Toronto Region
The Power of Global Thinking

December 2011

Regional Innovation Cluster

LIFE SCIENCES IN THE TORONTO REGION

ABOUT TORONTO REGION RESEARCH ALLIANCE

The Toronto Region Research Alliance (TRRA) is a public-private partnership supported by a wide range of regional stakeholders from the private sector, universities, colleges, and research hospitals. TRRA is funded by the government of Ontario and is a key partner in delivering Ontario's Innovation Agenda.

MISSION

TRRA is a regional economic development organization promoting increased investment in research and innovation to further economic prosperity.

GOALS

1. Increase awareness of the Toronto Region among global R&D decision-makers and influencers
2. Retain and grow foreign investment into regional organizations, and attract innovative foreign companies to locate here
3. Become the pre-eminent source of intelligence on regional research assets and associated international trends
4. Promote enhanced research intensity among regional businesses
5. Advance initiatives to strengthen research and innovation capacity

VISION

To transform the Toronto Region into a top 5 global center for research and research-intensive industry

TORONTO REGION INNOVATION ZONE

TRRA defines the Toronto Region based on the location of key innovation clusters in a broad geographic area anchored by the City of Toronto, and includes the surrounding regions of Durham, Guelph, Halton, Hamilton, Peel, York, Waterloo and Wellington.

TABLE OF CONTENTS

TABLE OF CONTENTS

EXECUTIVE SUMMARY

The Life Sciences sector is a focal point for national science and technology strategies and policies around the world because it is recognized as a critical contributor to a nation's overall prosperity. The promotion of Life Sciences clusters leads to a culture of creativity, enables competitive research and business environments, and ultimately quickens local access to new medical discoveries and technologies.

Canada has likewise placed a priority on the Life Sciences by increasing healthcare investments and creating industrial research and development (R&D) incentives, even during recent global economic turmoil and budget re-evaluations. In return, the producers of Life Sciences innovations must seek not only new knowledge and inventions, but also methods and technology platforms to build efficiencies into the existing healthcare system.

Canada's pharmaceutical and medical device markets rank in the top ten globally, and are largely concentrated in the Toronto Region. Building on a tradition of medical innovations, the Life Sciences cluster in the Toronto Region is an integrated ecosystem of multinational and start-up businesses, supporting services, reputable researchers and renowned research centres. This critical mass of industry, intellectual capital, and significant R&D infrastructure forms a large Life Sciences footprint.

The global share of Life Sciences publications from the Toronto Region has grown 25% over the past decade, with notable strength in the fields of oncology, neurology, and medical imaging. The University of Toronto and McMaster University are major recipients of government funding for Life Sciences research, with correspondingly large shares of recognized scientific and medical experts within their teaching faculties.

Businesses are establishing operations here to tap into this sizable research base and to access locally-developed cutting-edge technologies and the broader North American market, with the support of financial R&D incentives. The Toronto Region is the place to collaborate, to perform research, and to do business in the Life Sciences sector.

This report aims to highlight the research assets and industry strengths in the Toronto Region, which make it one of the most vibrant and innovative Life Sciences clusters in the world.

Sector Definition

The Life Sciences sector as described in this report focuses on human health-related **pharmaceuticals**, **biotechnology** and **medical technology** subsectors.

The biotechnology subsector covered in this report concentrates on human medical applications, and excludes agricultural and industrial applications.

LIST OF FIGURES

LIST OF FIGURES

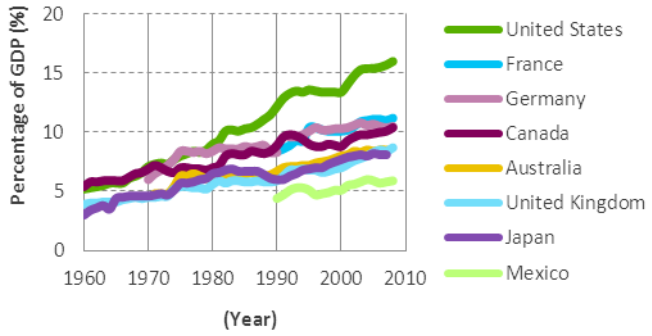
LIST OF TABLES

GLOBAL CONTEXT

Human health is a basic and fundamental concern for individuals, communities and governments around the world. Developing countries are struggling with acute health conditions and infectious diseases, and need low-cost solutions to improve access to and distribution of care. In contrast, developed countries are faced with chronic disease management and mounting healthcare expenditures.

In 2008, the global average expenditure on health was 8.5% of gross domestic product (GDP), rising from 8.3% in 2000. Canada allocated 9.8% of GDP to health expenditures in 2008, up from 8.8% in 2000, 7.0% in 1980 and 5.4% in 1960. See Figure 1 for health expenditure trends of selected countries[1]. See Table 1 for data on selected countries and regions[2].

Figure 1: Total health expenditures of selected countries, as % of gross domestic product



Source: adapted from OECD data

Innovative solutions are needed to address complex health problems and increasing healthcare costs. The Life Sciences industry targets improved health outcomes via the creation and application of sophisticated products, such as pharmaceutical drugs, medical devices and surgical instruments. Advanced technologies are also being

Table 1: Life expectancies and health expenditures for selected countries and regions

	Life expectancy at birth (years)		Total health expenditure as % of GDP		Government health expenditure as % of total health expenditure		Total health expenditure per capita, average exchange rate (US$)	
Country	2000	2009	2000	2008	2000	2008	2000	2008
Australia	80	82	8.0	8.5	66.8	65.4	1,728	4,180
Canada	79	81	8.8	9.8	70.4	69.5	2,082	4,445
China	71	74	4.6	4.3	38.3	47.3	44	146
France	79	81	10.1	11.2	79.4	75.9	2,184	4,966
Germany	78	80	10.3	10.5	79.8	74.6	2,366	4,720
Japan	81	83	7.7	8.3	81.3	80.5	2,827	3,190
Singapore	78	82	2.8	3.3	44.9	34.1	648	1,404
United Kingdom	78	80	7.0	8.7	79.3	82.1	1,767	3,771
Unites States of America	77	79	13.4	15.2	43.2	47.8	4,703	7,164
Region								
Africa	50	54	5.5	6.0	43.7	49.8	34	83
The Americas	74	76	11.4	12.6	45.3	49.4	1,842	2,902
South-east Asia	62	65	3.9	3.8	32.1	41.3	20	47
Europe	72	75	8.0	8.5	73.8	73.7	931	2,283
Eastern Mediterranean	63	66	4.2	4.2	47.9	53.2	92	153
Western Pacific	72	75	6.0	5.8	63.7	67.1	291	447
Global	*66*	*68*	*8.3*	*8.5*	*56.4*	*60.5*	*484*	*854*

Source: World Health Organization

harnessed to increase the efficiency and effectiveness of existing solutions.

Life Sciences research and development (R&D) activities extend from understanding the basic building blocks of life to applying this understanding to treat diseases and disorders. The stakes and R&D costs are high for inventors and developers because a product is considered successful when a medical cure or improved quality of life is achieved. And yet, there is no shortage of new entrants into the diverse subsectors of the growing Life Sciences industry.

Table 2: Global R&D expenditures for top research-intensive industries

Industry	2009 R&D Expenditures as % of Sales	Rank for 2009 R&D Expenditures
Pharmaceuticals & biotechnology	15.9	1
Software & computer services	10.3	4
Technology hardware & equipment	8.7	2
Leisure goods	6.6	8
Healthcare equipment & services	6.3	12
Automobiles & parts	4.7	3
Average, top 1,000 corporate R&D spenders	3.6	—

Source: adapted from BIS 2010 R&D Global Scoreboard

The Life Sciences sector is a key contributor to the knowledge-based economy. R&D activities are core to the success of the industry and are directed heavy investments, even in comparison with other research-intensive industries, such as Information and Communications Technology, and Advanced Manufacturing. See Table 2 for a comparison of world-wide R&D expenditures for the top industries[3].

The estimated 2009 global market sizes for the key Life Sciences subsectors were:

- **Pharmaceuticals and biotechnology**: US$ 1.1 trillion (five-year compound annual growth rate [CAGR] of 6.7%), forecasted to reach US$ 1.4 trillion by 2014[4].
- **Medical devices**: US$ 297 billion (five-year CAGR of 4.9%), forecasted to reach US$ 369 billion by 2014[5].

Key industry challenges

The Life Sciences industry has seen its traditional business models altered by recent industry-specific challenges and global recessionary events. A key concern faced by branded pharmaceutical companies is the large number of drug patent expirations in which market exclusivity will end on a number of blockbuster drugs that produce over US$ 1 billion in annual sales. The introduction of generic versions of branded drugs to market is expected to reduce branded sales over the next five years in the range of US$ 75 billion[6] to US$ 250 billion[7], and this coincides with a thin branded drug pipeline. Lower cost drug plans for government funded medical care is fueling opportunities for generic pharmaceutical companies, while branded companies are responding via new models of innovation.

In the medical device subsector, bringing products to market and the adoption of products by end-users is challenged by the need to demonstrate value for money. A Boston Consulting Group study revealed that while total R&D spending by medical technology companies grew 14% annually between 2001 and 2009, it remained flat at 5% to 7% as a share of revenue[8]. Furthermore, regulatory approvals for medical devices have increased for incremental products while decreasing for new products, indicating that companies are relying on existing products with enhanced features rather than on *bona fide* novel innovations.

Other concerns across the industry include long and costly product development cycles, challenging regulatory approval and ethics review processes, ethical concerns over the use of cutting edge discoveries in biotechnology and regenerative medicine, increased scrutiny over academic collaborations relating to intellectual property and research freedom, and decreasing R&D productivity. The industry is affected by political and regulatory factors; these intertwining landscapes are continuously evolving in response to societal needs and adoption of advanced technologies. Its customers are healthcare institutions, physicians, researchers and consumers who are making purchasing decisions based on a mixture of factors such as brand recognition, clinical evidence and budget constraints.

Response to shifting terrain

Faced with these challenges, the Life Sciences industry is conducting strategic re-assessments and responding to a terrain shaped by internal and external pressures. The industry is pursuing new growth opportunities, including establishing a presence in emerging markets, acquiring companies with specialty products or emergent technologies, outsourcing traditionally in-house R&D functions, establishing innovative collaborations, and targeting potentially lucrative markets, such as products for the aging population and orphan diseases. The pharmaceutical subsector is cultivating a broadening niche of outsourced R&D in which the contract research market size was estimated at US$ 20 billion in 2008 and is expected to reach US$ 35 billion in 2015[9].

Mega-mergers in the pharmaceutical subsector have been instrumental in levering the ability of new mega-companies to gain rapid access to new technologies and to maintain or grow market share. Some recent significant mergers include Merck/Schering-Plough (US$ 41 billion), Roche/Genentech (US$ 47 billion), and Pfizer/Wyeth (US$ 68 billion), all in 2009, Abbott/Solvay (US$ 7 billion) in 2010 and Sanofi/ Genzyme (US$ 20 billion) in 2011.

The medical technology space has also been fertile ground for mergers and acquisitions (M&A) activity. Boston Scientific and Johnson & Johnson battled over stent maker Guidant before Boston Scientific's US$ 24.2 billion offer was accepted in 2006. Danaher has been acquiring medical technology companies, starting with Radiometer AS for blood analyte systems and two dental device companies, Gendex and Kaltenbach & Voigt GmBH, in 2004[10] to its US$ 6.8 billion acquisition of Beckman Coulter in 2011. In 2010, Samsung acquired two medical device companies, Medison and Prosonic, to announce its entry into the medical technology market and to create a large footprint in ultrasound diagnostics. In 2011, Sony acquired diagnostic device maker Micronics for an undisclosed amount[11].

Private equity firms have also been attracted to the growth potential of medical technology companies. Biomet was acquired by a private equity consortium for US$ 11.4 billion in 2006, Bausch & Lomb by Warburg Pincus for US$ 4.5 billion, Molnlycke Health Care Group by Investor AB and Morgan Stanley for US$ 3.7 billion, Pharmaceutical Technologies & Services by The Blackstone Group for US$ 3.3 billion, and Kodak Health Group by Onex Corp for US$ 2.55 billion, all in 2007, and ConvaTec by Avista Capital Partners and Nordic Capital for US$ 4.1 billion in 2008[12].

Some companies are divesting lines of business as a means of focusing on core competencies. AstraZeneca spun off its gastrointestinal research program in 2008. Johnson & Johnson stopped manufacturing drug-eluting cardiac stents[13] and Pfizer closed its animal health and nutrition businesses, with the intention to focus more sharply on new drug development[14].

Pharmaceutical companies are delving deeply into collaborative "open innovation" models. R&D activities are integrated into newly-created research hubs with universities and hospitals as a means of sharing risk and pooling resources. In 2010, Roche set up a 100 million Swiss francs public-private partnership in Singapore with six scientific and medical institutions to create a translational medicine research hub. Pfizer has consolidated its R&D facilities and established Centers for Therapeutic Innovation to connect academic collaborators with Pfizer researchers. Partnerships include sites in San Francisco (US$ 85 million deal) in 2010, New York, Boston (US$ 100 million deal) and San Diego (US$ 50 million deal) in 2011, and the company plans to expand into Europe and Asia in 2012. GlaxoSmithKline (GSK) launched a $50 million GSK Canada Life Sciences Innovation Fund to invest in early-stage research by academic and health institutions, research centres and start-up biotechnology companies in November 2011.

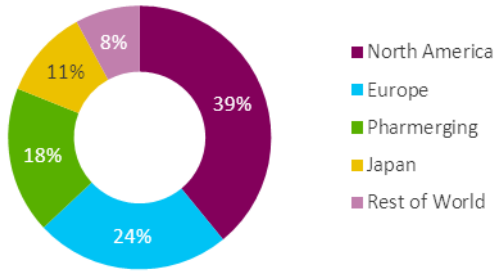
The Life Sciences industry has re-positioned itself to market improved health outcomes rather than the sale of goods and services, making the success of this approach depend on the industry's ability to create and cultivate trust with its customers. Moreover, a company that can remain agile on the shifting terrain, while adopting new technologies, will be prepared to identify and engage in new opportunities.

Pharmaceutical subsector

The pharmaceutical subsector develops and markets small molecule drugs to diagnose, treat or prevent disease. The global pharmaceutical market size was estimated at US$ 856 billion in 2010 (Figure 2) and is expected to reach US$ 1.1 trillion by 2015[15].

This subsector is dominated by sizeable companies, such as Pfizer, GlaxoSmithKline and Sanofi-Aventis, which have extensive branded product portfolios, operate on a global level, and generate tens of billions of dollars in annual sales. Specialty and generic pharmaceutical companies are numerous and tend to operate on a regional scale, although consolidation has led to increased reach. Pharmaceutical companies may be segmented by branded, generics and over-the-counter (OTC) drugs, with differing development cycles and sales channels. OTC drugs can be purchased without a prescription, and are not covered in this report.

Figure 2: Global pharmaceutical market size (2010). "Pharmerging" countries, as defined by IMS, include: Brazil, China, India, Mexico, Russia, South Korea and Turkey.



Source: IMS Institute for Healthcare Informatics

Branded pharmaceuticals

Branded drugs are patent-protected for a limited period of time, giving patent assignees exclusive rights to manufacture the drug or license it to another company. In Canada, these drugs are prescribed by a physician. Branded pharmaceutical companies typically organize their sales force by geography and therapeutic area, enabling sales agents to present targeted portfolios to specialists. Canadian provinces and territories have formularies that list drugs covered by their public insurance benefit plans. Manufacturers must submit new drugs to federal authorities for sales and marketing approval and to provincial authorities for listing and to negotiate costing terms.

There is a potential risk to human health with the launch of each new branded drug to market. This necessitates the demonstration of robust safety and efficacy data, adding time and cost to the development process (Figure 3). Commonly accepted figures for developing a single new drug include: 10,000 initial screening targets, 10 years in development and US$ 1 billion spent on R&D. However, a London School of Economics report[16] has suggested that a much lower figure of US$ 50 million may be more accurate for a new drug.

