET scanner

D. Ontario's Top Neuroscience Institutions

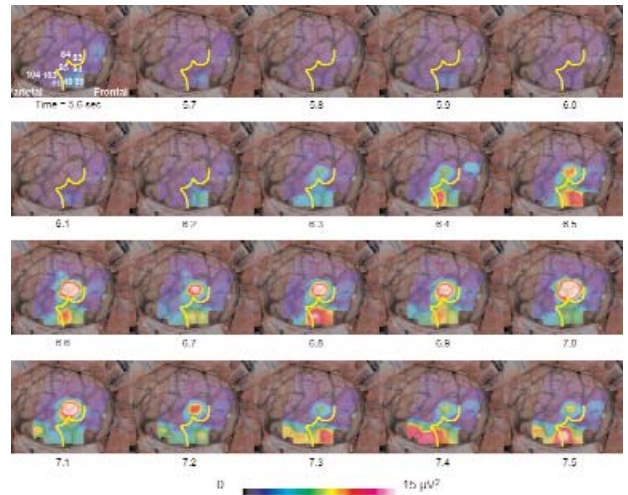
I. BAYCREST ROTMAN RESEARCH INSTITUTE (RRI) – TORONTO

In January 2009, an international panel led by the Helen Wills Neuroscience Institute at the University of California, Berkeley (UC Berkeley), ranked Baycrest among the world's best in the field of aging-brain studies. After a five-year review, the RRI's cognitive neuroscience program was considered comparable to similar endeavours at other global institutions, such as the Massachusetts Institute of Technology (MIT), University College London (UCL), UC Berkeley and the University of California, Los Angeles (UCLA).

According to the panel, "in the field of memory and aging, RRI scientists are probably the best in the world." RRI's excellence in theoretical science and brain research, complemented by its on-site imaging technologies, continues to attract the most eminent brain researchers in the world, including Endel Tulving, Fergus Craik and RRI's founding director, Dr. Donald Stuss.

II. THE HOSPITAL FOR SICK CHILDREN (SICKKIDS) – TORONTO

SickKids, Canada's most research-intensive hospital dedicated to children's health, is a world leader in the following fields: neurology and neurosurgery, epilepsy, stroke, multiple sclerosis, headaches, neurometabolic disease, hydrocephalus and brain tumours. In August 2008 the Canada Foundation for Innovation's Large-Scale Institutional Endeavours announced an award of more than \$90 million to SickKids. The hospital's Research Institute is involved in seven programs, including neurosciences and mental health. In the fiscal year 2006–2007, its research budget totaled nearly \$140 million.



Topographic mapping of seizure activities during an epileptic seizure, superimposed on a brain-surface image, can localize cortical epileptic zones and aid in presurgical evaluation. (Image courtesy of the Centre for Brain and Behaviour: Akiyama, Otsubo, Ochi, Galicia, Weiss, Donner, Rutka, Snead III, 2006)

Centre for Brain and Behaviour

Comprised of individuals involved in the paediatric neurosciences, which span the clinical departments of neurology, neurosurgery and psychiatry, the centre links to its research counterpart, the Program in Neurosciences & Mental Health. Its mission is to advance the integration of research, clinical care, education and outreach to improve the health, quality of life and well-being of children worldwide with disorders of the brain and spinal cord.

Functional Neuroimaging Centre (FNC)

SickKids is among the few paediatric facilities in the world with an MEG (magnetoencephalography) and a dedicated research MRI, which are housed in the FNC. MEG studies deal with childhood epilepsy, autism, ADHD and brain tumours.

III. McMASTER UNIVERSITY – HAMILTON

McMaster University's renowned medical school anchors several institutes and centres dedicated to neuroscience research. In August 2008 the Canada Foundation for Innovation (CFI) awarded \$34.7 million in funding to establish the Hamilton Health Sciences Cardiac, Vascular and Stroke Research Institute (CVSRI), whose estimated project cost is \$90.9 million. The new institute will bring together clinical and basic research in cardiovascular diseases and thrombosis.



Dr. John Bienenstock, centre, with his team at the McMaster Brain-Body Institute at St Joseph's Healthcare Hamilton.

