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CANADA'S TOP 100 CORPORATE R&D SPENDERS
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CANADA'S INNOVATION LEADERS 2018

Doubling down on impact

Researchers and institutions are under increasing pressure to maximize the impact of publicly funded research. It's changing the paradigm for how science is done – and who is doing it.

By Debbie Lawes

Two realities have governed scientific research from its early days. The first is that only individuals with a Ph.D., or those in training for one, conduct research. Secondly, scientists are rewarded with tenure, promotions and grant funding for publishing their research in scientific journals that few outside of academia read.

That disconnect has been most pronounced between those who generate new knowledge and those who ultimately will use it. These "knowledge users" usually weren't asked about their needs, didn't participate in the research, and had little say when it came to translating the results of that research into practical applications.

Dr. Vivek Goel, Vice President, Research and Innovation at the University of Toronto (U of T), described this as the "traditional knowledge-push" approach.

How times are changing. Government and philanthropic research funders want to see more "knowledge pull" from those needing solutions. As a result, they are demanding greater accountability for publicly funded research, including meaningful partnerships with non-academics and evidence of impact. At the same time, many of today's so-called "wicked problems" have no easy solutions – everything from climate change and conflict to obesity and homelessness. A better way was needed.

"Now the talk is about co-creation of knowledge," says Goel. "You sit down with your community partners from the very start to identify what's important to you, what problems you need solving and how we can work with you … It can't be something the universities do own their own. It has to be led by the community."

U of T has taken two recent steps to encourage collaborations that increase research impact. One has been strengthening partnerships with local government, community groups and charitable organizations. "We created a staff position in our research services office to court those sort of partnership projects … we're really starting to build that research area," says Goel.

In 2017, the university also established the President's Impact Award to recognize researchers who have an impact on society beyond academia or a specific field of research.

"We recognize great teachers and great researchers at U of T but we have not similarly recognized those individuals who take their research out of the university and have an impact on society," explains Goel. "It gives these scholars recognition and credit for those activities, beyond the traditional 'publish or perish' reward approach."

RESEARCH BY AND FOR INUIT

Maximizing the impact of scientific research has become essential in Canada's far north where the effects of climate change are affecting everything from food security and health to housing and infrastructure. The urgent need to understand and adapt to those changes is transforming how research is done: from research *on* Inuit to research *with* Inuit and, more recently research *by and for* Inuit.

This evolving approach reflects the findings of the report by the Truth and Reconciliation Commission which stresses the importance of research models in which "Aboriginal communities have ownership, control, access, and possession."

Université Laval has been a pioneer in northern research for more than 50 years. Today, it is the host institution for several major programs, including the ArcticNet Network of Centres of Excellence, the Amundsen research icebreaker, Sentinel North and the Quebec northern institute. In one project Laval's Dr. Michel Allard is collaborating with residents in the small village of Salluit in northern Quebec (Nunavik) to understand how thawing permafrost will impact their plans for new residential and economic development.

"The goal is to help them to produce urban planning maps for community expansion, and improve the stability and safety of their major infrastructure like airport runways and bridges," says Dr. Eugénie Brouillet, Laval's Vice Rector, Research, Creation, and Innovation.

"We also have to integrate their knowledge into the planning of the research and the project itself," she adds. "The results need to be directly relevant to the community's needs."

The Quebec northern institute, for example, has a First Peoples Working Group that includes members from the Cree, Innu, Inuit and Naskapi nations who define research needs and priorities for indigenous communities. Similarly, ArcticNet has Inuit representatives on both its board of directors and management committee, "so they are involved in all aspects of the research program," explains Brouillet.

The Social Sciences and Humanities Research Council (SSHRC) has promoted research by and with Indigenous peoples since the early 2000s. It is currently looking at ways to better support Indigenous-led research.

"How can we make it easier for non-academic institutions to be involved and to partner with researchers?" says Dr. Brent Herbert-Copley, Executive Vice President at SSHRC.

"We have put in guidelines for the evaluation of indigenous research across our funding so that peer review committees have guidance in terms of how to make judgements on that," he says. "We also work really hard to involve indigenous experts and scholars in our adjudication committees. Where we have committees that are dealing specifically with indigenous research, we involve elders in that process."

A recent review of SSHRC's partnership activities found that research is more likely to have an impact on policy and organizational practice when non-academic partners are deeply integrated in the research project, including establishing its objectives and planning the work.

> Several reports published in recent years show that Canada needs to do better in accelerating the application and translation of knowledge.
>
> **Marc Fortin, Vice-President of Research Partnerships, Natural Sciences and Engineering Research Council**

Such was the case with Laval researcher Dr. Marie-Hélène Gagné who has a long-standing partnership with child protection agencies in Quebec to reduce the incidence of child neglect and physical and psychological abuse. That partnership produced a model for child protection services that has been adopted in parts of Quebec, resulting in decreased wait times, better quality of service and better access to services.

"That's a nice example of where the researcher, working in close partnership with social service agencies and non-governmental organizations is leading to concrete changes on the ground and meaningful change in terms of peoples' lives," says Herbert-Copley.