Generic pharmaceuticals

Generic pharmaceuticals have the same active ingredients as and bioequivalence (similar pharmacokinetic profile) to the original formulation, and may be marketed once the patent on the original drug expires. They may be produced by any pharmaceutical company without exclusivity, provided the drug is approved by regulatory bodies. These include Health Canada in Canada, Food and Drug Administration (FDA) in the United States, European Medicines Agency (EMEA) in the European Union, and Pharmaceuticals and Medical Devices Agency in Japan. Generic drugs have a shortened drug development pathway and streamlined submission process for formulary listing (Figure 4). The development time for a generic drug is within the range of three to six years, and is estimated to cost $4 million[17].

Figure 3: Stage-gate process for branded drug development

Figure 4: Process for generic drug development

Source: CGPA

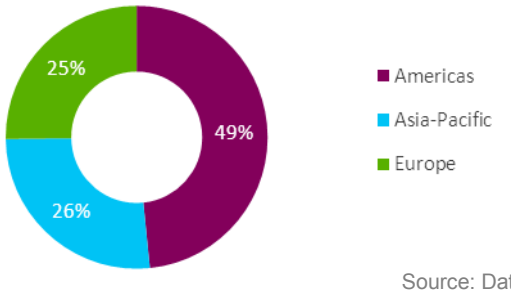
Biotechnology subsector

Biotechnology companies develop drugs of biological origin which are produced through technological means. The global biotechnology market size was estimated at US$ 201 billion in 2009 and is expected to reach US$ 318 billion by 2014 (Figure 5)[18].

The field of biotechnology leaped forward in the 1970s and 1980s with the concurrence of key genetic engineering technology advancements: recombinant DNA technology with restriction enzymes and polymerase chain reaction (PCR) technology. Recombinant DNA technology enabled researchers to insert genes from one organism into another to be "expressed" or to produce proteins encoded by the foreign genes. PCR technology enabled researchers to exponentially amplify copies of DNA to be used for analysis, diagnosis and other applications.

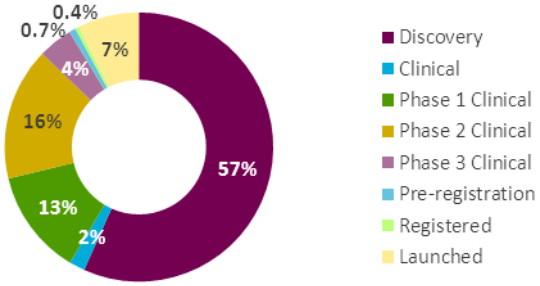
The first biopharmaceutical, a recombinant human insulin trademarked Humulin, was approved for market in 1978, and over 160 biotechnology drugs have been launched to date. Another 1,100 drugs are in various stages of discovery (Figure 6)[19]. Cancer is the most common therapy area investigated with 570 biotechnology drugs (26%), followed by immunity and infection with 370 drugs (17%) and cardiovascular with over 170 drugs (8%). See Figure 7 for the biotechnology drug discovery and manufacturing process[20], which differs from that in the pharmaceutical subsector.

Figure 5: Global biotechnology market size (2009)



Source: Datamonitor

Figure 6: Highest development status of biotechnology drugs. Over 1,200 biotechnology drugs in pipeline between "Discovery" and "Launched" phases at time of data collection.



Source: adapted from Thomson Pharma

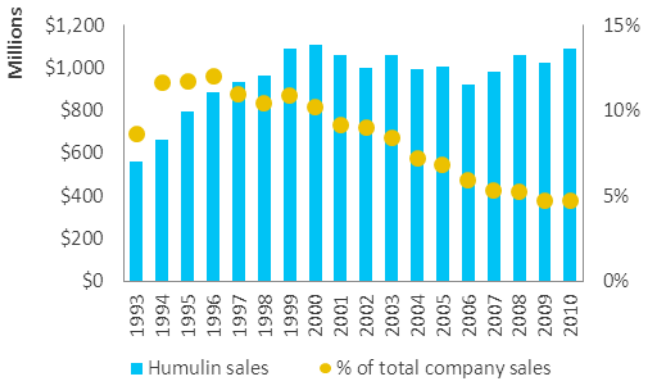
Figure 7: Typical process for biotechnology drug discovery and manufacturing

Source: Biotechnology Industry Organization

Humulin, world's first biotech drug

Genentech created Humulin, a recombinant human insulin used to treat diabetes, by inserting human genes into a new system for synthetic insulin production. In 1982, Humulin was licensed to Eli Lilly, with royalty payments to Genentech ending in 1998. By 1993, Humulin was generating sales of more than US$ 500 million. In 1996, Eli Lilly received FDA approval to market a new human insulin analog, Humalog, as the company prepared for the 2001 Humulin patent expiration. Humulin as a percentage of sales declined annually as Eli Lilly shifted customers over to alternate insulin products (Figure 8).

Figure 8: Sales figures for Humulin, first approved biotechnology drug. Invented by Genentech, marketed by Eli Lilly.



Source: SEC 10-K filings for Eli Lilly

Medical devices subsector

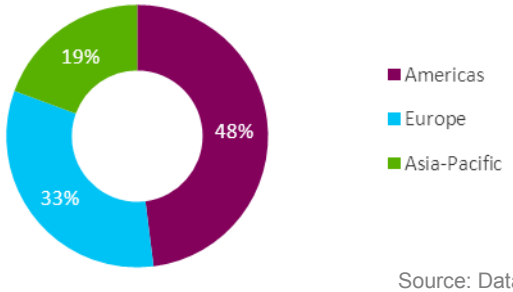
Medical device companies develop and market devices and equipment for the healthcare industry. Health Canada defines medical devices as instruments used for "the diagnosis, treatment, mitigation or prevention of a disease, disorder or abnormal physical state, or its symptoms […], restoring, correcting or modifying a body function or the body structure," or the diagnosis and care of pregnancy[21]. The global medical device market size was estimated at US$ 297 billion in 2009 and is expected to reach US$ 369 billion by 2014 (Figure 9)[5].

Medical devices are classified from low to high risk with corresponding stringency in licensing requirements. In Canada, the risk classification levels are[22,23]:

- Class I (low risk): Exempt from licensing. Does not need Health Canada marketing approval. An establishment licence is required to ensure manufacturing facilities conform to documentation standards. Examples: some surgical instruments, bandages, hospital beds.
- Class II (low-to-moderate risk): Requires device licensing by asserting safety and efficacy. Examples: short-term catheters, ultrasound transducers.
- Class III (moderate-to-high risk): Requires device licensing by demonstrating safety and efficacy of the device. Examples: shoulder prostheses, automatic delivery peritoneal dialysis systems.
- Class IV (high risk): Requires device licensing by demonstrating safety and efficacy of the device. Examples: aneurysm clips, cardiac pacemakers.

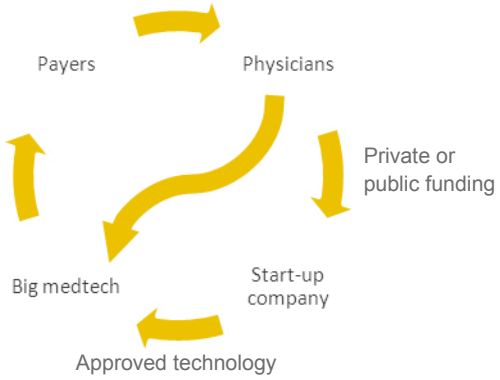
Trends in the medical devices subsector include: miniaturization and mobile solutions, advancements in minimally invasive treatments, and innovative pricing models that place more emphasis on disposable units rather than equipment that requires large capital investments. These trends highlight the pricing pressures driven by healthcare systems around the world to reduce in-patient hospital care and to shorten recovery time.

Figure 9: Global medical technology market size (2009)



Source: Datamonitor

Figure 10: Typical medical technology innovation cycle



Source: Ernst & Young

Medical device development cycle

The typical development cycle for medical devices is marked by its cyclical and incremental nature, short development time, high level of physician engagement, and small allotments of funding investments (Figure 10)[24]. Generally, start-up companies gain marketing approval for new products before transferring them to large medical technology companies for commercialization. Established companies have resources to bring products to market, but are moving from early technology acquisition and seeking products with demonstrated sales and existing customers.

Interestingly, the medical device subsector has attracted new large-scale entrants. Companies with industrial development and manufacturing expertise are enticed by the expected demand for medical devices and the historically strong market performance, and view it as an opportunity to add patent-protected products to their profit margins[10]. A major challenge for these companies is to build a highly-specialized sales force with access to physicians, healthcare institutions and hospital group purchasing organizations.

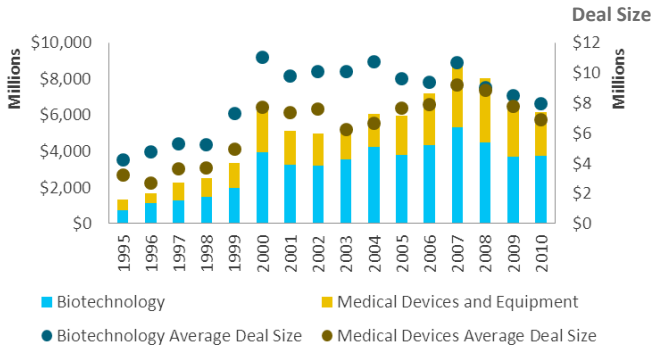
Venture capital investments in the Life Sciences

Traditionally, Life Sciences venture capital investments have focused on expansion and later-stage funding. The United States (US) is a key market for venture capital investments. The global recessionary events in 2008 and 2009 led to a contraction in Life Sciences funding in the US from a 2007 high of US$ 9.0 billion (Figure 11)[25].

Total Life Sciences investments have continued to shrink annually, sliding to US$ 6.2 billion in 2010. However, smaller-sized early-stage biotechnology deals rebounded and captured over 50% of investments in 2009 and 2010 (Figure 12). In contrast, medical device investments continue to be dominated by later stage deals (Figure 13), and tend to be smaller in size than biotechnology ones (Figure 11).

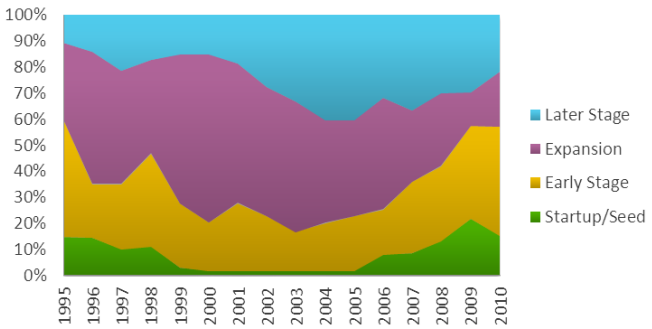
In Canada, Life Sciences investments also declined from a high of $633 million in 2007[26] to $215 million in 2009[27], demonstrating the challenging environment for raising funds. Life Sciences ranks second in investment dollars in Canada, after the information technology sector.

Figure 11: US Life Sciences venture capital investment (1995-2010)



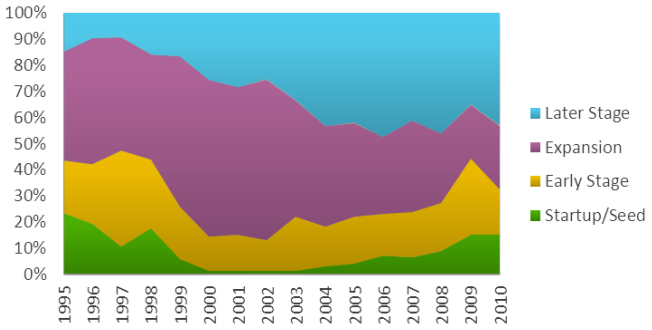
Source: PricewaterhouseCooper

Figure 12: US biotechnology venture capital investment, by share of investment stage (1995-2010)



Source: PricewaterhouseCooper

Figure 13: US medical devices venture capital investment, by share of investment stage (1995-2010)



Source: PricewaterhouseCooper

CANADA AND ONTARIO LANDSCAPE

The Life Sciences industry is strongly influenced by healthcare needs and allocation of costs. In Canada, the healthcare system revolves around a single payer-private provider model and is defined by five criteria set out by the Canada Health Act[28]:

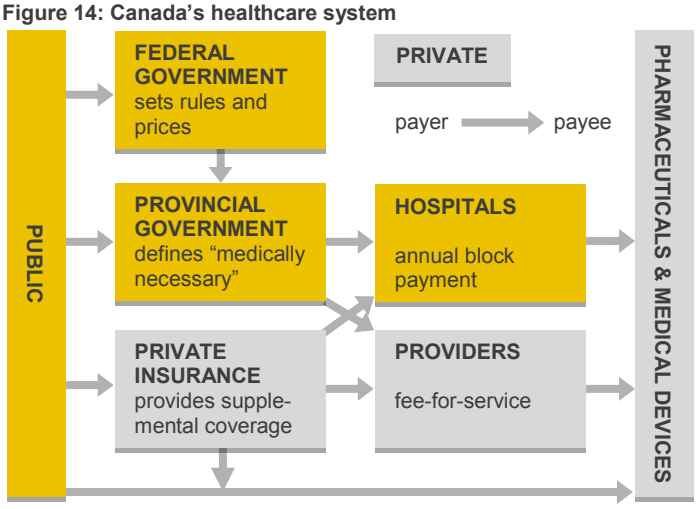
1. Public Administration
2. Comprehensiveness
3. Universality
4. Portability
5. Accessibility

Healthcare in Canada

The Canadian healthcare system is composed of 13 provincial and territorial health insurance plans. This national program was designed to "facilitate reasonable access to health services without financial or other barriers"[29]. The provincial and territorial governments are responsible for health care services for their residents, as the 'single payer', although funds are largely received via federal transfer payments in accordance with the Canada Health Transfer.

Publicly-funded insurance covers a basket of "medically necessary services" as defined by each provincial and territorial government. Private insurance is available for additional coverage of uninsured or partially covered services. It is important to note that the provincial and territorial governments are not directly involved in the delivery of healthcare services; these are provided by the private sector and publicly-funded non-profit organizations subject to government regulation (Figure 14).

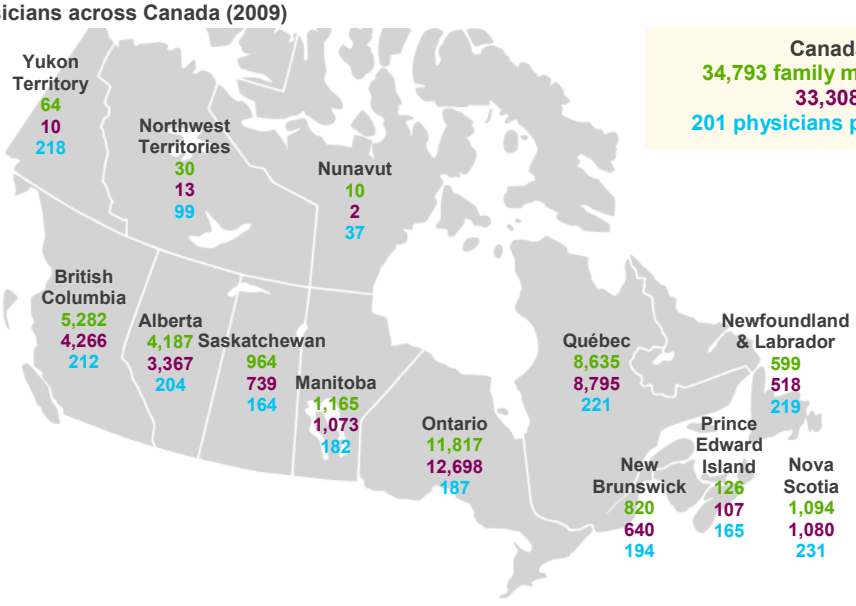
Figure 14: Canada's healthcare system



The Canadian healthcare market has a strong concentration in the province of Ontario, with 34% of family doctors and 38% of specialists in Canada. This correlates with Ontario representing 39% of Canada's population and operating six of Canada's 17 medical schools. (Figure 15)[30].