Brain-Body Institute (BBI)

In exploring the extent to which the brain and nervous system interact with bodily systems in the regulation of health and disease, BBI utilizes its state-of-the-art Imaging Research Centre, which is equipped with MRIs, PET and EEG facilities.

McMaster Institute for Neuroscience Discovery and Study (MiNDS)

MiNDS, a newly established graduate neuroscience program, involves more than 60 neuroscientists from the faculties of science, health sciences, engineering, social sciences and humanities.

Michael G. DeGroot Institute for Pain Research and Care

One of three initiatives established by philanthropist Michael DeGroot's donation of \$105 million – the largest amount that has been contributed to a Canadian institution – this centre has a mandate to examine the causes of different types of pain and to develop strategies for its prevention, diagnosis, management and care, with a special emphasis on thalamic pain.

IV. UNIVERSITY OF TORONTO – TORONTO

A global leader in health sciences research, the University of Toronto has 10 affiliated hospitals with world-class research facilities conducting basic and clinical research. Including its hospital partners, the university is the largest research institution in Canada and the fourth-largest in North America. Also, among all the institutions in Canada, it wins the most neuroscience funding grants from the Canadian Institutes of Health Research (CIHR) and the Natural Sciences and Engineering Research Council of Canada (NSERC).

Centre for Addiction and Mental Health (CAMH)

CAMH, an affiliate of the University of Toronto, is Canada's largest research facility for mental health and addictions, with more than 100 scientists dedicated to understanding mental illness and substance-use disorders, as well as improving diagnosis, prevention, intervention, treatment and public policy initiatives.

In August 2008, CAMH received a \$15-million award from the CFI to enhance current research with a focus on prevention. The grant will also support a \$38-million project with the goal to transform lives across six research themes: schizophrenia, mood disorders, addictions, community health and knowledge exchange, neuroimaging, and pharmacogenetics and neuroscience.

Centre for Research in Neurodegenerative Diseases (CRND)

CRND at the university's faculty of medicine is dedicated to research, education and discovery in relation to neurodegenerative diseases such as Alzheimer's, Parkinson's, FTD, ALS and prion diseases. The director of CRND is acclaimed neurologist and molecular geneticist Dr. Peter St George-Hyslop, who has made significant contributions to genetic research in Alzheimer's disease. Between 2000 and 2007, scientists at the centre published 435 papers in peer-reviewed journals and were awarded \$42 million in research funding.

Centre for the Study of Pain

An interdisciplinary collaboration among the university's faculties of dentistry, medicine, nursing and pharmacy, this centre is engaged in pain research, education and clinical activities. Dr. Ronald Tasker and Dr. Jonathan Dostrovsky conducted pioneering work on pain processing areas that led to the development of brain stimulation therapy.

V. UNIVERSITY OF WESTERN ONTARIO (UWO) – LONDON

Robarts Research Institute (RRI)

A private research institution, RRI became affiliated with the UWO in July 2007, integrating itself as a medical research institute within the university's Schulich School of Medicine & Dentistry. More than 40 senior scientists at RRI conduct work in cardiovascular, immunological and neurological areas. With its focus on Alzheimer's and other brain disorders, as well as cancer, diabetes, heart disease and stroke, the institute publishes more than 150 peer-reviewed articles each year. Highly regarded for its imaging research work, RRI has three MRI machines and, in 1996, became the first in Canada to install a high-field functional MRI laboratory. The institute, which received more than \$40 million in grant funding in 2007, is a partner of the university in an interdisciplinary collaboration, the Centre for Brain and Mind, whose mandate is to understand how the brain works.