PUTTING "KNOWLEDGE USERS" FIRST

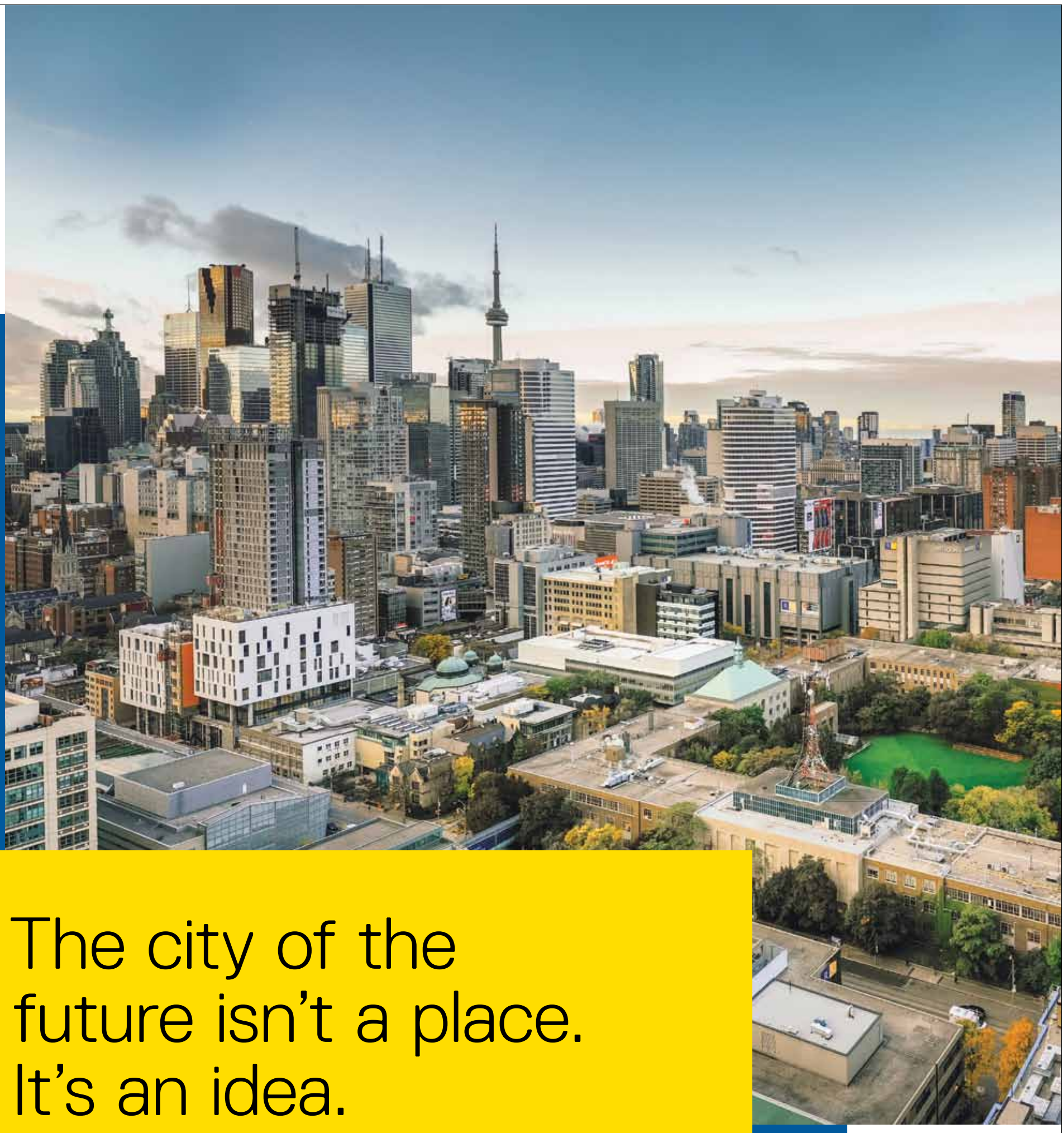
Granting agencies like SSHRC and the Natural Sciences and Engineering Research Council (NSERC) want more of their grantees – the knowledge generators – to partner with knowledge users.

"Canada ranks ninth amongst 34 OECD (Organisation for Economic Co-operation and Development) countries in terms of the most often cited publications, so we do well in terms of knowledge generation," says Marc Fortin, Vice-President of Research Partnerships at NSERC. "But several reports published in recent years show that Canada needs to do better in accelerating the application and translation of knowledge."

Towards that end, NSERC wrapped up a cross-country consultation in October with companies, public sector organizations and not-for-profits on its Research Partnerships Programs. NSERC plans to shrink its six programs into one, creating a single point of entry to quickly and easily start a first partnership and then grow it.

"We are modernizing and simplifying those programs to increase the connectivity between different components of the innovation system," says Fortin. "And as part of that, we will make municipal governments and community organizations partners in those projects, with funding support, which wasn't the case before."

Continued on page 11



The city of the future isn't a place. It's an idea.

Actually, it's a lot of ideas.

The city of the next century might seem like a distant presence on the horizon, but it's already taking shape in our labs and research centres. Ryerson University's bold thinking, diverse partnerships and commitment to inclusion place us at the forefront of a paradigm shift that's changing everything from the ways we produce and store energy to how democracies engage with their citizens.

Our researchers are reimagining the form and function of urban infrastructure, mapping the possibilities posed by global migration and harnessing big data to make our cities safer and more sustainable. The ingenuity behind these big ideas is the foundation upon which the city of the future rises.