Total health expenditure in Canada grew from $22 billion in 1980 to an estimated $192 billion in 2010 (Table 3)[31]. Historically, the healthcare system in Canada has focused on hospital and physician care. Although hospitals remained

Figure 15: Distribution of physicians across Canada (2009)



Source: CIHI

the largest funded category at 29% in 2010, this portion declined from 42% of the health budget in 1980. The category with the most significant funding increase is drugs, from 8.5% to 16%, and funding for public health nearly doubled from 3.8% to 7%.

Healthcare in Ontario

The Ministry of Health and Long-Term Care provides direction and leadership to Ontario's healthcare system, and is responsible for physicians, ambulance services, laboratories, provincial drug programs, independent health facilities and public health. The Ontario Health Insurance Plan (OHIP) is the provincial health plan. Coverage includes medically necessary services by physicians, and excludes prescription drugs from pharmacies, home care services, ambulance services, and long-term care outside of Ontario.

Ontario's healthcare planning and budgeting decisions are made at the regional level by non-profit corporations called Local Health Integration Networks (LHINs). There are 14 LHINs in Ontario (Figure 16). Hospitals, community care access centres (CCACs), community support services, long-term care, mental health and addiction services, and community health centres fall under the authority of LHINs. Current priorities for Ontario's healthcare system include: shortening surgical wait times, e-health adoption, access to family healthcare, and diabetes management.

The Government of Ontario has contributed $5 billion to the Toronto Region's healthcare infrastructure since 2005 under its $30 billion ReNew Ontario strategy[32]. Over 1,000,000 square feet of new space and 350,000 square feet of renovated space in Toronto Region hospitals have been completed as of December 2011, and another 3,350,000 square feet of new space is under construction.

Industry specialties by geography

Across Canada, regions are known for industry specialties (Figure 17). Vancouver is recognized for its biotechnology scene. The Toronto Region is a hub for medical device and pharmaceutical commercial operations. Montreal is a nucleus for pharmaceutical and biotechnology activity.

Table 3: Canadian health expenditure, by use of funds

Category	1980	2010	% Point Change
Total (C$ billions)	22.3	191.6	↑ 759%
Hospitals	41.9%	29%	↓ 12.9%
Other Institutions	11.4%	10%	↓ 1.4%
Physicians	14.7%	11%	↓ 3.7%
Other Professionals	10.1%	11%	↑ 0.9%
Drugs	8.5%	16%	↑ 7.5%
Capital	4.4%	4%	↓ 0.4%
Public Health	3.8%	7%	↑ 3.2%
Administration	2.3%	3%	↑ 0.7%
Other Health Spending	2.9%	6%	↑ 3.1%

Source: CIHI

Figure 16: Ontario's Local Health Integration Networks

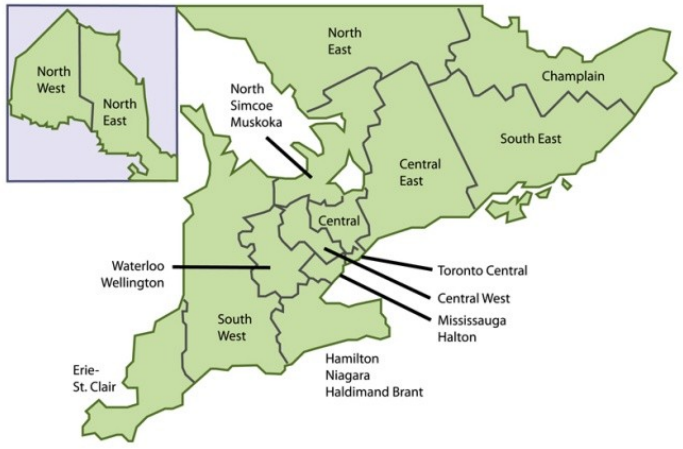
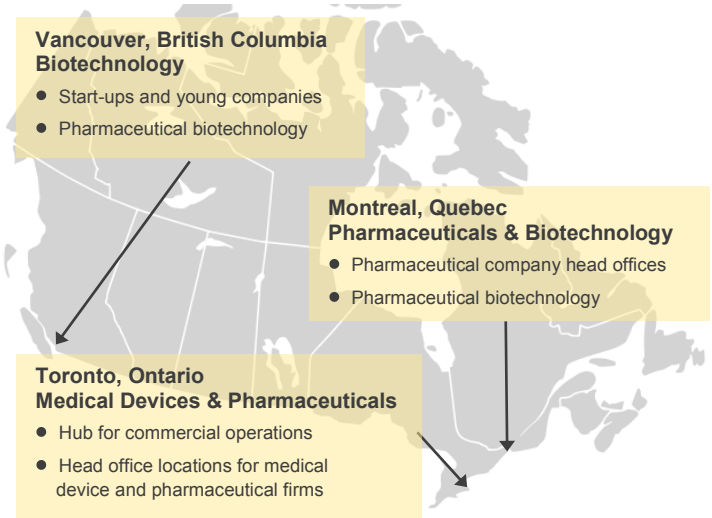


Figure 17: Major regions of Life Sciences industry in Canada



The Canadian Life Sciences market

The Canadian pharmaceutical market is the ninth-largest in the world, with over US$ 15 billion in branded drug sales[33] and over US$ 5.5 billion generic drug sales in 2010[34]. The Canadian medical device market size was over US$ 5.4 billion in 2010[35].

R&D spending in Canada and Ontario

In 2009, R&D spending in the Life Sciences in Canada was estimated at $6.4 billion, and represented nearly one-fifth of total gross domestic expenditures on R&D[36].

Academic sector performance and federal government funding contributions play an increasingly important role in Life Sciences R&D in Canada. The academic sector or 'Higher education' share of R&D performance grew from 55% in 1998 to 64% in 2009. During the same period, the private sector or 'Business enterprise' share declined from 38% to 30% (Figure 18).

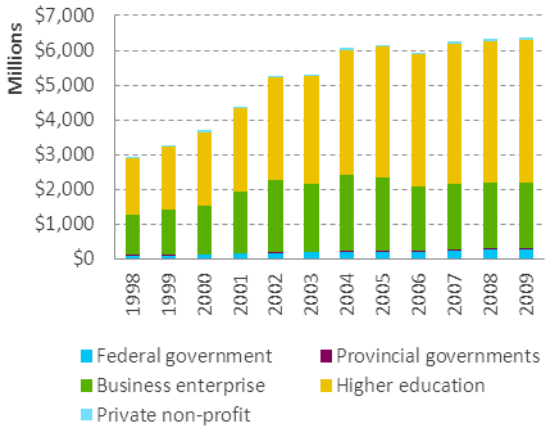
Between 1998 and 2009, the annual growth rates of R&D financing by the private sector, academic sector and federal government were 3%, 9% and 10% respectively. The federal share of funding has grown from 13% in 1998 to 21% in 2009. During the same period, the shares of academic and private sector financing declined from 29% to 27% and 32% to 23% respectively (Figure 19).

Within the academic sector, Ontario received $1.9 billion Life Sciences R&D dollars in 2007, or 47% of the total amount in Canada (Figure 20). Ontario received 56% of private sector investment in the academic sector, demonstrating the province's role as a Life Sciences R&D engine within Canada.

Financial incentives

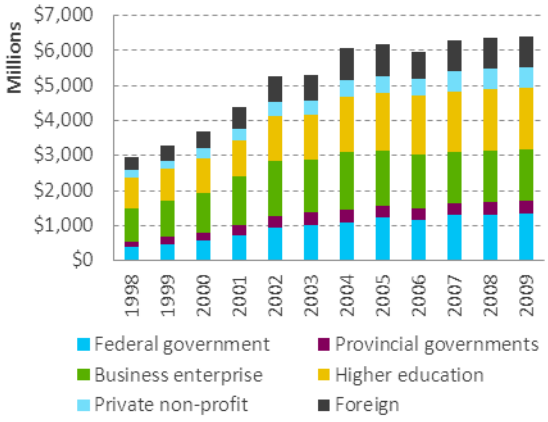
Canadian companies have access to federal and provincial tax credit and incentive programs for performing qualifying research and development work in Canada and Ontario (Table 4). Qualified applicants may reduce every $100 invested in R&D to $37 or less through these incentives. In addition, special funding programs are periodically offered to promote specific geography and sector-based collaborations (Table 5).

Figure 18: Life Sciences R&D spending by performing sector in Canada (1998-2009)



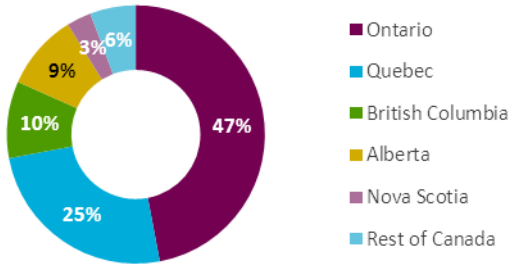
Source: Statistics Canada

Figure 19: Life Sciences R&D spending by financing sector in Canada (1998-2009)



Source: Statistics Canada

Figure 20: Academic Life Sciences R&D spending by province (2007)



Source: Statistics Canada

Table 4: Tax credit and incentive programs for innovation and scientific research

Ontario Business Research Institute Tax Credit (OBRITC)
This program provides a refundable tax credit for qualifying corporations that perform scientific research and experimental development (SR&ED) in Ontario under a contract with an eligible research institute. The OBRITC provides a 20% credit, up to a maximum annual credit of $4 million. For more information, visit: www.rev.gov.on.ca/en/credit/obritc
Ontario Flagship Program (OFP)
This program is administered by the Health Technology Exchange (HTX), a government-funded agency, as part of the Health Technology and Commercialization Program (HTCP). It supports Ontario-based multinational enterprises (including subsidiaries). The OFP provides up to 15% of the total project value, and the total project value should be between $1.5 and $15 million. For more information, visit: https://www.htx.ca/Funding/ontario_flagship_program_ofp.htm
Ontario Innovation Tax Credit (OITC)
This program provides a refundable tax credit for corporations that perform SR&ED in Ontario. The OITC provides a 10% credit, including 100% of current expenses and 40% of capital expenses, up to a maximum annual credit of $300,000. For more information, visit: www.rev.gov.on.ca/en/credit/oitc
Ontario Research and Development Tax Credit (ORDTC)
This program provides a non-refundable tax credit for corporations that carry out SR&ED in Ontario. The ORDTC provides a 4.5% credit, and may be used to reduce corporate income tax payable. For more information, visit: www.rev.gov.on.ca/en/credit/ordtc
Ontario Tax Exemption for Commercialization (OTEC)
This program provides a ten-year tax exemption for new corporations that commercialize intellectual property, including advanced health technologies, developed by qualifying Canadian universities and colleges. For more information, visit: www.rev.gov.on.ca/en/credit/otec
Federal Scientific Research and Experimental Development Tax Incentive Program (SR&ED)
This program provides cash refunds and/or tax credits to Canadian businesses for eligible R&D work performed in Canada. Canadian-controlled private corporations are eligible for a 35% investment tax credit on the first $3 million of qualified SR&ED work in Canada, and 20% thereafter. Other Canadian entities may be eligible for a 20% credit. Qualified SR&ED work includes: experimental development, applied research, basic research and support work. For more information, visit: www.cra-arc.gc.ca/txcrdt/sred-rsde/menu-eng.html

Table 5: Selected recent and ongoing financial incentive programs for international partnerships with Ontario researchers and companies

Ontario-China Research and Innovation Fund (OCRIF)
Ontario's Ministry of Economic Development and Innovation (MEDI) and China's Ministry of Science and Technology (MOST) will jointly invest up to $1 million each to support research collaborations, with neuroscience as a stated research priority. For more information, visit: http://www.mri.gov.on.ca/english/programs/ocrif/guidelines.asp
Ontario (Canada)-India Collaborative R&D Projects
This funding program provides repayable grants to private companies and non-repayable grants to publicly-funded researchers for collaborative R&D projects between Ontario and India. The funding program is delivered by International Science and Technology Partnerships Canada (ISTPCanada), the Government of Ontario and the Department of Biotechnology (India). Ontario partners are eligible to receive up to 50% of the project value, up to a maximum of $300,000. For more information, visit: http://www.istpcanada.ca/international_programs/India/IndiaActiveCFPs/index.php
Ontario-Israel Collaboration Program (OICP)
The Ontario Government and the Ministry of Industry, Trade and Labor (Israel) will support research collaborations, with neuroscience as a stated research priority. The funding program requires at least one industrial partner from either Ontario or Israel and provides up to $300,000 or up to 50% of R&D costs for technology-based products and processes for Ontario applicants. Israeli applicants are eligible for an unspecified amount of funding. For more information, visit: http://www.ciirdf.ca/international_programs/forOntarioIsrael/index.php

LIFE SCIENCES IN THE TORONTO REGION

The Toronto Region is home to Canada's largest Life Sciences cluster. It is the base for many multinational Life Sciences companies in Canada and competes with well-known Life Sciences hubs. Over 37,000 people are employed in the Life Sciences industry in the Toronto Region, compromising 30% of the Canadian Life Sciences workforce[37].

There is a critical mass of success factors which feed into Toronto Region's vibrant Life Sciences ecosystem:

- Anchor companies with supporting ancillary services
- Access to talent from highly-skilled professionals
- Prominent research centres
- A wealth of renowned experts
- Significant intellectual output

These advantages contribute to an environment that fosters medical and healthcare innovations and the flourishing Life Sciences cluster in the Toronto Region (Figure 21).

Toronto's Discovery District

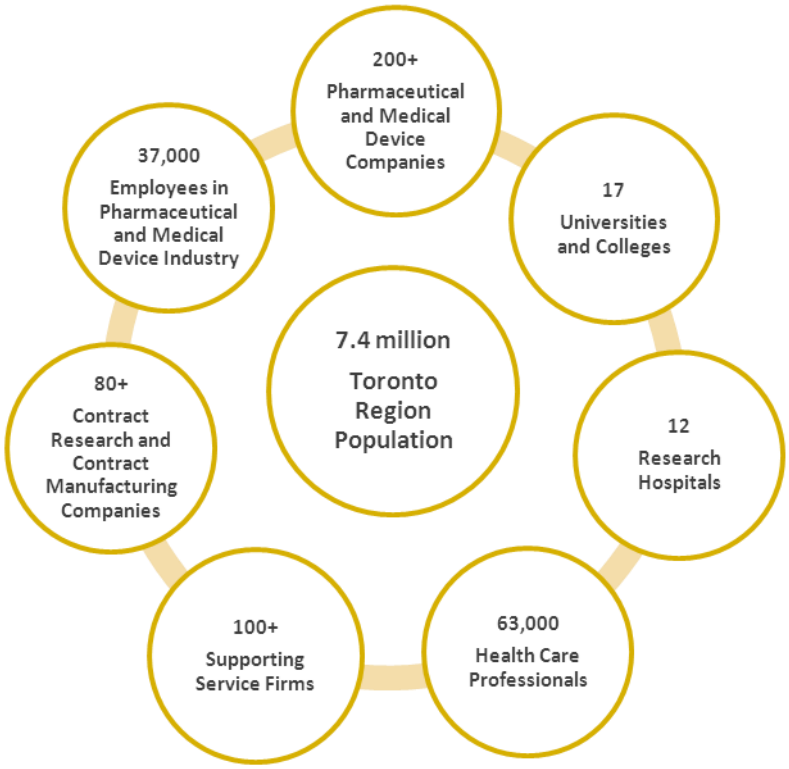
Located in the heart of downtown Toronto, the Discovery District spans 2.5 square kilometres of land and 7 million square feet of facilities including the University of Toronto and affiliated teaching and research hospitals, over 30 medical and related research centres, and a mix of biomedical companies.

Of note, the MaRS Centre is a 750,000 square foot complex that opened in 2005 in the centre of the District. It houses research space, incubator facilities and services to support science, technology and social entrepreneurship and to accelerate commercialization. A second construction phase adding 770,000 square feet commenced in 2011.