Lawson Health Research Institute

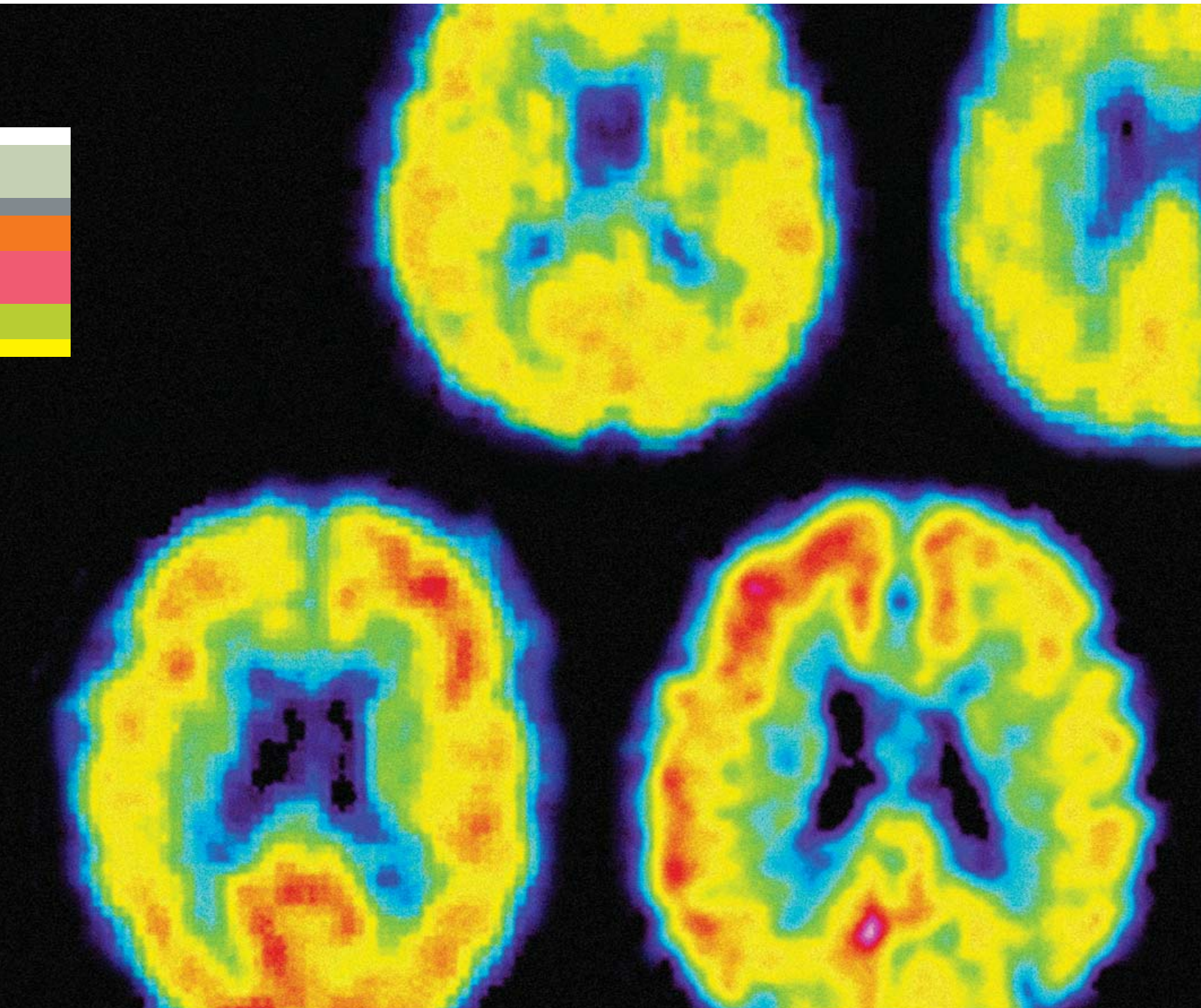
As the research arm of London Health Sciences Centre and St. Joseph's Health Care London, the institute is also affiliated with UWO. Its research is centred on 11 themes, including neurological disorders, mental health, imaging, clinical investigation and therapeutics, and aging, rehabilitation and geriatric care. This institute publishes approximately 900 peer-reviewed papers each year and receives more than \$60 million in research funding annually.



↑ Robarts Research Institute in London, Ontario.

↓ Tara Koyama, a master's student at Lawson Health Research Institute, takes a closer look under the microscope as she studies probiotics and allergies.