Ryerson University

ryerson.ca/research

November 15, 2018

Canada's TOP 50 RESEARCH UNIVERSITIES 2018

Rank 2017	Rank 2016	University	Sponsored Research Income FY2017 $000	Sponsored Research Income FY2016 $000	Sponsored Research Income % Change 2016-2017	Research Intensity $ per Faculty $000	Research Intensity $ per Graduate Student $000	Tier*	Province
1	1	University of Toronto++	$1,147,584	$1,008,256	13.8	$428.2	$63.7	M	ON
2	3	University of British Columbia	$577,190	$532,143	8.5	$249.9	$55.2	M	BC
3	4	Université de Montréal	$536,238	$522,878	2.6	$271.0	$33.9	M	QC
4	2	McGill University	$515,302	$547,458	-5.9	$296.7	$56.0	M	QC
5	5	University of Alberta	$513,313	$433,663	18.4	$242.1	$69.4	M	AB
6	7	University of Calgary	$380,388	$360,480	5.5	$250.4	$63.0	M	AB
7	8	McMaster University	$379,959	$354,619	7.1	$434.7	$82.8	M	ON
8	6	Université Laval	$356,675	$376,940	-5.4	$228.6	$34.3	M	QC
9	9	University of Ottawa	$324,581	$325,969	-0.4	$246.8	$47.5	M	ON
10	10	Western University	$249,669	$234,736	6.4	$166.1	$41.6	M	ON
11	14	Queen's University	$207,034	$151,808	36.4	$266.1	$44.3	M	ON
12	13	University of Waterloo	$189,333	$166,440	13.8	$163.1	$34.7	C	ON
13	12	University of Manitoba	$187,444	$191,290	-2.0	$155.3	$49.1	M	MB
14	11	University of Saskatchewan	$186,261	$215,928	-13.7	$185.2	$57.3	M	SK
15	16	Dalhousie University	$150,038	$135,958	10.4	$130.2	$44.6	M	NS
16	15	University of Guelph	$140,294	$148,911	-5.8	$184.1	$52.0	C	ON
17	18	Simon Fraser University	$138,964	$109,916	26.4	$156.3	$30.9	C	BC
18	17	Université de Sherbrooke	$132,455	$133,180	-0.5	$115.6	$13.4	M	QC
19	19	University of Victoria	$114,922	$99,589	15.4	$170.0	$35.7	C	BC
20	20	Memorial University of Newfoundland	$111,778	$91,178	22.6	$111.3	$29.7	M	NL
21	21	York University	$96,030	$66,566	44.3	$73.0	$16.6	C	ON
22	22	Université du Québec à Montréal	$67,790	$63,935	6.0	$61.1	$8.6	C	QC
23	24	Institut national de la recherche scientifique+	$64,434	$55,748	15.6	$426.7	$104.9	C	QC
24	23	Carleton University	$54,369	$58,690	-7.4	$67.9	$13.2	C	ON
25	25	Concordia University	$53,099	$50,810	4.5	$65.4	$8.4	C	QC
26	27	University of New Brunswick	$48,206	$38,128	26.4	$105.3	$30.2	C	NB
27	26	Ryerson University	$47,832	$47,130	1.5	$61.5	$18.2	C	ON
28	30	Laurentian University	$32,068	$23,444	36.8	$79.2	$35.9	U	ON
29	29	École de technologie supérieure+	$27,610	$26,116	5.7	$159.6	$16.8	U	QC
30	28	University of Windsor	$26,198	$30,041	-12.8	$51.6	$8.3	C	ON
31	31	Université du Québec à Chicoutimi	$24,945	$22,449	11.1	$107.1	$16.6	U	QC
32	32	Lakehead University	$21,997	$20,460	7.5	$68.7	$21.0	U	ON
33	36	Université du Québec à Rimouski	$20,581	$15,963	28.9	$106.1	$17.7	U	QC
34	33	Université du Québec à Trois-Rivières	$19,988	$20,237	-1.2	$44.4	$8.1	U	QC
35	38	Wilfrid Laurier University	$17,738	$14,216	24.8	$33.3	$11.0	U	ON
36	34	University of Lethbridge	$17,202	$19,678	-12.6	$48.9	$30.4	U	AB
37	37	Université du Québec en Abitibi-Témiscamingue	$16,153	$15,758	2.5	$130.3	$26.3	U	QC
38	35	University of Regina	$15,429	$17,609	-12.4	$39.0	$8.2	U	SK
39	39	Brock University	$14,228	$13,487	5.5	$26.5	$8.4	U	ON
40	41	Royal Military College of Canada+++	$12,903	$12,484	3.4	$68.6	$24.2	U	ON
41	40	University of Prince Edward Island	$12,867	$13,136	-2.0	$55.9	$28.7	U	PE
42	43	Université de Moncton	$11,952	$12,057	-0.9	$35.3	$21.5	U	NB
43	42	Trent University	$11,411	$12,310	-7.3	$46.4	$23.1	U	ON
44	44	University of Ontario Institute of Technology	$11,335	$10,084	12.4	$57.8	$15.1	U	ON
45	48	University of Northern British Columbia	$9,913	$7,640	29.8	$51.9	$17.2	U	BC
46	47	University of Winnipeg	$9,524	$7,730	23.2	$34.5	$40.7	U	MB
47	49	Saint Mary's University	$8,260	$7,324	12.8	$32.8	$13.0	U	NS
48	45	St. Francis Xavier University	$7,665	$8,334	-8.0	$34.8	$21.4	U	NS
49	46	Université du Québec en Outaouais	$7,095	$7,859	-9.7	$28.6	$5.7	U	QC
50		Cape Breton University	$6,719	$5,562	20.8	$56.0	$16.5	U	NS

Notes:
1. Sponsored research income includes all funds to support research received in the form of a grant, contribution or contract from all sources external to the institution.
2. Financial data were obtained from Statistics Canada, except where noted.
3. Fiscal 2016 research income figures may have been adjusted as more accurate information became available.
4. Faculty data for academic year 2016-2017 were used to calculate Research Intensity-$ per Faculty. Includes full, associate and assistant ranks. Data were obtained from Research Infosource Canadian University R&D Database.
5. Graduate student data for academic year 2016-2017 were used to calculate Research Intensity-$ per Graduate Student. Includes full and part-time students enrolled in graduate level (master's and doctorate) programs and courses leading to degrees, certificates or diplomas. Excludes students enrolled in health related internships/residencies and first professional programs. Data were obtained from Maritime Provinces Higher Education Commission, Ministère de l'Éducation et de l'Enseignement supérieur, Ontario Ministry of Advanced Education and Skills Development, Manitoba Advanced Learning Division, Alberta Advanced Education, BC HEADSet and some individual universities.
6. All data are provided for the main university including its affiliated institutions, where applicable.
7. All main institutions are members of the Canadian Association of University Business Officers (CAUBO).