Toronto Region: the place to collaborate

With the close proximity of existing infrastructure, talent, innovative output and opportunities, the Toronto Region is the place where the Life Sciences research and industry are collaborating and thriving.

Figure 21: Life Sciences cluster in the Toronto Region



ADVANTAGE 1—INDUSTRY

The Canadian Life Sciences industry is concentrated in the Toronto Region, with over half of the pharmaceutical and medical device companies located here and substantial investment directed to the region.

Nearly 50 global pharmaceutical and biotechnology companies have their Canadian headquarters in the Toronto Region, including Amgen, AstraZeneca, Bayer, GlaxoSmithKline, Ranbaxy, Roche, Takeda and Teva. Other multinational firms with a strong presence include Sanofi Pasteur, with its storied Toronto-based Connaught campus for vaccine research, and Pfizer, which has created strong links with cancer researchers in the Toronto Region. Sixteen of the top 25 global medical device companies operate in the Toronto Region, including Baxter, Siemens, Johnson & Johnson, GE Healthcare and Medtronic.

Significant Canadian-owned companies include Apotex and Valeant Pharmaceuticals. See Table 6 for selected start-up companies and Table 7 for sample international business transactions with companies in the Toronto Region.

Table 6: Selected start-up companies in the Toronto Region

Company	Focus
AIM Therapeutics	Asthma, chronic obstructive pulmonary disease
Amorfix Life Sciences	Misfolded protein diseases
Cynapsus	Parkinson's disease
Axela	Multiplex tools for biomarker testing
Cytochroma	Chronic kidney disease
Interface Biologics	Bio-polymer technologies
NeurAxon	Pain therapeutics
PlantForm Corp	Antibody drug program
Profound Medical	Prostate cancer
Spectral Diagnostics	Sepsis
Tornado Medical Systems	Imaging and spectroscopy
Xagenic Canada	Chip-based diagnostics
YM Biosciences	Oncology
ZBx	Rapid diagnostic assays

Recent industry investments include:

- GlaxoSmithKline launched a $50 million GSK Canada Life Sciences Innovation Fund to support commercialization by academic and health institutions, translational research centres and start-up companies.
- Sanofi Pasteur opened a new $101 million vaccine R&D

Table 7: Examples of international recognition for locally-developed technologies

International Company	Toronto Region Company	Transaction	Deal Value (US$)	Opportunity
Hunan Biopharmaceutical (China)	Microbix Biosystems	Joint venture	$190 million	Vaccine purification process technology
Roche (Switzerland)	Arius Research	Acquisition	$189 million	Monoclonal antibodies for cancer
Mitsubishi Tanabe Pharma (Japan)	Cytochroma	Licensing	$104 million	Small molecular drugs for kidney research
Hologic (USA)	Sentinelle Medical	Acquisition	$85 million	Magnetic resonance imaging technology for cancer
SonoSite (USA)	VisualSonics	Acquisition	$71 million	Ultrasound devices for animal studies
Bayer (USA)	Visible Genetics	Acquisition	$61.4 million	Molecular diagnostics for infectious diseases
Luminex (USA)	Tm Bioscience	Acquisition	$44 million	Molecular diagnostics for infectious diseases and genetic disorders
Endo Pharmaceuticals (USA)	Bioniche Life Sciences	Licensing	$20 million plus milestones	Biological products for cancer
Covidien (USA)	Nuvo Research	Licensing	$10 million plus milestones	Topical formulations for pain
Kimberly-Clark (USA)	Baylis Medical	Acquisition	Undisclosed	Radio-frequency pain management business
Venturepharm (China)	AlphaRx	Research collaboration	Undisclosed	Drug delivery research in China
Philips (Netherlands)	Traxtal	Acquisition	Undisclosed	Image-guidance technology
GeneDiagnostics (China)	GeneNews	Licensing	Undisclosed	Point-of-care diagnostics for cancer

facility in Toronto in 2011, with $13.9 million in support from the Government of Ontario.

- GlaxoSmithKline announced $30 million expansion plans for their dermatological manufacturing facility in Mississauga in 2011, with $3.6 million in support from the Government of Ontario.
- GE Healthcare opened its first Pathology Innovation Centre of Excellence (PICOE) in a $17 million joint venture with Omnyx in Toronto in 2011, with $2.25 million in support from Health Technology Exchange.
- India's Lambda Therapeutic Research acquired Biovail's contract research division in Toronto in 2010.
- Teva Canada invested $56 million to expand a production plant and retain or hire over 200 skilled workers in Stouffville in 2010, with $6.5 million in support from the Government of Ontario.
- Eisai, a global R&D-based pharmaceutical company, established its presence in Canada with a wholly-owned subsidiary in Mississauga in 2010.
- Therapure Biopharma announced $27.9 million expansion plans for their bio-manufacturing facility in Mississauga in 2010, with a $4.2 million grant from the Government of Ontario.

Ancillary services

Toronto Region's Life Sciences industry has access to a host of supporting specialized services, including: contract research organizations (CROs), contract manufacturing organizations (CMOs), regulatory affairs firms, logistical firms, healthcare marketing agencies, and physician education agencies. See Table 8 for a list of selected CROs in the Toronto Region.

Table 8: Selected contract research organizations in the Toronto Region, by specialty

Preclinical	Integrated	Disease-specific
Analytical Genetics Technology Centre	Cetero Research	Allied Clinical Research (allergy)
BioPharma Services	Clinetica Biosciences International	BioSci Research (dental)
CanCog Technologies	ClinQua Clinical Trials	Canadian Health Research Centre (cardiovascular)
Custom Biologics	Criterium	Canadian Urology Research Consortium (urology)
Key Molecular Corporation	Discovery Research International	CMX Research (urology)
Lambda Therapeutic Research	INC Research	Holburn Biomedical Corp (gastrointestinal)
Omnicare	Innomar Strategies	K. Papp Clinical Research (dermatology)
Mount Sinai Services	JSS Medical	Kendle Early Stage (neurology and psychiatry)
NoAb BioDiscoveries	Manna Research	Maple Leaf Medical Clinic (HIV/AIDS)
Pharma Medica Research	Ozmosis Research	Nexus Oncology (cancer)
Toronto Centre of Phenogenomics	Pharma Medica Research	Ontario Clinical Oncology Group (cancer)
	Pharmaceutical Product Development Canada	Photospectra Health Sciences (macular degeneration)
Specialty services		
Activation Laboratories	Diteba Research Laboratories	Operatrix Consulting
Advanced Proten Technology Centre	D-TARGET	PharmEng Technology
Applied Health Research Centre	Glycemic Index Laboratories	Population Health Research Institute
Axiom Real-Time Metrics	IRB Services	Probity Medical Research
AXON Clinical Research	Matrix Bioanalytical Group	Purcell
Centre for Applied Genomics	McDougall Scientific	Scian Research Services
Clearstone Labs	NovaTox	SGS Life Sciences
Context Clinical Research	Nucro-Technics	Torealis Research
Dalton Pharma Services	Nutrasource Diagnostics	Trial Management Group

ADVANTAGE 2—TALENT

The Toronto Region offers access to highly-skilled talent with its existing Life Sciences workforce and new graduates and trainees from internationally-renowned post-secondary institutions.

In addition to receiving training at one or more of Toronto Region's post-secondary institutions, trainees may gain valuable experience in some of Canada's top academic hospitals and their research institutes located in the Toronto Region. This integrated network of scientific researchers, engineers, academic faculty and healthcare professionals generates a continuous supply of qualified Life Sciences talent.

Top talent

The Toronto Region is home to nine universities and eight colleges (Table 9). In 2009, these institutions produced over 5,800 graduates from science programs and an additional 5,300 graduates from programs relevant to medical technology (Table 10).

Over 47,000 students were enrolled in Life Sciences-related programs in 2009. Enrolment in these programs experienced 4.0% compound annual growth over the past ten years, outpacing Toronto Region population growth of 1.7% over the same time period. Notably, Life Sciences doctoral program enrolment grew by 7.0%, indicating increasing appeal for Toronto Region post-secondary training (Figure 22).

This strength in training for Life Sciences research and innovation is augmented by a vibrant and prominent clinical community. Toronto Region universities produced over 4,200 annual new graduates in medical professions, such as medicine, nursing, pharmacy, optometry, dentistry, therapy and rehabilitation, and veterinary medicine.

In addition to chemical, biomedical and biotechnology technician and technologist programs, Toronto Region colleges offer specialized curricula in clinical research and regulatory affairs. These second-entry professional programs are delivered by industry experts, and are designed to meet industry demands for highly-skilled Life Sciences professionals. The programs are well-regarded across Canada, and are situated in the Toronto Region to feed directly into the existing base of Life Sciences companies.

Table 9: Toronto Region post-secondary institutions

Universities	Colleges
McMaster University *	Centennial College
Ontario College of Art and Design (OCAD) University	Conestoga College
Ryerson University	Durham College
University of Guelph	George Brown College
University of Ontario Institute of Technology	Humber College
University of Toronto *	Mohawk College
University of Waterloo	Seneca College
Wilfrid Laurier University	Sheridan Institute of Technology
York University	

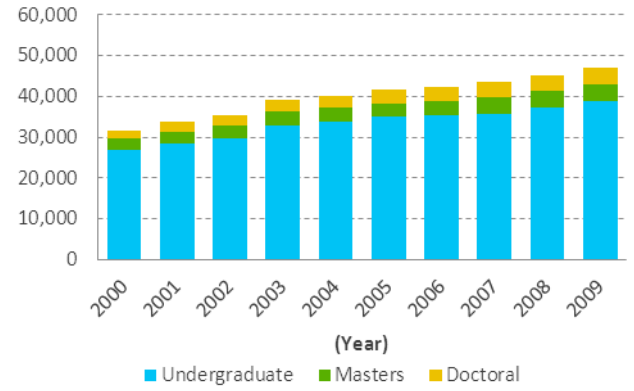
* Has a medical school

Table 10: Life Sciences-related programs, students and graduates from Toronto Region institutions (2009)

	Universities	Colleges
Programs	48	7
Enrolment (undergraduates/graduates)	38,000 / 8,300	475*
Graduation (undergraduates/graduates)	7,600 / 3,200	325*

* TRRA estimate based on available data

Figure 22: Life Sciences enrollees in Toronto Region universities



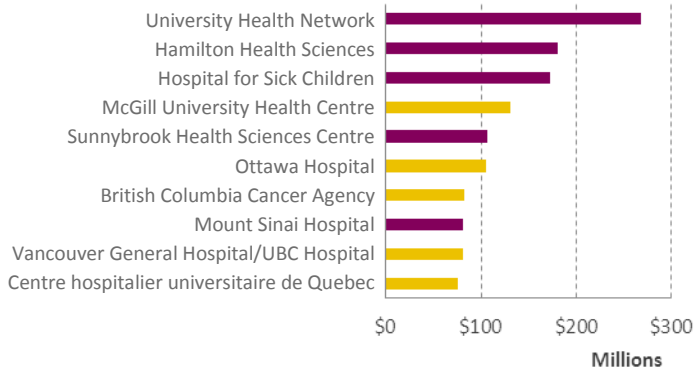
ADVANTAGE 3—RESEARCH CENTRES

State-of-the-art research facilities are attracting researchers and scientists from around the world, and large investments have been made to substantially increase the footprint of research space in the Toronto Region. Since 2005, $1 billion has been invested in over 1 million square feet of new research facilities.

Teaching hospitals

There are eleven teaching hospitals with research institutes located in the Toronto Region (Table 11). These hospitals are affiliated with medical or Life Sciences university faculty, and contribute to healthcare innovation by conducting cutting-edge research and advancing discoveries to transform patient care, as well as by training the next generation of researchers in their fields of interest.

Figure 23: Top 10 hospitals in Canada by research income (2010)



Source: RE$EARCH Infosource

Four of Canada's top five hospitals by research income in 2010 are located in the Toronto Region: University Health Network, Hamilton Health Sciences, Hospital for Sick Children, and Mount Sinai Hospital (Figure 23)[38]. Many have been approached for international partnerships to help develop new technologies, demonstrating recognition for their expertise abroad (Table 12).

Table 11: Teaching hospitals, affiliated research institutes and R&D priorities in the Toronto Region

Hospital	Affiliated Research Institute(s)	Research and Clinical Priorities
Baycrest	Rotman Research Institute	Brain function and cognition related to aging and the elderly
Holland Bloorview Kids Rehabilitation	Bloorview Research Institute	Treatments and assistive technologies for children with disabilities
Centre for Addiction and Mental Health		Mental illnesses and addiction
Hamilton Health Sciences Centre	Population Health Research Institute, Thrombosis/Atherosclerosis Research Institute, Escarpment Cancer Research Institute	Environmental and genetic factors of chronic diseases of adulthood
Hospital for Sick Children	Hospital for Sick Children Research Institute	Stem cell research, regenerative medicine technologies and genomic data for early treatment of childhood diseases
Mount Sinai Hospital	Samuel Lunenfeld Research Institute	Cellular, genomic and proteomic variations for targeted therapies against diseases
St. Joseph's Healthcare Hamilton	Firestone Institute for Respiratory Health, Hamilton Centre for Kidney Research, Brain-Body Institute	Respiratory diseases, non-invasive imaging technologies, kidney disease and dysfunction
St. Michael's Hospital	Keenan Research Centre, Li Ka Shing Knowledge Institute	Knowledge transfer, inner city health research and health in developing countries
Sunnybrook Health Sciences Centre	Sunnybrook Research Institute	Diagnostic and treatment technologies, cell-based and regenerative medicine
University Health Network (Princess Margaret Hospital, Toronto General Hospital, Toronto Western Hospital, Toronto Rehabilitation Institute)	Ontario Cancer Institute, Toronto General Research Institute, Toronto Western Research Institute	Fundamentals of disease, multidisciplinary research, commercialization, rehabilitation and home care technologies
Women's College Hospital	Women's College Research Institute	Women's health and cancer, HIV and mental health

Table 12: Selected recent international partnerships with Toronto Region hospitals and institutes

International Partner	Toronto Region Partner	Partnership
GE Healthcare (UK)	Hamilton Health Sciences	2011: Hamilton selected as first site to receive prototype molecular breast imaging technology to target breast cancer
Kuwait Cancer Care Centre (Kuwait)	University Health Network	2011: Training program for oncology nursing program in Kuwait
Hamad Medical Corporation (Qatar)	The Hospital for Sick Children	2010: Five-year partnership to create children's hospital in Doha, Qatar
Merck (USA)	Princess Margaret Hospital	2010: Global oncology research network to develop new cancer drugs
Beijing (China)	Baycrest	2010: Expertise for best practices geriatric care model in Beijing
Pfizer (USA)	Ontario Institute for Cancer Research	2009: $6 million cancer biomarker and drug development program
King Saud University (Saudi Arabia)	St Michael's Hospital	2009: Collaborative program to transfer laboratory discoveries to patient treatments

Research institutes

The Toronto Region is home to numerous institutes and centres focused on diverse medical and scientific topics, including brain research, cancer, cardiovascular, clinical trials, diabetes, genomics, medical devices, and stem cells and regenerative medicine (Table 13).