APPENDICES

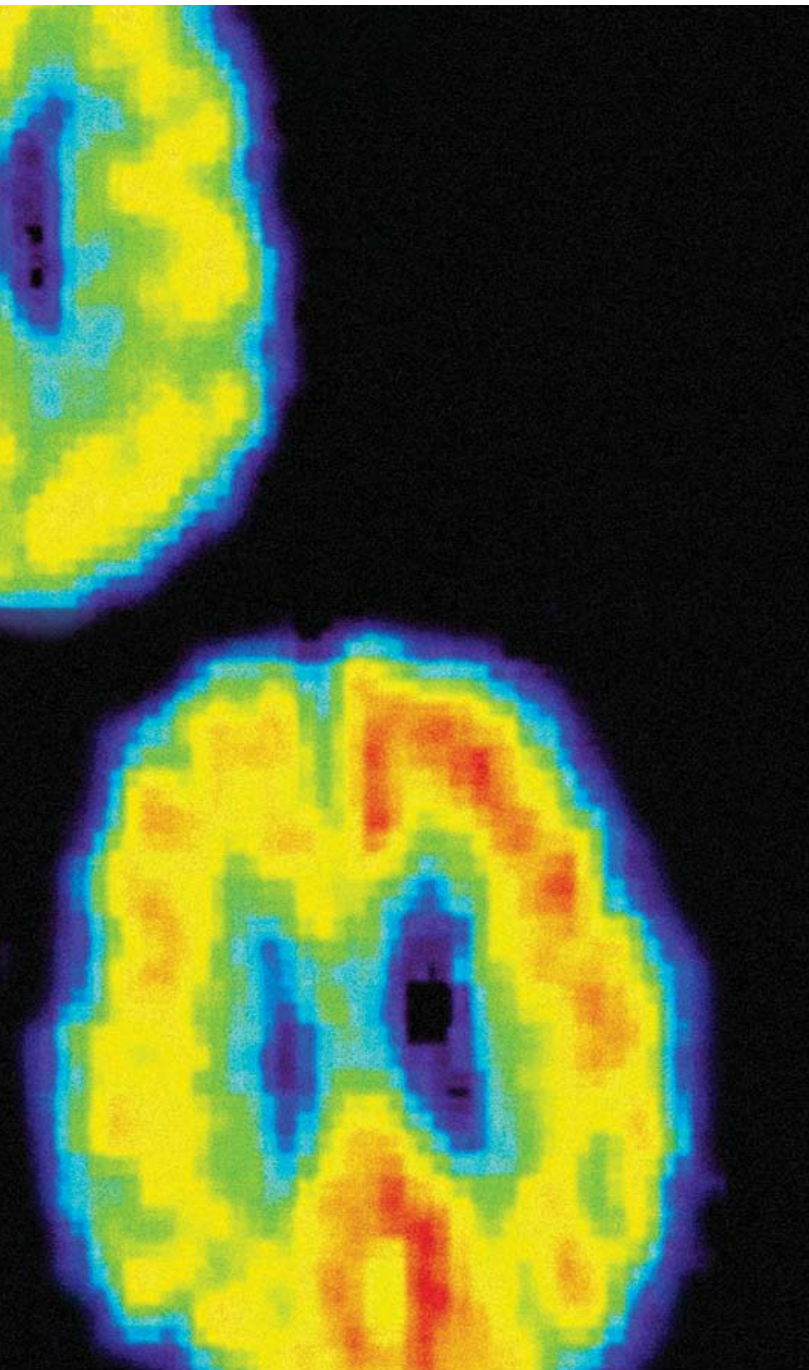


Image courtesy of John Loper/Mount Sinai Hospital

NEUROSCIENCE FUNDING IN CANADA

Federal funding

CANADIAN INSTITUTES OF HEALTH RESEARCH (CIHR)

CIHR, the major federal agency responsible for funding health research in Canada, was responsible in 2004–2005 for nearly 59% of all federal investment in health research. For the 2007–2008 fiscal year (April 1, 2007–March 31, 2008), CIHR contributed more than \$107 million towards brain research.

Thirteen institutes comprise CIHR. The Institute of Neurosciences, Mental Health and Addiction provides the bulk of neuroscience funding for research into brain functions and disorders, the spinal cord, sensory and motor systems, and the mind. The Institute of Aging supports and builds research capacity in the field of aging, including biological mechanisms and cognitive impairment. The institute also supports the Cognitive Impairment in Aging (CIA) Partnership, bringing together volunteers and organizations from the public and private sectors interested in addressing cognitive impairment issues in Canada.

NATURAL SCIENCES AND ENGINEERING RESEARCH COUNCIL (NSERC)

NSERC provides funding for science and technology professors and graduate students at universities and colleges across Canada. Universities in Ontario receive the bulk of the funding, followed by those in Quebec.