*Tier: M – Medical, C – Comprehensive, U – Undergraduate +Not a full-service university
++Sponsored research income administered by affiliated hospitals was reported one fiscal year in arrears
+++Sponsored research income figures were obtained directly from the university

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For further information, please visit researchinfosource.com

Research Universities of the Year 2018

Three universities gain Research Infosource's designation of *Research University of the Year* in their category for their performance on a balanced set of input and output measures. These full-service universities demonstrated superior performance on key measures of research success.

Rank	Medical	Score*	Rank	Comprehensive	Score*	Rank	Undergraduate	Score*
1	**University of Toronto**	**97.4**	1	**University of Waterloo**	**93.6**	1	**Lakehead University**	**88.8**
2	McMaster University	68.6	2	University of Guelph	82.4	2	University of Lethbridge	83.9
3	McGill University	64.4	3	Simon Fraser University	75.0	3	Université du Québec à Rimouski	80.7

*The score in each category is out of a possible 100 points based on the following measures and weighting: total sponsored research income (20%), research intensity per faculty (20%), research intensity per graduate student (10%), total number of publications in leading journals (20%), publication intensity (20%) and publication impact (10%). For each measure, the top ranking institution is assigned a score of 100 and the other institutions' scores are calculated as a percentage of the first ranked institution. To be eligible to be included in the Research Universities of the Year Tier rankings, full-service universities must have ranked in the top 50% in their respective tier for 5 out of 6 measures. See researchinfosource.com for details.

innovationatlas.com

CANADA'S TOP 50 **Research Universities**

DECADE-STRONG GAIN IN RESEARCH INCOME

Combined research income for *Canada's Top 50 Research Universities* jumped by 6.8% to $7.33 billion in Fiscal 2017, the largest year-on-year increase in a decade. The strong Fiscal 2017 result comes on the heels of a modest 2.2% gain in Fiscal 2016. Research income expanded at 33 universities and declined at 17 institutions. The increase in research income combined with only slight faculty growth meant that faculty research intensity – research income per faculty position – increased by 5.4% to $185,500. Graduate student research intensity – research income per graduate student – grew by 4.2% to $38,000.

Fiscal 2017 saw a positive reversal in Government research income with an increase of 5.1% over Fiscal 2016. Even though Government research income as a percent of the total has continued to decline over the past 5 years, Non-government research income is picking up the slack. In Fiscal 2017, combined funding from Non-government sources grew by almost double (9.8%), compared to that of Government. Among Federal Government funding sources, NSERC – Natural Sciences and Engineering Research Council posted the strongest growth (6.4%), with more modest growth among the other granting councils: Canadian Institutes of Health Research (2.0%), Social Sciences and Humanities Research Council (2.0%) and Canada Foundation of Innovation (1.4%). Provincial (4.9%) and Municipal (4.8%) governments also both increased their funding in Fiscal 2017, although research funding from Foreign government sources declined (-2.3%). Research funding from Not-for-profit organizations (11.0%) and Corporate (10.1%) were especially strong, as was Endowments (58.7%) – reversing a large decline in Fiscal 2016. Funding from Individuals posted a considerable drop (-36.7%), a reversal of Fiscal 2016's large increase.

THE $100 MILLION CLUB

Each year Research Infosource notes the accomplishments of its *$100 Million Club* – an elite group of universities that reported $100 million or more of research income. This year 20 universities – up from 18 in Fiscal 2016 – attained membership in the Club. The combined research income of Club members was $6.54 billion, an increase of 9.9% over Fiscal 2016. Club members accounted for 89% of total Top 50 research income, up from 87% of the total in Fiscal 2016. University of Victoria and Memorial University of Newfoundland both re-joined the Club in Fiscal 2017.

UNIVERSITY TIERS

Sixteen Medical universities accounted for $5.96 billion of research income (81% of the total) for a gain of 6.0% in Fiscal 2017. Twelve Comprehensive institutions posted $1.04 billion of research income (14% of the total) for a strong increase of 11.3%. Twenty-two Undergraduate universities recorded $337.6 million of research income (5% of the total) for a solid gain of 7.5%.

The top universities in each tier were: University of Toronto ($1.15 billion of research income) and 1st place overall); University of Waterloo ($189.3 million, 12th position overall); and Laurentian University ($32.1 million 28th place overall).

RESEARCH INCOME GROWTH

In Fiscal 2017 almost half the universities (23) exceed the national 6.8% research income growth. A stand-out in the Medical category was Queen's University, which gained an impressive 36.4% in its research income. York University (44.3%) was the research income growth leader in the Comprehensive category and the overall growth leader, while Laurentian University (36.8%) led its peers in the Undergraduate grouping.

FACULTY RESEARCH INTENSITY

Faculty research intensity – research income per faculty – averaged $185,500 in Fiscal 2017, up 5.4% over Fiscal 2016. The top ranked universities in the Medical category were: McMaster University posting an average research income of $434,700 per faculty position, followed by University of Toronto ($428,200) and McGill University ($296,700). University of Guelph ($184,100) topped the Comprehensive grouping followed by University of Victoria ($170,000) and University of Waterloo ($163,100). Université du Québec en Abitibi-Témiscamingue attracted $130,300 of research income per faculty, while Université du Québec à Chicoutimi ($107,100) and Université du Québec à Rimouski ($106,100) were leaders among Undergraduate institutions.

GRADUATE STUDENT RESEARCH INTENSITY

Graduate student research intensity – research income per graduate student – averaged $38,000 in Fiscal 2017, an increase of 4.2% over Fiscal 2016. Winners by category were: McMaster University was in top spot in the Medical category ($82,800), followed by University of Alberta ($69,400) and University of Toronto ($63,700). In the Comprehensive category, University of Guelph led in top spot ($52,000), followed by University of Victoria ($35,700) and University of Waterloo ($34,700). University of Winnipeg ($40,700), Laurentian University ($35,900) and University of Lethbridge ($30,400) attracted the most research income per graduate student in the Undergraduate tier.