Table 13: Notable Life Sciences research institutes and centres in the Toronto Region

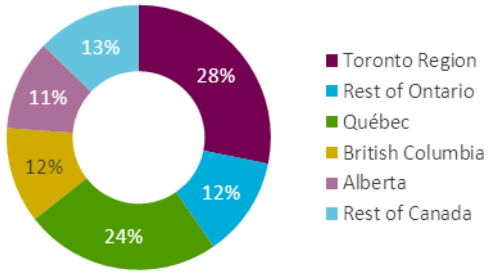
Institute	Description
Centre for Commercialization of Regenerative Medicine (CCRM)—Toronto, ON	CCRM has core scientific expertise in stem cell research and biomaterials, and aims to accelerate regenerative medicine-related products. In addition to scientific leadership, CCRM has assembled an industry consortium to access technology platforms and to provide market orientation.
Centre for Modeling Human Disease (CMHD)—Toronto, ON	CMHD generates mutant mouse models of human disease and develops phenotyping tools for researchers across Canada.
Clinical Trials Network Centre—Waterloo, ON	This centre was established by Juvenile Diabetes Research Foundation Canada (JDRF) and the Government of Canada to promote clinical diabetes research. The University of Waterloo provides technology and data management expertise and McMaster University provides clinical trials management expertise for this initiative.
McMaster Institute for Molecular Biology and Biotechnology (MOBIX)—Hamilton, ON	MOBIX is an institute at McMaster University focused on molecular biology and diagnostic and therapeutic interventions, and consists of the Antimicrobial Research Centre, the McMaster Immunology Research Centre, the Centre for Evolutionary and Genomics Biotechnology and the Centre for Functional Genomics.
Ontario Brain Institute (OBI)—Toronto, ON	OBI is a centre of excellence in brain research, translation and innovation. It provides funding, promotion, education and training of brain research across Ontario.
Ontario Genomics Institute (OGI)—Toronto, ON	OGI aims to foster, fund and manage large-scale genomics projects in Ontario and to catalyze commercialization of developed technology platforms and products.
Population Health Research Institute (PHRI)—Hamilton, ON	PHRI is a joint institute of McMaster University and Hamilton Health Sciences. The institute coordinates large, global clinical trials and has expertise in cardiovascular diseases and epidemiological studies.
Stem Cell and Cancer Research Institute (SCC-RI)—Hamilton, ON	SCC-RI is a research institute at McMaster University which focuses on human stem cell research in regenerative medicine and human cancer.
Techna Institute for the Advancement of Technology and Health (Techna)—Toronto, ON	Techna is a University Health Network-University of Toronto institute. It aims to accelerate medical technology development and clinical application in five core areas: informatics and communication technologies, guided therapeutics, nanotechnology and radiochemistry, photonics, and design and engineering for health.
Toronto Centre for Phenogenomics (TCP)—Toronto, ON	TCP operates a state-of-the-art mouse facility for academic and industry partners. It houses the Mouse Imaging Centre (MICe), Canadian Mouse Mutant Repository (CMMR), and Centre for Modeling Human Disease (CMHD).

International reputation and global reach

International consortia are also creating global networks of research expertise, and establishing bases in the Toronto Region in order to lever renowned scientific expertise and leadership.

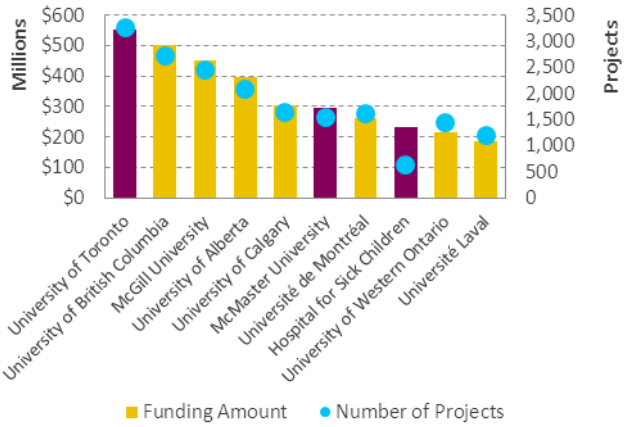
- The **Canadian Institute for Advanced Research (CIFAR)** coordinates cutting-edge research by 384 researchers across 16 countries and 103 academic and research institutions around the world. Current Life Sciences-related programs include experience-based brain and biological development, and genetic networks[39].
- The **DTCC Consortium** formed by the Toronto Centre for Phenogenomics (part of The Hospital for Sick Children), University of California Davis (USA), Children's Hospital Oakland Research Institution (USA) and Charles River Laboratories (USA) was awarded US$ 34 million by National Institutes of Health (NIH) for the five-year second phase of the Knockout Mouse Project (KOMP). KOMP2 will establish a repository of knockout mouse lines and phenotype data to be accessed by researchers around the world for the creation of models of human diseases[40].
- The **International Cancer Genome Consortium (ICGC)** is a voluntary scientific organization spanning North America, Europe, Asia and Australia, with the secretariat located at the Ontario Institute for Cancer Research (Canada). The ICGC is focused on coordinating large-scale cancer genome mapping studies and disseminating the data to the global research community[41].
- The **Structural Genomics Consortium (SGC)** is a public-private partnership operating out of the University of Oxford (UK) and the University of Toronto (Canada). Since 2004, the SGC has been accelerating drug discovery through its contribution of over 1,000 three-dimensional protein structures to the public domain, development of 120 biochemical assays, and involvement in over 240 research collaborations[42].

Figure 24: Public funding of Life Sciences research across Canada (2001-2010). Total = $6.6 billion.



Source: CFI, CIHR and NSERC

Figure 25: Top 10 Canadian institutions by public funding for Life Sciences research (2001-2010)



Source: CFI, CIHR and NSERC

Funding

Public funding of Life Sciences research was examined between 2001 and 2010. The Canada Foundation for Innovation (CFI) invests in research infrastructure[43]. The Canadian Institutes of Health Research (CIHR) is Canada's main federal funding agency for health research[44]. The Natural Sciences and Engineering Research Council of Canada (NSERC) funds basic research, academic-industry partnerships, and training of scientists and engineers[45].

Over the past decade, these agencies have invested $6.6 billion in Life Sciences research in Canada, with $1.9 billion directed to Toronto Region researchers (Figure 24) and the top ten Canadian institutions account for 51% of public funding (Figure 25). The University of Toronto was ranked #1, with $550 million for 3,200 projects. Other top Toronto Region institutions include: McMaster University with $300 million for 1,500 projects, and the Hospital for Sick Children with $230 million for 600 projects.

ADVANTAGE 4—EXPERTS

The Canada Research Chairs (CRC) program was initiated by the Government of Canada in 2000 to establish 2,000 research professorships across Canada through an annual investment of $300 million[46]. Tier 1 Chairs are awarded to established and recognized researchers in their field of study. Tier 2 Chairs are awarded to emerging researchers who are anticipated to be future leaders in their field.

The Toronto Region boasts of more Canada Research Chairs in the Life Sciences than any Canadian province (Figure 26). Nearly half of Toronto Region's Life Sciences-related Canada Research Chairs are Tier 1 (Figure 27). See Appendix D for a full list of Canada Research Chairs in the Toronto Region.

Notable research areas of strengths include:

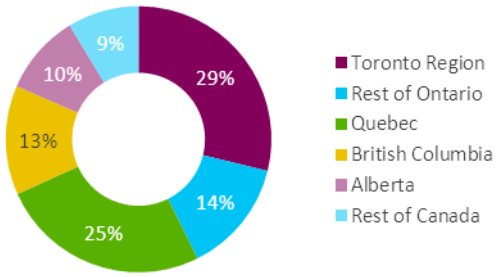
- Biochemistry
- Molecular Biology
- Infectious and Parasitic Diseases
- Information Technology
- Physical Chemistry
- Respiration
- Blood
- Animal Biology
- Evolution and Ecology

Niche areas include:

- Neoplasms
- Analytical Chemistry
- Pregnancy/Childbirth
- Bioengineering and Biophotonics
- Biomedical Signal Analysis
- Congenital Anomalies
- Design and Manufacturing

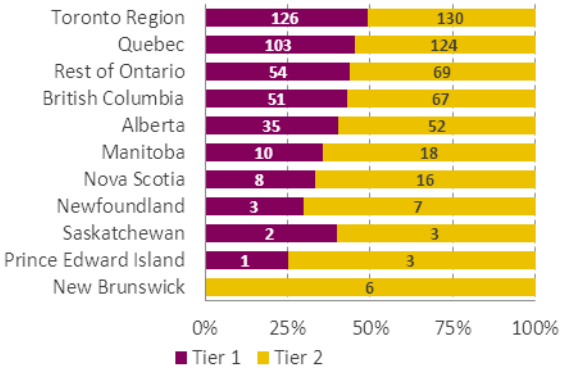
The Toronto Region has two of the top ten universities for total number of Canada Research Chairs in the Life Sciences (Figure 28). The University of Toronto is ranked #1 with 168 related Canada Research Chairs in 2010, or nearly twice as many experts as the second-ranked university. McMaster University is ranked #7 overall in Canada for number of Life Sciences experts.

Figure 26: Life Sciences-related Canada Research Chairs by province (2010). Total chairs = 888.



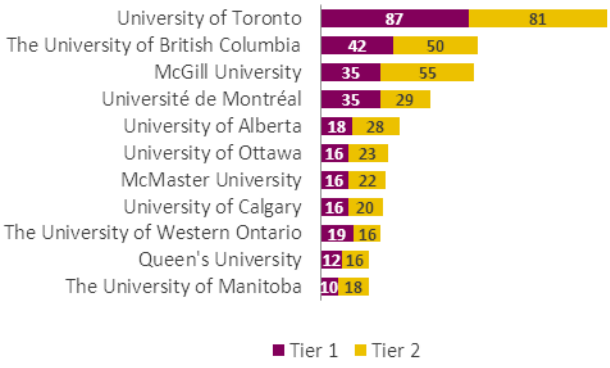
Source: CRC

Figure 27: Life Sciences-related Canada Research Chairs by province and tier (2010). Total chairs = 888.



Source: CRC

Figure 28: Life Sciences-related Canada Research Chairs, Top 10 universities (2010). Total chairs = 888.



Source: CRC

ADVANTAGE 5—INTELLECTUAL OUTPUT

The Toronto Region is a top performer for producing medical discoveries and technologies, and contributing to the scientific community at-large.

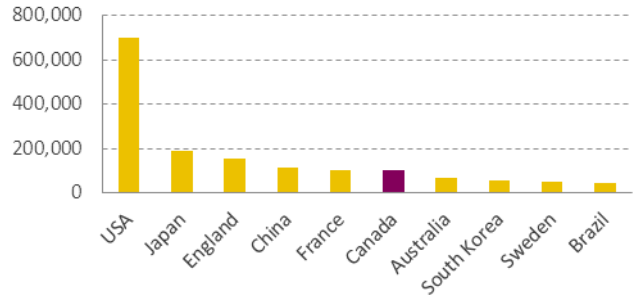
With the existing cluster of businesses, talent, institutions and experts, the Toronto Region has a reputation of excellence in Life Sciences research and development. Publications and patents are two metrics to help quantify and compare the innovative output of a sector in the region.

Publications

Life Sciences publications comprise of a vast range of subjects from scientific fields of study, such as biochemistry, immunology and radiology, to disease categories, such as cancer, infectious disease and orthopaedics. Canada is ranked #6 globally for number of Life Sciences-related publications over the past decade (Figure 29).

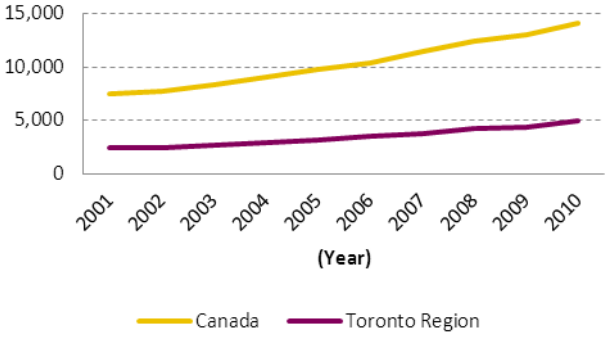
While the global number of Life Sciences-related publications has grown by 65% since 2001, Canadian contributions have grown nearly 90% and the Toronto Region contribution has more than doubled (107%). Over the same period, the Toronto Region's global share of Life Sciences-related publications has increased by 25% (from 1.4% to 1.7%, see Figure 30).

Figure 29: Top 10 countries by number of Life Sciences publications (2001-2010)



Source: Web of Science

Figure 30: Life Sciences publications in the Toronto Region and Canada (2001-2010)



Source: Web of Science

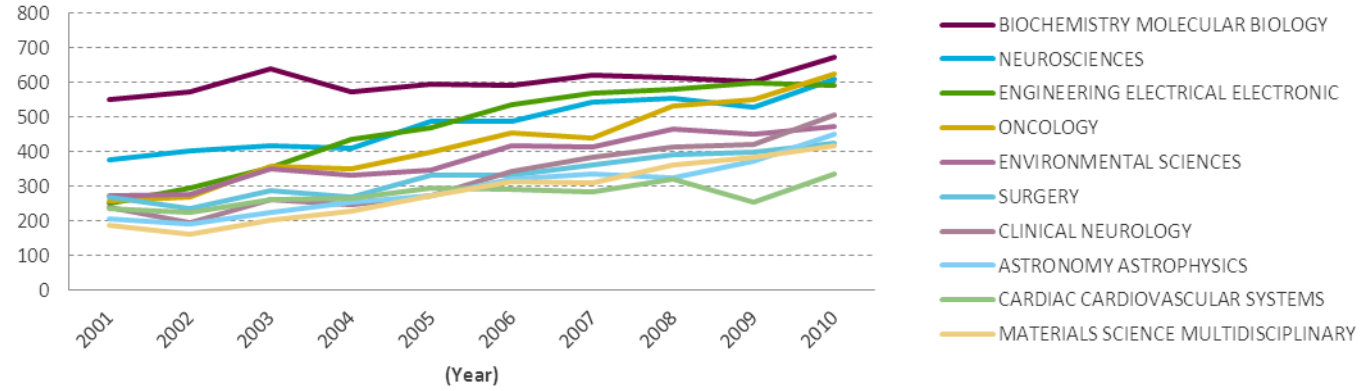
In terms of a 10-year compound annual growth rate for Life Sciences-related publications, the Toronto Region's rate of 6.2% has an edge over the global rate of 5.7% (Table 14).

Table 14: Life Sciences publications over the past decade

Region	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
World	176,300	180,300	191,700	202,800	214,600	226,300	242,800	259,700	274,100	291,600
Canada	7,500	7,800	8,400	9,100	9,800	10,400	11,400	12,400	13,100	14,200
Toronto Region	2,400	2,500	2,700	2,900	3,200	3,500	3,700	4,200	4,400	5,000

Within the overall top ten scientific categories (not restricted to Life Sciences) attributed to the Toronto Region, notable categories include: Oncology (a ten-year CAGR of 10.2%), Electrical or Electronic Engineering (10.0%), Materials Science (9.3%), Astronomy or Astrophysics (9.0%) and Clinical Neurology (8.7%) (Figure 31). From the next ten categories, publications attributed to the Toronto Region in Public, Environmental, and Occupational Health (9.7%) and Radiology, Nuclear Medicine, and Medical Imaging (9.5%) have also grown rapidly.

Figure 31: Top 10 categories of scientific publications in the Toronto Region (2001-2010)



Source: Web of Science

Table 15: Granted Life Sciences patents over the past decade

Region	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
World	33,100	31,800	32,200	27,500	23,100	27,900	25,700	23,500	24,200	33,500
Canada	930	960	940	840	670	860	820	770	760	990
Toronto Region	303	300	280	230	200	280	290	260	220	310

Source: Delphion

Patents

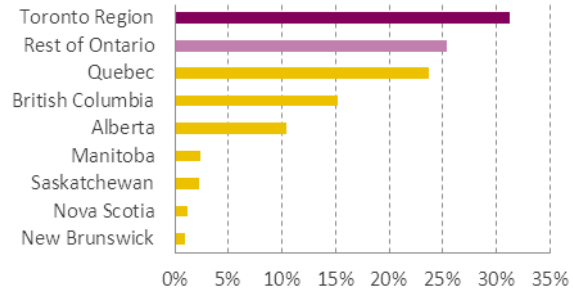
Patents are a form of intellectual property in which exclusive rights to an invention are granted to inventors or their assignees for a specific period of time. Patents are often used as a measure of innovativeness.

Over the past decade, the number of granted Life Sciences-related patents experienced a low of 23,000 in 2005 to a high of 33,500 in 2010 (Table 15)[47]. Inventors in the Toronto Region and Canada have consistently contributed 1% and 3% respectively of the global total.