CANADA FOUNDATION FOR INNOVATION (CFI)

Since 1998, CFI has invested approximately \$160 million in neuroscience-related projects.

CANADA RESEARCH CHAIRS (CRC) PROGRAM

The CRC Program, which currently has more than 1,800 chairs, invests \$300 million a year in research professorships.

Networks of Centres of Excellence

CANADIAN STROKE NETWORK (CSN)

Since it was established in 1999, CSN has received more than \$58 million in funding.

NATIONAL INITIATIVE FOR THE CARE OF THE ELDERLY (NICE)

NICE is a national network of researchers and clinicians in medicine, nursing and social work who are involved in the care of older adults. Its 2005–2009 initiative is funded by a \$1.76-million federal grant.

MaRS INNOVATION

A Centre of Excellence for Commercialization and Research (CECR), MaRS Innovation is a joint venture partnering the non-profit innovation hub MaRS, the federally funded BioDiscovery Toronto and 14 Toronto institutions, including hospitals and universities.

Other funding

VOLUNTARY HEALTH ORGANIZATIONS

Several Canadian voluntary health organizations provide additional research funding. The Heart and Stroke Foundation of Canada invested approximately \$59 million in research in 2007 and is currently funding 900 researchers across the country. Neuroscience Canada is the only national non-profit organization dedicated exclusively to supporting neuroscience research. In 2003 it launched the \$8-million Brain Repair Program to explore the ability of the brain to be repaired or to repair itself.

The newly formed Neurological Health Charities Canada (NHCC) is a collective of 12 organizations and foundations representing Canadians with chronic brain disorders and injuries. Among its members are the Alzheimer Society of Canada and Parkinson Society Canada. NHCC's mission is to improve the quality of life of individuals affected by brain diseases, disorders and injuries by urging government to give brain health top priority in their agendas and ensuring that research, prevention, treatments and support for these conditions are universally accessible and fully funded. Each member of the NHCC provides as much as \$8 million in research funding to support the condition it is dedicated to.

NATIONAL INSTITUTES OF HEALTH (NIH)

Canadian researchers are competitive at winning NIH funding from the U.S. In the fiscal year 2006, NIH awarded more than \$20 million to researchers in Canada to fund neuroscience-related projects. The Howard Hughes Medical Institute also funds international researchers. Since 2002, more than \$5 million has been awarded to seven Canadian neuroscientists.

SUMMARY OF ONTARIO NEUROSCIENCE COMPANIES

Company	Symbol	Location	Sector	Neurological Indications
Aegera Therapeutics	Private	Ottawa	therapeutics	pain
Amgen	NASDAQ: AMGN	Mississauga (headquarters: California)	therapeutics	pain
Amorfix Life Sciences Ltd.	TSX:AMF	London, Toronto	therapeutics	ALS, Alzheimer's, Parkinson's
Apotex	Private	Toronto, Etobicoke, Mississauga, Brantford, Windsor	therapeutics	various
AstraZeneca	NYSE:AZN	Mississauga	therapeutics	anxiety, Alzheimer's, depression, pain, stroke
Biogen Idec Canada	NASDAQ:BIIB	Mississauga (headquarters: Cambridge, Massachusetts)	therapeutics	MS
BioMS	TSX:MS	Toronto	therapeutics	MS
Biovail Corporation	TSX and NYSE: BVF	Mississauga	therapeutics	pain, depression
Boehringer Ingelheim	Private	Burlington	therapeutics	Parkinson's, stroke
CanCog Technologies Inc	Private	Toronto	drug development	anxiety, Alzheimer's, depression, MCI, Parkinson's, schizophrenia
Cannasat Therapeutics	Toronto Venture Exchange (CTH-V)	Toronto	therapeutics	anxiety, depression, movement disorders, pain
Cascade Therapeutics	Private	Toronto (MaRS)	therapeutics	anxiety, epilepsy, pain, schizophrenia, sleep disorders
Cerebral Diagnostics	Private	Toronto	devices	pain
Cervelo Pharmaceuticals	Private	Mississauga	therapeutics	inflammation, pain
Cita (acquired by Vernalis)	Private	Mississauga	therapeutics	Alzheimer's, pain, Parkinson's
Clera	Private	Toronto (MaRS)	therapeutics	depression
Critical Outcome Technologies	TSX Venture Exchange: COT	London	therapeutics	MS
Eli Lilly	NYSE:LLY	Toronto	therapeutics	ADHD, bipolar disorder, pain, depression, OCD, schizophrenia