REGIONAL PERFORMANCE

From a regional perspective, Atlantic Canada's 8 universities posted the strongest growth, increasing their combined research income by 14.7% to $357.5 million. Ontario's 18 universities were also strong performers, growing their total research income by 10.6% to $2.98 billion, representing 41% of the Top 50 total; with strongest gains made among their Undergraduate universities (14.3%) and Medical universities (11.2%). In Western Canada, their 11 universities reported combined research income of $2.15 billion, an increase of 7.8%, and accounted for 29% of the total in Fiscal 2017. Quebec's 13 universities had a slight combined decrease in research income in Fiscal 2017 of -0.9% to $1.84 billion and represented 25% of the Top 50 total.

Regional Research Income Growth by Tier

	% Change 2016-2017				
	Total (50)	West (11)	Ontario (18)	Quebec (13)	Atlantic Canada (8)
Medical	6.0	6.4	11.2	-2.5	15.3
Comprehensive	11.3	21.2	7.0	8.7	26.4
Undergraduate	7.5	-1.1	14.3	7.4	2.3
Total Top 50	6.8	7.8	10.6	-0.9	14.7

RESEARCH UNIVERSITIES OF THE YEAR

Research Infosource is pleased to highlight the achievements of 3 *Research Universities of the Year* – institutions that excelled on a number of key measures of research success. This year's winners were: University of Toronto in the Medical category, University of Waterloo in the Comprehensive category and Lakehead University in the Undergraduate category.

SPOTLIGHT ON UNIVERSITY RESEARCH PARTNERSHIPS

Research Infosource shines the spotlight on university research partnerships as measured by grants or contracts received from corporate and not-for-profit sources between FY2013-FY2017 at full-service universities. For results, see page 11.

THIS YEAR AND NEXT

Fiscal 2017 was a very rewarding year for *Canada's Top 50 Research Universities*. With a total gain of 6.8% in their research income our leading universities experienced their best result in a decade. In fact, this is the first year in 10 years where research income has grown by 6% or more; the last time was Fiscal 2008 (6.0%). With the Federal Government promising further increases in research funding – especially for basic research – the medium-term prospect appears bright indeed. More money for research allows more knowledge to be generated, more training opportunities for graduate students and, in principle, more applied research results for society at large. Canadians will be looking to see how the new investments will produce new research outputs and impacts. It will be up to university researchers to demonstrate that the new investments have been worthwhile.

Top Universities by Tier FY2017

Research Income

Income	Overall	Medical	$000
1	1	University of Toronto	$1,147,584
2	2	University of British Columbia	$577,190
3	3	Université de Montréal	$536,238
		Tier Average (16)	$372,244
Income	**Overall**	**Comprehensive**	**$000**
1	12	University of Waterloo	$189,333
2	16	University of Guelph	$140,294
3	17	Simon Fraser University	$138,964
		Tier Average (11)	$88,822
Income	**Overall**	**Undergraduate**	**$000**
1	28	Laurentian University	$32,068
2	31	Université du Québec à Chicoutimi	$24,945
3	32	Lakehead University	$21,997
		Tier Average (21)	$14,761

Research Income Growth (% Change 2016-2017)

Growth	Overall	Medical	%
1	11	Queen's University	36.4
2	20	Memorial University of Newfoundland	22.6
3	5	University of Alberta	18.4
		Tier Average (16)	6.0
Growth	**Overall**	**Comprehensive**	**%**
1	21	York University	44.3
2	26	University of New Brunswick	26.4
3	17	Simon Fraser University	26.4
		Tier Average (11)	11.0
Growth	**Overall**	**Undergraduate**	**%**
1	28	Laurentian University	36.8
2	45	University of Northern British Columbia	29.8
3	33	Université du Québec à Rimouski	28.9
		Tier Average (21)	7.7

Faculty Research Intensity ($ per Faculty)

Intensity	Overall	Medical	$000
1	7	McMaster University	$434.7
2	1	University of Toronto	$428.2
3	4	McGill University	$296.7
		Tier Average (16)	$249.3
Intensity	**Overall**	**Comprehensive**	**$000**
1	16	University of Guelph	$184.1
2	19	University of Victoria	$170.0
3	12	University of Waterloo	$163.1
		Tier Average (11)	$105.4
Intensity	**Overall**	**Undergraduate**	**$000**
1	37	Université du Québec en Abitibi-Témiscamingue	$130.3
2	31	Université du Québec à Chicoutimi	$107.1
3	33	Université du Québec à Rimouski	$106.1
		Tier Average (21)	$51.3

Graduate Student Research Intensity ($ per Graduate Student)

Intensity	Overall	Medical	$000
1	7	McMaster University	$82.8
2	5	University of Alberta	$69.4
3	1	University of Toronto	$63.7
		Tier Average (16)	$48.2
intensity	**Overall**	**Comprehensive**	**$000**
1	16	University of Guelph	$52.0
2	19	University of Victoria	$35.7
3	12	University of Waterloo	$34.7
		Tier Average (11)	$20.6
intensity	**Overall**	**Undergraduate**	**$000**
1	46	University of Winnipeg	$40.7
2	28	Laurentian University	$35.9
3	36	University of Lethbridge	$30.4
		Tier Average (21)	$15.7

Notes: Based on full-service universities on the 2018 Top 50 Research Universities list. Apparent ties due to ranking.

PARTNER PERSPECTIVE

Research at York University: Impact on a global scale

Through our research, York University aspires to employ the knowledge we gain in the service of society. Four projects illustrate how research at York is making an impact on a global scale.