Between 2001 and 2010, Toronto Region inventors were granted nearly 2,700 Life Sciences-related patents, or over 30% of the total Canadian output, contributing to more patents than any province outside of Ontario (Figure 32).

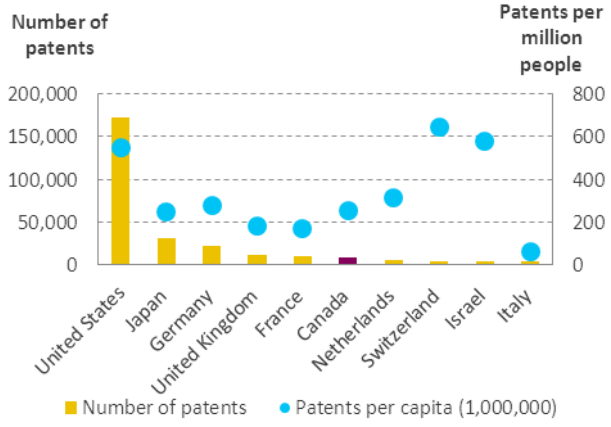
Canada is the sixth-ranked country in the number of Life Sciences-related patents, with over 8,500 patents granted between 2001 and 2010. On a per capita basis, Canada is ranked sixth with about 255 Life Sciences-related patents granted per 1,000,000 people (Figure 33).

Figure 32: Percentages of Canadian Life Sciences-related patents by province (2001-2010)



Source: Delphion

Figure 33: Number of granted patents and patents per capita for inventors by country (2001-2010)

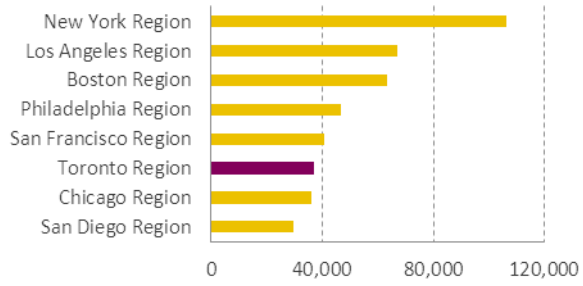


Source: Delphion

LIFE SCIENCES CLUSTER BENCHMARK COMPARISON

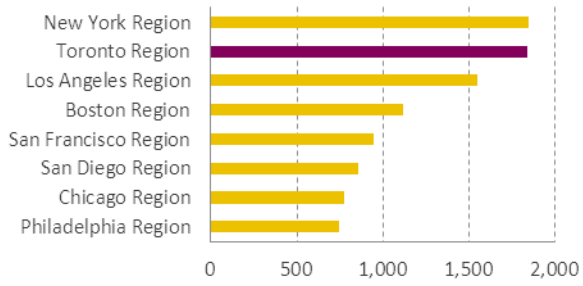
A number of metropolitan areas across North America have strong Life Sciences business clusters. The Toronto Region compares favourably in industry size, as measured by size of labour force and number of companies. See Figures 34 and 35 for the top Life Sciences regions in North America by employment size and number of establishments[37,48].

Figure 34: Top regions in North America by number of Life Sciences-related jobs (by NAICS code)



Sources: U.S. Census Bureau and Statistics Canada

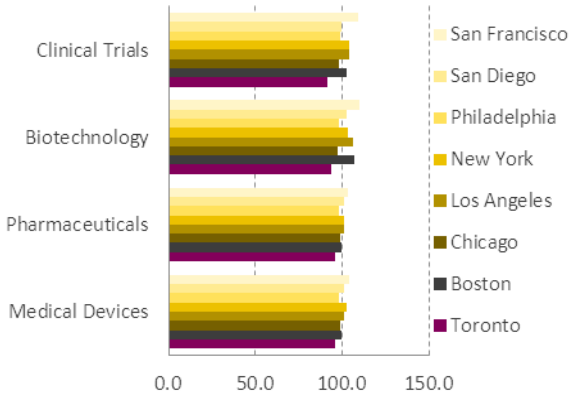
Figure 35: Top regions in North America by number of Life Sciences-related establishments (by NAICS code)



Sources: U.S. Census Bureau and Statistics Canada

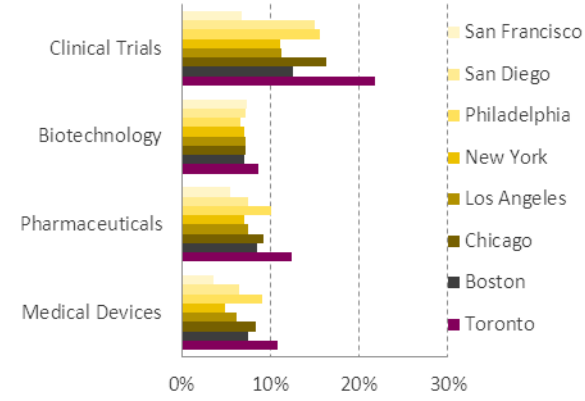
Cost factors contribute to Toronto Region's attractiveness for Life Sciences businesses. KPMG's annual Competitive Alternatives report on business locations includes four Life Sciences subsectors: medical devices manufacturing, pharmaceuticals manufacturing, biotechnology R&D and clinical trials management. Across the identified North American Life Sciences cluster regions, the Toronto Region is the top performer for lowest business costs and highest net profit as a percentage of sales for each subsector. See Figure 36 and 37[49].

Figure 36: Business cost index by subsector (U.S. average = 100.0)



Source: KPMG

Figure 37: Net profit as % of sales by subsector



Source: KPMG

Table 16: Average salary comparison for common pharmaceutical and biotechnology roles (US$)

Role	San Francisco, CA	Philadelphia, PA	New York, NY	Chicago, IL	Boston, MA	Toronto Region
Chemical Plant Operator	62,500	55,000	59,500	55,000	58,000	58,500
Clinical Research Coordinator	110,500	95,500	105,000	97,000	103,500	98,500
Regulatory Affairs Manager	131,000	114,000	135,000	114,500	124,000	108,000
Research Chemist	95,500	82,000	90,000	84,000	89,500	81,500
Quality Assurance Analyst	105,000	89,000	100,500	92,000	98,000	92,500

Source: ERI Salary Assessor

Table 17: Average salary comparison for common medical technology roles (US$)

Role	San Francisco, CA	Philadelphia, PA	New York, NY	Chicago, IL	Boston, MA	Toronto Region
Electrical Engineer	111,500	95,000	106,000	97,500	105,000	92,000
Field Service Technician	62,000	53,500	59,500	84,500	85,500	60,000
Quality Assurance Analyst	99,500	84,500	95,500	87,000	93,000	87,500
Quality Control Tester	71,500	61,500	68,000	62,000	67,000	65,500
Regulatory Affairs Manager	123,000	107,000	127,000	107,500	116,500	101,500

Source: ERI Salary Assessor

Tables 16 and 17 contain the average salaries of typical Life Sciences positions in selected cities with significant Life Sciences industries[50]. The Toronto Region's salaries for Life Sciences professionals are lower or comparable to other known clusters in North America.

CONCLUSION

Innovation plays a critical role in the economic growth of all countries, from emerging to advanced industrial markets. The Life Sciences is a common priority sector for many governments, because it is closely tied to improved health outcomes, increased healthcare efficiencies and the enrichment of each country's standard of living. R&D activities are key to the success of the Life Sciences sector.

It is important to note that the industry is constantly seeking ingenuity internally and externally, and has a strong and growing relationship with academic research communities. In this regard, Canada is a well-known leader for developing research talent and scientific expertise in the field. It is no surprise that Canada has one of the largest Life Sciences markets in the world, despite its small population size.

The Toronto Region is home to the largest Life Sciences cluster in Canada, and fourth-largest cluster in North America. Companies that set up businesses here have access to generous financial incentive programs and research funding to help offset R&D costs.

The Toronto Region is recognized as one of the top regions in the world to perform and collaborate on Life Sciences R&D and business activities. The region plays host to top Life Sciences multinational companies and supporting ancillary services, a well-trained and highly-skilled workforce, research centres and post-secondary institutions known for their research excellence, prominent researchers, and key innovative contributions in the form of publications and patents.

Significant business prospects exist in the Toronto Region for Life Sciences businesses, including:

- Research collaborations with local experts, research centres and research-focused companies.
- Licensing agreements and acquisition of innovative products and technology platforms.
- Setting up sales offices to access the North American market.
- Setting up R&D and manufacturing facilities with support from local talent and ancillary services.

The Toronto Region has emerged as a prime business location for global Life Sciences investment and innovation. Given the existing research strengths and multinationals' interest in the region, there is tremendous opportunity for businesses to join the Life Sciences hub in the Toronto Region, while fostering the continued growth of the sector. The cluster provides a rich backdrop of research activity and productivity, in which industry and academic Life Sciences sector participants collaborate on common goals of discovery, technology development and innovation.

APPENDICES

Appendix A—Methodology and Notes

All currency figures are in Canadian dollars unless otherwise noted.

APPENDIX B—Abbreviations

CAGR	Compound annual growth rate
CCAC	Community Care Access Centre
CFI	Canada Foundation for Innovation
CIFAR	Canadian Institute for Advanced Research
CIHR	Canadian Institutes for Health Research
CMO	Contract manufacturing organization
CRC	Canada Research Chairs
CRO	Contract research organization
CHA	Canada Health Act
EMEA	European Medicines Agency
FDA	Food and Drug Administration in the United States
GDP	Gross domestic product
GSK	GlaxoSmithKline
ICGC	International Cancer Genome Consortium
KOMP	Knockout Mouse Project
LHIN	Local Health Integration Network
M&A	Mergers and acquisitions
NAICS	North American Industry Classification System
NIH	National Institutes of Health
NSERC	Natural Sciences and Engineering Research Council of Canada
OHIP	Ontario Health Insurance Plan
OTC	Over-the-counter pharmaceuticals
PCR	Polymerase chain reaction
R&D	Research and development
SGC	Structural Genomics Consortium
SR&ED	Scientific, research and experimental development

Appendix C—Sector Definition

The sector definition is based on the 2007 North American Industry Classification System (NAICS). The following codes were included:

325410	Pharmaceutical and Medicine Manufacturing
334512	Measuring, Medical and Controlling Devices Manufacturing
339110	Medical Equipment and Supplies Manufacturing
541710	Research and Development in the Physical, Engineering and Life Sciences

APPENDIX D—TABLES

Life Sciences related university programs

Area of Study	Specialization
General Science	General Science
Agricultural/Biological Sciences	Animal Science, Plant Science, Soil Science, Other Agriculture, Biochemistry, Genetics, Microbiology, Other Biology, Biophysics, Botany, Household Science, Food Science/Nutrition, Veterinary Sciences, Veterinary Specialities, Zoology, Toxicology
Engineering/Applied Science	Chemical Engineering, Electrical Engineering, Mechanical Engineering, Engineering Science, Engineering General
Health Professions/Occupations (only graduate-level enrollees included)	Biochemistry, Genetics, Microbiology, Biophysics, Dentistry, Dental Specialties, Medicine, Anatomy, Embryology, Endocrinology, Pharmacology, Physiology, Other Basic Sciences, Medical Specialties, Immunology, Pathology, Other Paraclinical Sciences, Surgical Specialties, Optometry, Pharmacy, Aural/Oral Rehabilitation, Other Rehabilitation, Medical Technology, Other Health Professions
Mathematics/Physical Sciences	Computer Science, Chemistry

Life Sciences related college programs

	Specialization
Technical (Diploma)	Biotechnology Technician, Biotechnology Technologist, Biomedical Engineering Technology, Bioinformatics, Chemical Laboratory Technology – Pharmaceutical
Specialty (Graduate Certificate)	Clinical Research, Regulatory Affairs/Pharmaceutical Regulatory Affairs and Quality Operations

Canada Research Chairs in the Life Sciences in the Toronto Region (2010)

Name	Tier	Research Discipline	Chair Title
MCMASTER UNIVERSITY			
Andrews, David W.	1	Biochemistry	Membrane Biogenesis
Ayers, Paul W.	2	Theoretical Physics and Chemistry	Theoretical Chemistry and Chemical Biology
Bennett, Patrick	1	Psychology in NSE	Vision Science
Bhandari, Mohit	2	Musculo-Skeletal	Musculoskeletal Trauma and Surgical Outcomes
Bhatia, Mick	1	Molecular Biology	Human Stem Cell Biology
Boyle, Michael	1	Population Health - General	the Social Determinants of Child Health
Brennan, John D.	2	Analytical Chemistry	Bioanalytical Chemistry
Brown, Eric	2	Biochemistry	Antimicrobial Research
Cook, Deborah J.	1	Health Services Research - General	Canada Research Chair of Research Transfer in Intensive Care
Doble, Bradley	2	Molecular Biology	Stem Cell Signaling
Draper, Jonathan	2	Cell Biology	Human Stem Cell Lineage Commitment
Eikelboom, John	2	Blood	Cardiovascular Medicine
Fang, Qiyin	2	Biomedical Engineering	Biophotonics
Fradin, Cécile	2	Cell Biology	Molecular Biophysics
Ghosh, Raja	2	Chemical Engineering	Bioseparations Engineering
Golding, G. Brian	1	Evolution and Ecology	Bioinformatics
Hayward, Catherine P.	2	Blood	Molecular Hemostasis
Hitchcock, Adam	1	Physical Chemistry	Canadian Light Source-Canada Research Chair for Materials Analysis
Jordana, Manel	1	Respiration	Immunobiology of Respiratory Diseases and Allergy
Larché, Mark	1	Life Sciences Related to Human Health and Disease	Allergy and Immune Tolerance
Lavis, John N.	2	Multidisciplinary Health Research	Knowledge Transfer and Exchange
Li, Yingfu	2	Biochemistry	Directed Evolution of Nucleic Acids
Mothersill, Carmel	1	Biochemistry	Radiobiology
Nair, Parameswaran	2	Respiration	Airway Inflammometry
Nikolova, Natalia	2	Electrical and Electronic Engineering	High-Frequency Electromagnetics
Norman, Geoffrey R.	1	Education	Cognitive Dimensions of Clinical Expertise

Canada Research Chairs in the Life Sciences in the Toronto Region (2010)

Name	Tier	Research Discipline	Chair Title
MCMASTER UNIVERSITY			
Paré, Guillaume	2	Other in HS	Genetic and Molecular Epidemiology
Poinar, Hendrik	2	Biochemistry	Paleogenetics
Rosenbaum, Peter L.	1	Multidisciplinary Health Research	Childhood Disability Research, Dissemination and Mentoring
Rutherford, M.D.	2	Psychology in NSE	Social Perceptual Development
Sekuler, Allison	2	Psychology in NSE	Cognitive Neuroscience
Singh, Sheila	2	Molecular Biology	Human Cancer Stem Cell Biology
Steinberg, Gregory	2	Metabolism and Nutrition	Metabolism, Obesity and Type 2 Diabetes
Weitz, Jeffrey	1	Blood	Thrombosis
Whelan, Timothy	2	Neoplasms	Health Services Research in Cancer
Wong, Kon Max	1	Electrical and Electronic Engineering	Signal Processing
Wood, Christopher M.	1	Animal Biology	Environment and Health
Wright, Gerard D.	1	Biochemistry	Molecular Studies of Antibiotics
RYERSON UNIVERSITY			
Guan, Ling	1	Information Technology	Multimedia and Computer Technology
Kolios, Michael	2	Biomedical Engineering	Biomedical Applications of Ultrasound
Krishnan, Sridhar	2	Biomedical Signal Analysis	Biomedical Signal Analysis
Sidani, Souraya	1	Health Services Research - General	Design and Evaluation of Health Interventions
Wolfaardt, Gideon M.	2	Evolution and Ecology	Environmental Interfaces and Biofilms
Yang, Victor	2	Bioengineering and Biophotonics	Bioengineering and Biophotonics
UNIVERSITY OF GUELPH			
Bienzle, Dorothee	2	Multidisciplinary Health Research	Veterinary Pathology
Hall, J. Christopher	1	Multidisciplinary in NSE	Recombinant Antibody Technology
King, Allan	1	Animal Biology	Animal Reproductive Biotechnology
Ladizhansky, Vladimir	2	Cell Biology	Biophysics
Lam, Joseph S.	1	Microbiology	Cystic Fibrosis and Microbial Glycobiology
Mason, Georgia	2	Animal Biology	Animal Welfare