Company	Symbol	Location	Sector	Neurological Indications
EMD Serono (affiliate of Merck Serono S.A., Geneva, Switzerland)	Public	Mississauga (headquarters: Rockland, Massachusetts)	therapeutics	MS
Fralex Therapeutics	TSX:FXI	Toronto	devices	anxiety, pain, depression
GeneNews	TSX:GEN	Toronto	diagnostics	Alzheimer's, bipolar disorder, schizophrenia
Generex	NASDAQ:GNBT	Toronto	therapeutics	pain
GlaxoSmithKline	NYSE:GSK	Mississauga (headquarters: U.K.)	therapeutics	epilepsy, depression, migraine, OCD
Intronix Technologies Corporation	Private	Bolton	devices	N/A
Kadmus Pharmaceuticals (acquired by Organon)	Private	Toronto (headquarters: California)	therapeutics	pain
Key Molecular Corporation	Private	Toronto	therapeutics	Parkinson's, schizophrenia
Medtronic	NYSE:MDT	Mississauga (headquarters: Minneapolis)	devices	pain, Parkinson's
MindCare Centres (part of NeuroPsycho-Therapeutics Corporation-NPTx)	Private	Toronto, Ottawa	devices	depression
Mylon-Tech Health Technologies	Private	Mississauga	devices	pain
NeurAxon	Private	Research operations, MaRS (headquarters: Waltham, Massachusetts)	therapeutics	migraine, pain
Neuroimage Inc.	Private	Toronto	devices	imaging
NoAb Biodiscoveries Inc.	Private	Mississauga	drug discovery	N/A
(Teva) Novopharm	Private	Mississauga (headquarters: Rockland, Massachusetts)	therapeutics	MS

Company	Symbol	Location	Sector	Neurological Indications
NPS Allelix Corporation (subsidiary of NPS Pharmaceuticals)	Private	Mississauga	therapeutics	inflammation
Organon (part of Schering-Plough)	Private	Scarborough (headquarters: Netherlands)	therapeutics	depression, insomnia
Oryx Pharmaceuticals	Private	Mississauga	therapeutics	depression, epilepsy, insomnia
PainCeptor Pharma Corporation	Private	Ottawa (headquarters: St-Laurent, Quebec)	therapeutics	pain
Performance Enterprises	Private	Markham	devices	cognition, stroke
Sandstrom Trade & Technology Inc.	Private	Welland	devices	imaging
Solvay Pharma Inc. (subsidiary of Solvay SA)	Private	Markham	therapeutics	depression, OCD
Swiss Medica	OTC:SWME	Toronto	therapeutics	pain
Transition Therapeutics	TSX:TTH	Toronto (MaRS)	therapeutics	Alzheimer's, MS
UCB Pharma Canada Inc.	BRU:UCB	Burlington (headquarters: Brussels)	therapeutics	ADHD, epilepsy, migraine, pain, Parkinson's, restless leg syndrome
Vasogen	NASDAQ: VSGN TSX: VAS	Mississauga	therapeutics	ALS, Alzheimer's disease, Parkinson's disease
Wyeth Pharmaceuticals Inc	NYSE:WYE	Markham, Mississauga	therapeutics	Alzheimer's, depression, MS, pain, schizophrenia
XLR Imaging	Private	London	devices	imaging
XLTEK (division of Natus); aka Excel-Tech	TSX:NRV	Oakville	devices	epilepsy, sleep disorders
Zinc Therapeutics	Private	Ottawa	therapeutics	neurological indications, stroke

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- Canadian Institutes of Health Research. Institute of Aging**. <http://www.cihr-irsc.gc.ca/e/8671.html>
- National Institutes of Health. National Institute of Mental Health**. <http://www.nimh.nih.gov>
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- Neuroscience Canada**. <http://www.neurosciencecanada.ca/>
- Ontario Economic Development**. <http://www.investinontario.com>
- Toronto Region Research Alliance (TRRA)**. <http://www.trra.ca/torontoregion>

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