Vision: Science to Applications (VISTA) Program

Funded by the Canada First Research Excellence Fund (2016-2023), VISTA is a collaborative program that builds on York's world-leading interdisciplinary expertise in biological and computer vision. In collaboration with over 50 academic, public and for-profit partners from around the world, VISTA will propel Canada as a global leader in the vision sciences by integrating visual neuroscience with computer vision to drive innovation. The aim is to advance visual science through research that spans computational and biological perspectives and results in real-world applications.

One VISTA-funded project by Health Professor Shayna Rosenbaum looks at how the brain transforms early visual information into memories. The findings of this research may be used to help individuals with memory difficulties.

International research collaborations to advance scholarship on a global scale

Related to VISTA, York is collaborating with two German universities: the Justus-Liebig-Universität Giessen and the Philipps-Universität Marburg. This partnership began with the International Research Training Group, established via a Natural Sciences and Engineering Research Council of Canada CREATE grant in 2013, undertaken by Health Professor Denise Henriques. It also involves Queen's and Western Universities in addition to the two German partner institutions. The

Professor Dr. Michael Bölker, Philipps-Universität Marburg (left), and Dr. Robert Haché (right), York University, signing the MOU.

relationship was formalized in a 2014 Memo of Understanding (MOU).

This collaboration fosters international research excellence, increases global engagement, facilitates more graduate student co-supervision and allows for more international exposure to York research. VISTA offers foreign students and researchers access to advanced, world-leading research. VISTA will prepare the next generation of industry-ready, highly qualified vision research personnel on a global scale.

Borderless Higher Education for Refugees (BHER) Project

Professors Wenona Giles (Faculty of Liberal Arts & Professional Studies or LA&PS) and Don Dippo (Faculty of Education) co-lead the BHER Project, which seeks to improve equity in higher education, prepare local uncertified refugee teachers, improve teaching practices, and provide a number of university degree programs in and around the Dadaab refugee camps in Kenya.

The project, which began in 2013, received funding from the Canadian International Development Agency. Today, it serves as a model in other marginalized communities throughout the world.

In 2015, 59 students in the Dadaab refugee camps graduated from the York University Certificate of Completion in Educational Studies program. Two thirds of the 59 students already work as teachers in the camps' schools.

Work & Climate Change (WCC) Network Partnership

Professor Carla Lipsig-Mummé, LA&PS, has spent two decades spearheading the WCC network partnership. The core questions include how the world of work, which is a major producer of greenhouse gases, can increasingly and effectively contribute to the struggle to slow climate change and, within this context, the role that social science can play.

This network has grown from five partners and eight researchers in the 1990s to 52 partners today, including researchers, trade unionists, engineers, health workers, policy-makers and environmental advocacy groups. This group has produced research on green initiatives in the workplace, collaboratively developed programs for green education and training, and initiated the creation and implementation of green plans.

Lipsig-Mummé was awarded the prestigious Social Sciences and Humanities Research Council Impact Award, in the Partnership category, for this work in 2018.

Clockwise from top left: Professors Shayna Rosenbaum, Wenona Giles, Don Dippo and Carla Lipsig-Mummé.

PARTNER PERSPECTIVE

To support an innovation system, funders must themselves be innovators

Dr. Marc Fortin
Vice-President, Research Partnerships
Natural Sciences and Engineering Research Council of Canada

Canada is a world-leader in the generation of knowledge and ideas. and investments made by organizations that support research and innovation has been money well spent in delivering significant benefits to Canadians. To address the challenges and opportunities of the 21st century, these organizations must be innovators in their own right – improving their programs so that they support connections and partnerships across disciplines and organizations. Continued success and benefits for Canada will mean designing funding programs so they not only support the creation of knowledge but also the mobilization of that knowledge in solving increasingly complex challenges facing Canada and Canadians.

In part, Government funding for research mitigates "market failures", that is, insufficient resources in part of a system. Traditionally, research support programs define objectives and establish metrics for monitoring specific results, such as increases in the number of trainees, patents, company revenue or jobs. These metrics do a good job of measuring program performance, but fall short in measuring overall systems effects and how one program contributes to a more robust national innovation system.

A national system of innovation has interdependencies among ideas, talent, research, funding and other inputs. So, increasing support for innovation is not necessarily a simple question of "scaling up" one program. Effectively connecting different components of the system (e.g. research, training, commercialization) is needed. Connecting public interventions and investments from different departments or programs that support innovation may be just as important to national performance. For example, it is not just about how many trainees are generated, or the skills acquired, but whether some of that highly skilled research talent is moving from university labs to companies.

NSERC is currently redesigning six programs that connect academic research expertise in Canadian universities with other (knowledge user) organizations. These programs were initially designed to intervene in different parts of the system: research experiences for students, industrial chairs, collaborative research with industry partners, etc. To enhance impact from its investments, NSERC is consolidating and connecting these program components to allow for seamless integration of the necessary elements to initiate, and then grow, research initiatives that can generate benefits for Canada.

NSERC is designing the next generation of research partnerships programs with a more open program architecture and a single point of entry. We need to provide knowledge generators and users greater flexibility to build research partnerships that are "fit for purpose" for their challenge or problems, and to allow them to grow their initiatives by evolving the partnerships and the projects to achieve system impact.

Improving support for innovation is more than creating, modifying or consolidating individual funding programs. Individual mandates or programs can collectively have greater impact by connecting at the meta level. This could result in a "behaviour" of greater collaboration between funding organizations if given the right flexibility in terms of deadlines, review processes and other criteria at the program level.

Realizing impact on national challenges will require deliberate connections and concerted interventions. The problems that Canadians seek to address through innovation are increasingly complex and interrelated. Climate change, resource management and other challenges call for multidisciplinary research efforts and, therefore, broader partnerships and the mobilization of talent and ideas. In addition, knowledge generation has become increasingly distributed across organizations and internationally. Collaboration among research funding programs could play a facilitating role in supporting researchers as well as decision makers to access expertise across this distributed system. The users of knowledge need this.