Canada Research Chairs in the Life Sciences in the Toronto Region (2010)

Name	Tier	Research Discipline	Chair Title
UNIVERSITY OF GUELPH			
Sharom, Frances	1	Biochemistry	Membrane Protein Biology
Weese, J. Scott	2	Infectious and Parasitic Diseases	Zoonotic Diseases
Whitfield, Chris	1	Microbiology	Molecular Microbiology
UNIVERSITY OF ONTARIO INSTITUTE OF TECHNOLOGY			
Forbes, Shari	2	Analytical Chemistry	Decomposition Chemistry
McGregor, Carolyn	2	Information Technology	Health Informatics
UNIVERSITY OF TORONTO			
Arrowsmith, Cheryl	1	Biochemistry	Structural Proteomics
Aarts, Michelle	2	Molecular Biology	Signal Transduction in Ischemia
Agrawal, Aneil	2	Evolution and Ecology	Genetics of Evolutionary Interactions
Alman, Benjamin	2	Musculo-Skeletal	
Anderson, Adam	2	Psychology in SSH	Cognitive Neuroscience
Angers, Stephane	2	Molecular Biology	Functional Architecture of Signal-Transduction Complexes
Attisano, Liliana	1	Biochemistry	Signalling Networks in Cancer
Bassett, Anne S.	1	Mental and Behavioural Disorders	Schizophrenia Genetics
Bazett-Jones, David P.	1	Cell Biology	Molecular and Cellular Imaging
Belsham, Denise	2	Endocrinology	Neuroendocrinology
Birn, Anne-Emanuelle	2	Population Health - General	International Health
Bombardier, Claire	1	Health Services Research - General	Knowledge Transfer for Musculoskeletal Care
Boone, Charles	1	Molecular Biology	Proteomics, Bioinformatics and Functional Genomics
Boulianne, Gabrielle	1	Central Nervous System -Organic	Molecular and Developmental Neurobiology
Brooks, Dina	2	Respiration	Rehabilitation for Chronic Obstructive Pulmonary Disease
Brown, Ian	1	Central Nervous System -Organic	Neurology of Stress
Brubaker, Patricia L.	1	Endocrinology	Vascular and Metabolic Biology
Brudno, Michael	2	Other in NSE	Computational Biology

Canada Research Chairs in the Life Sciences in the Toronto Region (2010)

Name	Tier	Research Discipline	Chair Title
UNIVERSITY OF TORONTO			
Chan, Warren	2	Biomedical Engineering	Biotechnology
Chang, Belinda S.	2	Molecular Biology	Comparative Evolutionary Neurobiology
Chau, Tom	2	Multidisciplinary Health Research	Pediatric Rehabilitation Engineering
Cheung, Peter	2	Biochemistry	Chromatin Regulation
Ciruna, Brian	2	Genetics	Developmental Genetics and Cell Biology
Clarke, David M.	1	Biochemistry	Membrane Biology
Collins, Richard	1	Molecular Biology	Proteomics, Bioinformatics and Functional Genomics
Cowen, Leah	2	Microbiology	Microbial Genomics and Infectious Disease
Culotti, Joseph G	1	Molecular Biology	Molecular Neurogenetics
Cunningham, John	2	Psychosocial Behavioural Research - General	Brief Interventions in Addictive Behaviours
Cutter, Asher	2	Genetics	Evolutionary Genomics
Dennis, Cindy-Lee	2	Pregnancy/Childbirth	Perinatal Community Health
Dennis, James W.	1	Cell Biology	Glycobiology
Dick, John E.	1	Blood	Stem Cell Biology
Drucker, Daniel J.	1	Diabetes Mellitus	Regulatory Peptides
Dumont, Daniel	1	Molecular Biology	Angiogenic and Lymphangiogenic Signalling
Durocher, Daniel	2	Molecular Biology	Proteomics, Bioinformatics and Functional Genomics
Eleftheriades, George	1	Electrical and Electronic Engineering	Nano- and Micro-Structured Electromagnetic Materials and Applications
El-Sohemy, Ahmed	2	Metabolism and Nutrition	Nutrigenomics
Fish, Eleanor	1	Infectious and Parasitic Diseases	Women's Health and Immunobiology
Fleming, Alison	1	Psychology in NSE	Behavioural Neurobiology and Genetics
Floras, John S.	1	Cardiology	Integrative Cardiovascular Biology
Foster, Stuart	1	Biomedical Engineering	Ultrasound Imaging
Frankland, Paul W.	2	Life Sciences Related to Human Health and Disease	Cognitive Neurobiology
Frappier, Lori D.	1	Molecular Biology	Molecular Virology
Frey, Brendan	2	Electrical and Electronic Engineering	Information Processing and Machine Learning

Canada Research Chairs in the Life Sciences in the Toronto Region (2010)

Name	Tier	Research Discipline	Chair Title
UNIVERSITY OF TORONTO			
Gagnon, France	2	Population Health - General	Genetic Epidemiology
Ganguli, Rohan	1	Mental and Behavioural Disorders	Chronic Disease Management
George, Susan R.	1	Mental and Behavioural Disorders	Molecular Neuroscience
Giaever, Guri	2	Genetics	Chemical Genetics
Gilbert, Richard E.	1	Diabetes Mellitus	Diabetes Complications
Gingras, Anne-Claude	2	Biochemistry	Functional Proteomics
Girardin, Stephen	2	Infectious and Parasitic Diseases	Innate Immunity and Microbial Pathogenesis
Grady, Cheryl	1	Mental and Behavioural Disorders	Neurocognitive Aging
Gramolini, Anthony	2	Cardiology	Cardiovascular Proteomics and Molecular Therapeutics
Green, Robin E.A.	2	Psychosocial Behavioural Research - General	Traumatic Brain Injury—Cognitive Rehabilitation Neuroscience
Guttman, David	2	Genetics	Comparative Genomics
Hanley, Anthony J.	2	Diabetes Mellitus	Epidemiology of Type 2 Diabetes
Harris, Tony	2	Cell Biology	Cell Polarity and Animal Development
Heerklotz, Heiko	2	Drugs/Pharmaceutical Sc./Chemistry/Nonmedical Use of Drugs	Lipid Science and Technology
Henkelman, R. Mark	1	Multidisciplinary Health Research	Imaging Technologies in Human Disease and Preclinical Models
Heximer, Scott	2	Cardiology	Cardiovascular Physiology
Horner, Richard	1	Respiration	Sleep and Respiratory Neurobiology
Howell, Patricia Lynne	1	Biochemistry	Structural Biology
Hughes, Timothy R.	2	Molecular Biology	Functional Genomics
Hynynen, Kullervo	1	Multidisciplinary Health Research	Imaging Systems and Image-Guided Therapy
Ikura, Mitsuhiko	1	Molecular Biology	Cancer Structural Biology
Jadad, Alejandro R.	1	Information Technology	eHealth Innovation
Jenkins, David J. A.	1	Metabolism and Nutrition	Nutrition and Metabolism
Jha, Prabhat	2	Population Health - General	Health and Development

Canada Research Chairs in the Life Sciences in the Toronto Region (2010)

Name	Tier	Research Discipline	Chair Title
UNIVERSITY OF TORONTO			
Jockusch, Rebecca	2	Physical Chemistry	Biophysical Analytical Chemistry
John, Sajeev	1	Condensed Matter Physics	Optical Sciences
Josselyn, Sheena A.	2	Life Sciences Related to Human Health and Disease	Molecular and Cellular Cognition
Jurisica, Igor	2	Artificial Intelligence	Integrative Computational Biology
Jurisicova, Andrea	2	Life Sciences Related to Human Health and Disease	Molecular and Reproductive Medicine
Kain, Kevin C.	1	Infectious and Parasitic Diseases	Molecular Parasitology
Kaplan, David	1	Neoplasms	Cancer and Neuroscience
Kassner, Andrea	2	Physics	Neuro-Imaging
Kaul, Rupert	2	Infectious and Parasitic Diseases	HIV
Kay, Lewis	1	Biochemistry	Proteomics, Bioinformatics and Functional Genomics
Keller, Gordon M.	1	Cell Biology	Embryonic Stem Cell Biology
Kerbel, Robert	1	Neoplasms	Tumour Biology, Angiogenesis and Anti-Angiogenic Therapy
Kislinger, Thomas	2	Biochemistry	Proteomics in Cancer Research
Klip, Amira	1	Biochemistry	Cell Biology of Insulin Action
Kumacheva, Eugenia	1	Polymer Chemistry	Advanced Polymer Materials
Lam, Tony	2	Metabolism and Nutrition	Obesity
Lambe, Evelyn	2	Central Nervous System -Organic	Developmental Cortical Physiology
Levine, Joel	2	Genetics	Cardiac Regeneration
Li, Ren-Ke	1	Cardiology	Infectious Diseases and Inflammation
Liles, W. Conrad	1	Infectious and Parasitic Diseases	Statistical Methods for Health Care
Lou, W.Y. Wendy	2	Statistics and Probability	Neurogenetics
Lozano, Andres M.	1	Molecular Biology	Neuroscience
Lye, Stephen	1	Pregnancy/Childbirth	Improvement in Health and Function
Mak, Tak	1	Cell Biology	Inflammation Responses and Traumatic Injury
Mandelis, Andreas	1	Biomedical Engineering	Diffusion-Wave Sciences and Technologies
Martin, Alberto	2	Life Sciences Related to Human Health and Disease	Antibody Diversification

Canada Research Chairs in the Life Sciences in the Toronto Region (2010)

Name	Tier	Research Discipline	Chair Title
UNIVERSITY OF TORONTO			
McCulloch, Christopher	1	Cell Biology	Matrix Dynamics
Meyer, Jeffrey	2	Physical Chemistry	Neurochemistry of Major Depressive Disorder
Miller, Freda D.	1	Central Nervous System -Organic	Developmental Neurobiology
Minassian, Berge	2	Genetics	Pediatric Neurogenetics
Mogridge, Jeremy	2	Microbiology	Bacterial Pathogenesis
Moran, Michael F	1	Biochemistry	Molecular Therapeutics
Naguib, Hani	2	Materials Science and Technology	Smart and Functional Polymers
Nagy, Andras	1	Genetics	Stem Cells and Regeneration
Narod, Steven A.	1	Neoplasms	Breast Cancer
Nathens, Avery	2	Accidents, Poisoning, Violence	Systems of Trauma Care
Neal, Radford	1	Statistics and Probability	Statistics and Machine Learning
Neel, Benjamin	1	Life Sciences Related to Human Health and Disease	Signal Transduction and Human Disease
Ohashi, Pamela	1	Cell Biology	Autoimmunity and Tumour Immunity
Ohh, Michael	2	Neoplasms	Molecular Oncology
Okamoto, Kenichi	2	Central Nervous System -Organic	Molecular and Cellular Neuroscience
Orser, Beverley	2	Central Nervous System -Organic	Anaesthesia
Pai, Emil F.	1	Biochemistry	Structural Biology
Park, Chul B.	1	Design and Manufacturing	Microcellular Plastics
Paterson, Andrew D.	2	Genetics	Genetics of Complex Diseases
Pelletier, Laurence	2	Cell Biology	Centrosome Biogenesis and Function
Penn, Linda	1	Neoplasms	Molecular Oncology
Pomès, Régis	2	Mental and Behavioural Disorders	
Post, Martin	1	Respiration	Fetal, Neonatal and Maternal Health
Raught, Brian	2	Life Sciences Related to Human Health and Disease	Proteomics and Molecular Medicine
Redelmeier, Donald A.	1	Health Services Research - General	Medical Decision Sciences
Reid, Nancy	1	Statistics and Probability	Statistical Theory and Applications

Canada Research Chairs in the Life Sciences in the Toronto Region (2010)

Name	Tier	Research Discipline	Chair Title
UNIVERSITY OF TORONTO			
Robertson, Janice	2	Cell Biology	Molecular Mechanisms of Amyotrophic Lateral Sclerosis
Robinson, Brian	1	Metabolism and Nutrition	Vascular and Metabolic Biology
Robinson, Lisa A.	2	Life Sciences Related to Human Health and Disease	Leukocyte Migration in Inflammation and Injury
Roder, John C.	1	Central Nervous System -Organic	Learning and Memory
Rosenblum, Norman D.	1	Congenital Anomalies	Developmental Nephrology
Rotin, Daniela	1	Biochemistry	Biochemistry and Signal Transduction
Rowe, Locke	1	Evolution and Ecology	Evolutionary Ecology
Roy, Peter J.	2	Genetics	Molecular Neurobiology
Ryan, Jennifer	2	Multidisciplinary Health Research	Cognitive Neuroscience of Memory
Salter, Michael W.	1	Central Nervous System -Organic	Neuroplasticity and Pain
Sellen, Daniel	2	Anthropology	Human Ecology and Public Nutrition
Sessle, Barry J.	1	Central Nervous System -Organic	Craniofacial Pain and Sensorimotor Function
Sharpe, Simon	2	Biochemistry	Structural Biology of Membrane-Active Proteins
Sherman, Philip Martin	1	Gastro Intestinal Disease	Gastrointestinal Disease
Shoichet, Molly	1	Biomedical Engineering	Tissue Engineering
Shojania, Kaveh G.	2	Health Services Research - General	Patient Safety and Quality Improvement
Sicheri, Frank	1	Molecular Biology	Structural Principles of Signal Transduction
Siminovitch, Katherine	1	Life Sciences Related to Human Health and Disease	Mechanisms Regulating Immunologic Disease
Simmons, Craig	2	Biomedical Engineering	Mechanobiology
Sokolowski, Marla	1	Genetics	Genetics and Behavioural Neurology
Stanford, William L.	2	Genetics	Stem Cell Bioengineering and Functional Genomics
Stanley, Elise F.	1	Central Nervous System -Organic	Molecular Brain Science
Stephan, Douglas	1	Inorganic Chemistry	Inorganic Materials and Catalysis
Stewart, Bryan A.	2	Central Nervous System -Organic	Molecular Genetics of Neural Communication
Straus, Sharon E.	1	Health Services Research - General	Knowledge Translation and Quality of Care
Sugita, Shuzo	2	Central Nervous System -Organic	Intercellular Communication

Canada Research Chairs in the Life Sciences in the Toronto Region (2010)

Name	Tier	Research Discipline	Chair Title
UNIVERSITY OF TORONTO			
Sun, Yu	2	Mechanical Engineering	Micro and Nano Engineering Systems
Tillier, Elisabeth	2	Genetics	Analytical Genomics
Trimble, William S.	1	Cell Biology	Molecular Cell Biology
Tu, Jack V.	1	Health Services Research - General	Health Services Research
Tymianski, Michael	1	Molecular Biology	Translational Stroke Research
Tyndale, Rachel F.	2	Mental and Behavioural Disorders	Pharmacogenetics
Uetrecht, Jack	1	Drugs/Pharmaceutical Sc./Chemistry/Nonmedical Use of Drugs	Immunotoxicology
Upshur, Ross	2	Health Services Research - General	Primary Care Research
Van Lieshout, Pascal	2	Multidisciplinary Health Research	Oral Motor Function Across the Lifespan
Verma, Subodh	2	Cardiology	Atherosclerosis
Volchuk, Allen	2	Cell Biology	Diabetes
Walker, Gilbert	1	Physical Chemistry	Molecular Microscopy and Nanophotonic Devices
Wang, Lu-Yang	2	Central Nervous System -Organic	Brain and Behaviour
Wheeler, Aaron R.	2	Analytical Chemistry	Bioanalytical Chemistry
Wilde, Andrew	2	Cell Biology	Molecular Medicine and Cell Biology
Wodak, Shoshana	1	Molecular Biology	Computational Biology and Bioinformatics
Wrana, Jeffrey	1	Cell Biology	Systems Biology
Wright, Graham A.	1	Biomedical Engineering	Imaging for Cardiovascular Therapeutics
Zamble, Deborah B.	2	Biochemistry	Metallobiochemistry
Zandstra, Peter	1	Biomedical Engineering	Stem Cell Bioengineering
Zhuo, Min	1	Central Nervous System -Organic	Pain and Cognition
Zúñiga-Pflücker, Juan-Carlos	1	Blood	Developmental Immunology
UNIVERSITY OF WATERLOO			
Callaghan, Jack	2	Musculo-Skeletal	Spine Biomechanics and Injury Prevention
Chen, Pu	2	Chemical Engineering	Nano-Biomaterials
Chou, C. Perry	2	Chemical Engineering	Biomanufacturing