Innovation requires re-thinking assumptions and disrupting the accepted conventions to create a better way of doing things. Supporting innovation often dictates courses of action that are perhaps unnatural to government departments or organizations focused on their individual legislated responsibilities and accountabilities. The current diverse and complementary mandates of Canada's funding organizations should cover many of the needs of our innovation system. However, greater coordination and collaboration amongst funding agencies by finding the right connection points will be the most effective means of ensuring that research investments achieve the greatest impact for Canada.

PARTNER PERSPECTIVE

INDUSTRY AND ACADEMIA:
Partners in driving innovation in Canada

Dr. Tom Corr
President and CEO
Ontario Centres of Excellence

For over thirty years, Ontario Centres of Excellence (OCE) has had a front-row seat to a profound transformation in the relationship between industry and academia in Ontario and the rest of Canada.

OCE's origins coincide with a turning point in Canada's economy when it began to shift from being North American-focused and commodities-based to being knowledge based, innovation driven and globally oriented. Aware of the power of innovation to stimulate economic growth, governments increasingly began turning to colleges, universities and research hospitals with an eye out for applied research breakthroughs that could be transformed into leading-edge technologies, products and services. The new imperative was to ensure that the world-class research being produced by postsecondary institutions and research hospitals was commercialized and utilized by industry to its full potential.

Despite some resistance rooted in historically distinctive missions and vastly different cultures, industry and academia soon recognized they each had a lot to gain by collaborating. Colleges, universities and research hospitals could apply their expertise and knowledge to solving real-world problems while offering students valuable skills training; industry gained access to the leading-edge academic research and highly qualified personnel that increases their competitiveness.

On behalf of the Ontario government, OCE has for three decades been building bridges between industry and academia and working to establish ourselves as a trusted broker of connections. Intrinsic to OCE's approach is the deployment across the province of over 30 experienced business development managers to scout out research with strong potential to translate into valuable technologies, products and services and to support industry-academia collaborations that move research from the lab to the marketplace resulting in economic growth through exports and job creation.

One of OCE's key programs, the Collaboration Voucher Program, has helped hundreds of Ontario manufacturing companies gain easy access to the expertise and leading-edge knowledge of the Province's colleges, universities and research hospitals. Projects supported by the program cover a wide range of economic sectors, from auto and aerospace to cleantech and agricultural.

For example, Orangeville-based E. Hofmann Plastics, which produces rigid packaging for the food industry, was ready to jump on an environmental movement away from single-serve coffee pods. With support from the Collaboration Voucher Program, the company partnered with the Centre for Advanced Polymer Processing and Design at McMaster University to develop a compostable bioplastic-based material containing natural fillers.

Lafarge Canada, the country's largest producer of diversified construction materials, including cement, joined with Queen's University in a project to replace fossil fuels used in its production of cement, with locally produced, lower-carbon fuels.

Also equipped with a collaboration voucher, Mori Essex Nurseries collaborated with the University of Guelph's Gosling Research Institute for Plant Preservation (GRIPP) to overcome the disadvantage of having to import rootstocks from international producers by cultivating a domestic supply of apple rootstocks on a commercial scale.

Ontario's colleges are just as eager to work side by side with companies in developing creative solutions to industry challenges. About 10,000 students each year work with companies on research and development activities across Ontario. OCE encourages these collaborations through various programs, including the Colleges Applied Research and Development Fund (CARDF), which connects students to the needs of the industries and economies of the future.

Once operating in parallel universes, industry and academia have now become true partners in driving innovation in Canada. At the same time, the contribution of colleges, universities and research hospitals along with their industry partners has led to economic development in communities across Ontario. During the past five years, OCE has funded projects, the majority of which involved industry-academic collaborations, in 160 communities across Ontario.

Industry-academic collaborations will continue to be an integral and growing part of OCE's program offerings. We are excited to currently be involved in some major initiatives that are being rolled out across the Province. Opportunities for academic researchers and students will only expand as we move into exciting new program areas such as autonomous vehicles, 5G, next-generation digital infrastructure, and artificial intelligence.

PARTNER PERSPECTIVE

How universities can build a robust innovation culture

Sylvain Coulombe
Associate Vice-Principal,
Innovation and Partnerships
McGill University

Bringing ideas from the university research environment to market is a complex dance. While basic research – and often a little serendipity – are at the heart of discovery, commercializing inventions requires a robust innovation ecosystem. Universities can support this process by operating offices equipped to support faculty and students to commercialize their research applications, develop business research partnerships, and forge links with science and technology leaders.

In recent years, the research and innovation landscape in Canada has undergone significant changes, including the emergence of granting programs that reward interdisciplinary approaches. In principle, this focus on collaborative research is positive. However, on campuses across the country, including at McGill, collaborative space is limited. Researchers must therefore remain creative in cultivating connections among their fellow researchers and research partners. And they must be open to discovering the unexpected applications of their research.

Take for example the case of a McGill-start-up conceived in the lab of McGill's Professor Thomas Szkopek. When Szkopek began researching graphene oxide, a new and exciting 21st century material, he did so with the hope of contributing significantly to energy storage technology. He did not immediately consider that his work might also contribute to cutting-edge audio technology in the form of the world's first graphene headphones. That is until a student in his lab, Peter Gaskell, asked an intriguing question: could the properties of graphene oxide create the ideal conditions for professional, high-quality sound, clear of distortion across the entire band of human hearing?

Gaskell's question triggered a series of fruitful collisions, bolstered by university-led support, culminating in the launch of Ora Graphene Audio, a Montreal start-up based on a patented McGill technology. It may be tempting to say, "And the rest is history," but the intervening steps from idea to innovation illustrate the increasingly important role universities can play in our innovation ecosystems and economies.

For a conference presentation, the Ora Graphene Audio team produced its first prototype of an audio transducer based on graphene oxide technology. This prototype received an Innovation Award from McGill's Faculty of Engineering, a small but critical investment, sufficient to hire a summer student to improve the prototype.