Canada Research Chairs in the Life Sciences in the Toronto Region (2010)

Name	Tier	Research Discipline	Chair Title
UNIVERSITY OF WATERLOO			
Cook, Richard	1	Statistics and Probability	Statistical Methods for Health Research
Danckert, James A.	2	Psychology in NSE	Cognitive Neuroscience
Duhamel, Jean	2	Materials Science and Technology	Characterization of Synthetic and Biological Macromolecules by Fluorescence
Eliasmith, Chris	2	Multidisciplinary in NSE	Theoretical Neuroscience
Foldvari, Marianna	1	Biomedical Engineering	Bionanotechnology and Nanomedicine
Heikkila, John J.	1	Molecular Biology	Stress Protein Gene Research
Irving, Elizabeth	2	Animal Biology	Vision Science
Itier, Roxane J.	2	Psychology in NSE	Cognitive Neuroimaging and Neurodevelopmental Disorders
Li, Dongqing	1	Mechanical Engineering	Micro-Fluidics and Nano-Fluidics
Li, Ming	1	Information Technology	Bioinformatics
Mansour, Raafat R.	1	Electrical and Electronic Engineering	Micro and Nano Integrated RF Systems
Munro, J. Ian	1	Information Technology	Algorithm Design
Pawliszyn, Janusz	1	Analytical Chemistry	New Analytical Methods and Technologies
Ren, Carolyn	2	Mechanical Engineering	Lab-on-a-Chip Technology
Rush, James	2	Life Sciences Related to Human Health and Disease	Integrative Vascular Biology
Staines, W. Richard	2	Central Nervous System -Organic	Sensorimotor Control
Wan, Justin	2	Information Technology	Scientific Computing
Yeow, John	2	Biomedical Engineering	Micro and Nanodevices
Zhou, Norman Y.	2	Materials Science and Technology	Microjoining
WILFRID LAURIER UNIVERSITY			
Melnik, Roderick	1	Applied Mathematics	Mathematical Modelling
Servos, Philip R.	2	Psychology in NSE	Cognitive Neuroscience
YORK UNIVERSITY			
Benchimol, Samuel	1	Molecular Biology	Biomedical Health Research
Bohme, Diethard	1	Physical Chemistry	Chemical Mass Spectrometry
Crawford, J. Douglas	1	Central Nervous System -Organic	Visual-Motor Neuroscience

Canada Research Chairs in the Life Sciences in the Toronto Region (2010)

Name	Tier	Research Discipline	Chair Title
YORK UNIVERSITY			
Hood, David A.	1	Life Sciences Related to Human Health and Disease	Cell Physiology
Katz, Joel	1	Multidisciplinary Health Research	Health Psychology
Krylov, Sergey N.	2	Analytical Chemistry	Bioanalytical Chemistry
Tsotsos, John	1	Artificial Intelligence	Computational Vision
White, K. Andrew	2	Molecular Biology	Plant Biotechnology and Structural Biology
Wu, Jianhong	1	Applied Mathematics	Industrial and Applied Mathematics

APPENDIX E—VISUAL

Word map of Toronto Region's Canada Research Chairs research descriptions

Source: TRRA analysis of CRC database; Image created on wordle.net

APPENDIX — ENDNOTES

[1]OECD. (2010). *OECD Health Data 2010*. Paris: Organisation for Economic Co-operation and Development.

[2]WHO. (2011). *World Health Statistics 2011*. Geneva: WHO Press.

[3]BIS. (2010, November). *2010 R&D Scoreboard*. Retrieved February 15, 2011, from Department for Business Innovation & Skills: http://webarchive.nationalarchives.gov.uk/20101208170217/http://www.innovation.gov.uk/rd_scoreboard/?p=3

[4]Datamonitor. (2010). *Global Pharmaceuticals, Biotechnology & Life Sciences*. New York: Datamonitor.

[5]Datamonitor. (2010). *Global Health Care Equipment & Supplies*. New York: Datamonitor.

[6]Harrison, C. (2011, January). Patent watch: the patent cliff steepens. *Nature Reviews Drug Discovery*, 10(1), 12-13.

[7]Alazraki, M. (2011, February 27). *10 Popular Drugs Set to Lose Their Patents*. Retrieved June 16, 2011, from Daily Finance: http://www.dailyfinance.com/2011/02/27/top-selling-drugs-are-about-to-lose-patent-protection-ready

[8]Calcoen, D., Davis, S., Durand, C., & Schweizer, C. (2010, December). High *Science 2010: Rising to the Challenge of Driving Medtech Innovation in Turbulent Times*. Retrieved June 22, 2011, from In Vivo for Boston Consulting Group: http://www.bcg.com/documents/file70753.pdf

[9]Business Insights. (2009, August). *Summary for the CRO Market Outlook: Emerging markets, leading players and future trends*. Retrieved September 12, 2011, from Reportlinker: http://www.reportlinker.com/p0148141-summary/The-CRO-Market-Outlook-Emerging-markets-leading-players-and-future-trends.html

[10]Lawyer, P., & Alford, R. (2005, June). *Industrial Revolution: The New Medical Device Acquirers*. Retrieved June 22, 2011, from In Vivo: The Business & Medicine Report: http://www.bcg.com/documents/file14633.pdf

[11]FierceMedicalDevices. (2011, September 28). Sony *acquires Micronics, Inc., US diagnostic device development venture, Acquisition to accelerate development and commercialize*. Retrieved September 28, 2011, from FierceMedicalDevices: http://www.fiercemedicaldevices.com/press-releases/sony-acquires-micronics-inc-us-diagnostic-device-development-venture-acquis?utm_medium=nl&utm_source=internal

[12]Private Equity Professionals. (2010, March 29). *Private equity grabs chunk of medical device market*. Retrieved September 12, 2011, from Private Equity Professionals Digest: http://pepdigest.com/index.php?option=com_content&view=article&id=3469:private-equity-grabs-chunk-of-medical-device-market-&catid=34:news-to-know&Itemid=24

[13]Wilson, D. (2011, June 15). *Johnson & Johnson to End Line of Drug-Coated Heart Stents*. Retrieved June 16, 2011, from New York Times: http://www.nytimes.com/2011/06/16/health/16stent.html?_r=1&ref=health

[14]Randall, T. (2011, July 8). *Pfizer unit sales add payoff to pipeline drugs in deal seen at $22 billion*. Retrieved July 8, 2011, from Bloomberg: http://www.bloomberg.com/news/2011-07-08/pfizer-unit-sales-add-payoff-to-pipeline-drugs-in-deal-seen-at-22-billion.html

[15]IMS Institute for Healthcare Informatics. (2011, May). *The Global Use of Medicines: Outlook Through 2015*. Retrieved June 15, 2011, from IMS Institute for Healthcare Informatics: http://www.imshealth.com/portal/site/imshealth/menuitem.0103f29c72c419cd88f611019418c22a/?vgnextoid=755548274bb9e210VgnVCM100000ed152ca2RCRD#

[16]Light, D. W., & Warburton, R. (2011, March). *Demythologizing the high costs of pharmaceutical research*. BioSocieties, 6, 34-50.

[17]CGPA. (2010, February). *Generic Prescription Drug Development*. Retrieved June 15, 2011, from Canadian Generic Pharmaceutical Association: http://www.canadiangenerics.ca/en/resources/docs/GenericDrugDevelopment.pdf

[18]Datamonitor. (2010). *Global Biotechnology*. New York: Datamonitor.

[19]Thomson Reuters Pharma. (n.d.). *Technologies database*. Retrieved May 24, 2011, from Thomson Reuters Pharma: http://www.thomson-pharma.com/

[20]BIO. (2010, May). *Healing, Fueling, Feeding: How Biotechnology Is Enriching Your Life*. Retrieved June 20, 2011, from Biotechnology Industry Organization: http://www.valueofbiotech.com/sites/default/files/pdfs/BioReport_HEAL%20Only.pdf

[21]Government of Canada. (2011, June 15). *Food and Drugs Act (R.S.C., 1985, c. F-27)*. Retrieved June 27, 2011, from Department of Justice, Canada: http://laws-lois.justice.gc.ca/eng/acts/F-27/FullText.html

[22]MaRS. (2010). *How Devices are Approved in Canada*. Retrieved June 28, 2011, from MaRS Entrepreneur's Toolkit: http://www.marsdd.com/dms/entrepreneurtoolkit/Regulatory-PDFs/How_Devices_Are_Approved_in_Canada/

[23]Health Canada. (2009, February 3). *DRAFT Guidance for the Risk-based Classification System*. Retrieved June 28, 2011, from Drugs and Health Products: http://www.hc-sc.gc.ca/dhp-mps/md-im/applic-demande/guide-ld/risk5_risque5_main_principal-eng.php

[24]E&Y. (2010, October). *Pulse of the industry: Medical technology report 2010*. Retrieved June 27, 2011, from Ernst & Young, Medical Technology: http://www.ey.com/Publication/vwLUAssets/Pulse_Industry_Medical_Technology_Report-OCT-2010/$FILE/PulseIndustryMedicalTechnologyReport%20OCT%202010.pdf

[25]PricewaterhouseCooper. (2011). *MoneyTree(TM) Report*. Retrieved July 26, 2011, from PricewaterhouseCoopers: MoneyTree(TM) Survey Report: https://www.pwcmoneytree.com/MTPublic/ns/nav.jsp?page=historical

[26]Industry Canada. (2007). *Venture Capital Monitor, Q4 2007*. Retrieved July 26, 2011, from SME Financing Data Initiative: http://www.sme-fdi.gc.ca/eic/site/sme_fdi-prf_pme.nsf/eng/h_02055.html

[27]CVCA. (2010). *Think Canada (Again)*. Retrieved July 26, 2011, from Canada's Venture Capital & Private Equity Association: http://www.vcractive.com/clients/CVCA_Think_Canada_Again/

[28]Government of Canada. (2011, September 14). *Canada Health Act*. Retrieved September 27, 2011, from Department of Justice: http://lois-laws.justice.gc.ca/eng/acts/C-6/FullText.html

[29]Government of Canada. (2010, April 19). *Canada Health Act (CHA)*. Retrieved September 27, 2011, from Health Canada: http://www.hc-sc.gc.ca/hcs-sss/medi-assur/cha-lcs/index-eng.php

[30]CIHI. (2010, December). *Supply, Distribution and Migration of Canadian Physicians*. Retrieved September 27, 2011, from Canadian Institute for Health Information: http://secure.cihi.ca/cihiweb/products/SMDB_2009_EN.pdf

[31]CIHI. (2010, October 27). *National Health Expenditure Trends, 1975 to 2010*. Retrieved March 7, 2011, from Canadian Institute for Health Information: https://secure.cihi.ca/estore/productSeries.htm?pc=PCC52

[32]Infrastructure Ontario. (2011). *Current Projects*. Retrieved December 8, 2011, from Infrastructure Ontario: http://www.infrastructureontario.ca/What-We-Do/Projects/Current-Projects/

[33]IMS Health. (2010, December). *2010 Pharmaceutical Market Performance by Segment.* Retrieved March 28, 2011, from IMS Health: http://www.imshealth.com/deployedfiles/imshealth/Global/Americas/North%20America/Canada/Web%20Article/News_Releases/2010CanadaPharmaResults-TablesEN.pdf

[34]CGPA. (2011). *The Canadian Generic Market Year 2010*. Retrieved August 8, 2011, from Canadian Generic Pharmaceutical Association: http://www.canadiangenerics.ca/en/resources/market_trends.asp

[35]Mergent. (2011, March). *North America: Medical Equipment Sectors*. Fort Mill: Mergent, Inc.

[36]Statistics Canada. (2010, March). *Science Statistics: Estimates of total spending on research and development in the health field in Canada 1998 to 2009*. Retrieved March 9, 2011, from http://www.statcan.gc.ca/pub/88-001-x/88-001-x2010003-eng.pdf

[37]Statistics Canada. (2011, April 7). *Industry - North American Industry Classification System 2002 (433), Class of Worker (6) and Sex (3) for the Labour Force 15 Years and Over of Canada, Provinces, Territories, Census Metropolitan Areas and Census Agglomerations, 2006 Census*. Retrieved June 28, 2011, from 2006 Census: Data Products: http://www12.statcan.gc.ca/census-recensement/2006/dp-pd/tbt/Rp-eng.cfm?LANG=E&APATH=3&DETAIL=0&DIM=0&FL=A&FREE=0&GC=0&GID=0&GK=0&GRP=1&PID=92102&PRID=0&PTYPE=88971,97154&S=0&SHOWALL=0&SUB=742&Temporal=2006&THEME=74&VID=0&VNAMEE=&VNAMEF=

[38]RE$EARCH Infosource. (2011). *Canada's Top 40 Research Hospitals 2011*. Retrieved December 1, 2011, from Canada's Hospital Innovation Leaders: http://www.researchinfosource.com/2011Top40sup.pdf

[39]CIFAR. (2011). *CIFAR By the Numbers*. Retrieved December 8, 2011, from Canadian Institute for Advanced Research: http://www.cifar.ca/cifar-by-the-numbers

[40]The Hospital for Sick Children. (2011, September 29). *Scientific Consortium awarded $34 million from the National Institutes of Health*. Retrieved December 7, 2011, from The Hospital for Sick Children Newsroom: http://www.sickkids.ca/AboutSickKids/Newsroom/Past-News/2011/Scientific-Consortium-awarded.html

[41]International Cancer Genome Consortium. (2011, July 15). *International Cancer Genome Consortium*. Retrieved September 13, 2011, from International Cancer Genome Consortium: http://www.icgc.org/

[42]Chawaf, A. A. (2011, August 9). Manager, Strategic Alliances, Structural Genomics Consortium. (J. Chan, Interviewer)

[43]CFI. (2011). *Funded Projects Database*. Retrieved October 13, 2011, from Canada Foundation for Innovation: https://www2.innovation.ca/pls/fci/fcienrep.base

[44]CIHR. (2011). *Funding Decisions Data*. Retrieved October 13, 2011, from Canadian Institutes of Health Research: http://webapps.cihr-irsc.gc.ca/cfdd/db_search?p_language=E

[45]NSERC. (2011). *Awards Search Engine*. Retrieved October 13, 2011, from Natural Sciences and Engineering Research Council of Canada: http://www.outil.ost.uqam.ca/CRSNG/Outil.aspx?Langue=Anglais

[46]CRC. (2011). *Chairholders: Find an Expert*. Retrieved May 18, 2011, from Canada Research Chairs: http://www.chairs-chaires.gc.ca/chairholders-titulaires/index-eng.aspx

[47]Delphion. (2011). http://www.delphion.com

[48]U.S. Census Bureau. (2008). *2008 County Business Patterns (NAICS)*. Retrieved June 27, 2011, from U.S. Census Bureau: http://censtats.census.gov/cgi-bin/msanaic/msadetl.pl

[49]KPMG. (2010, March 30). *Competitive Alternatives - Detailed Results*. Retrieved June 28, 2011, from Competitive Alternatives: KPMG's Guide to International Business Location: http://www.competitivealternatives.com/results/locationmenu.aspx

[50]ERI. (2011, June). *Salary Assessor*. Redmond, WA: Economic Research Institute.

For more information:

info@trra.ca
Tel: 1 146 673 6670
www.trra.ca