McGill's Innovation and Partnership (I+P) team, an administrative unit dedicated to facilitating collaborative research and innovation, provided another key to success. Upon learning about the technology, I+P mobilized to turn the invention disclosure into a patent application. Equally important were the I+P officers' connections with the local innovation ecosystem, including TandemLaunch, an incubator that specializes in creating start-ups from university research. With TandemLaunch's support, Ora Graphene Audio assembled a founding team, secured investments, and started on their path to deliver professional-quality sound to every audio device.

This is just one of the many striking stories of how universities help bring the great ideas generated in a research environment to commercial application. However, universities continue to face many challenges in fulfilling their commitments to support the innovation process. Most markedly, we must attempt to change a process-oriented and bureaucratic culture into an innovative and creative ecosystem, securing sufficient funding to support ideas throughout their maturation process and deploying means for the cross-fertilization of ideas.

Together, we must ensure that a robust and well-structured innovation office is there to support an idea from its first conceptual stages through to application. In addition, we must continue to grow local and international networks, connecting with donors, alumni, and community partners, and to plug them into the university ecosystem. When members of an innovation and partnerships office work in tandem with researchers to assume such activities, opportunities for financial support are diversified and efforts to build innovation ecosystems strengthened.

At a time when global challenges demand discoveries at the intersections of diverse disciplines, fostering an adaptable, agile and multi-sectorial innovation ecosystem is one of the most powerful ways that universities can act as economic accelerators. To succeed, we must ensure that our researchers, like those at Ora Graphene Audio, have the time, space, and flexibility they need to keep their eyes – and ears – open for unexpected opportunities.

FOCUS ON Intellectual Property

Betting Canada's future prosperity on the "invisible economy"

By Debbie Lawes

You can't see, touch or taste them, but Canada and the world's future prosperity depends on them. Intangible assets such as patents, trademarks and copyrights represented over 86% of the net worth of S&P 500 companies last year – up from just 16% in 1976.

"The global economy is roughly 30 years into a shift from a production economy of tangible goods to a knowledge-based economy of intangibles," says Jim Balsillie, Chair of the Council of Canadian Innovators based in Toronto, and former chair and co-CEO of Research in Motion (now BlackBerry). "If Canada wants to compete in the global marketplace in the future we need to have large, valuable IP (intellectual property) stocks and big data stocks," like Google, Facebook and Amazon.

Balsillie has been a vocal and persistent advocate on the need to reform Canada's approach to IP to stimulate innovation. While he would have preferred those changes to have happened 25 years ago, he's optimistic the federal government is now moving in the right direction.

A new IP strategy launched in April aims to help Canadian businesses understand, protect and access IP. It includes the creation of a third-party IP or "patent collective" where homegrown firms could access patents, expertise and advice. The government is also establishing a searchable and centralized portal for all IP held by government and academia, and investing in programs to improve IP literacy among Canadians.

"I would like to see our national IP strategies and national data strategies implemented with haste and probably to a greater scale than announced to date. I would like to see the strategies for IP and data fully factored into the supercluster funding agreement and I would like to see them factored into university research funding that is publicly funded. All of this could be done before Christmas," says Balsillie.

The government's largest research enterprise is also evolving its approach to IP, betting that less red tape and greater flexibility will result in more and bigger Canadian companies. The National Research Council's new "four doors" approach allows industry partners to choose the IP arrangement that works best for them, while also protecting the freedom of NRC researchers to continue working in a particular research area.

"We've been trying to simplify and speed up how people interact with us," says NRC President Iain Stewart.

The NRC can decide to freely share technology that's in the public good, or it can allow several companies to access the IP as part of a consortium. IP may also be developed jointly with the NRC and transferred to a single company.

These are just first steps. The NRC also wants the federal government to amend the NRC Act, which currently requires the organization to wait until technology is developed before transferring it. The legislation also limits licensing to "inventions", with no provision for software-based technologies like artificial intelligence and blockchain.

"That creates uncertainty in the relationships," says Stewart. "It would be nice if we could agree upfront that we will transfer that IP to you, if that's the scenario that makes sense for them."

Governments and universities take different approaches to IP. While the Public Servants Inventions Act states that any IP created by an employee of the Crown is owned by the Crown, universities are free to enact their own policies.

WHO OWNS THE IP?

In 1957, the University of Waterloo became the first academic institution in Canada to adopt an inventor-owned IP model.

"Each IP policy really needs to be a function of the institution's history, its culture, its research theme and the regional resources around the university that can support commercialization," says Scott Inwood, UW's Director of Commercialization.

UW's long history of industry collaboration, combined with its emphasis on co-ops and experiential learning, has fueled its reputation as Canada's most entrepreneurial university. Its biggest IP successes have emerged from two departments: its math faculty is a software-generating powerhouse and its engineering group, where patentable discoveries have led to the creation of over 700 start-up companies. UW's commercialization office currently has 275 patents under management.

UW's spin off successes include OpenText, Teledyne DALSA, and more recently, wearables manufacturer Thalmic Labs, which in 2016 raised $158 million – one of the largest venture capital investments in Canadian history.

McMaster University has what it describes as a "flexible IP policy". By default all McMaster research is university-owned, but it will assign the IP to researchers or company partners who prefer to manage their own commercialization. If McMaster continues to own the IP, it will share any revenues generated from licences with the creators.

> The global economy is roughly 30 years into a shift from a production economy of tangible goods to a knowledge-based economy of intangibles.
>
> **Jim Balsillie, Chair, Council of Canadian Innovators**

"I find this approach simpler," says Dr. Gay Yuyitung, Executive Director, McMaster Industry Liaison Office. "When you're doing sponsored research you will know in advance that the university will own the results of the research from our researchers. We can then transfer, license, or assign that technology to the sponsor company or to the researcher."

One recent success has been Turnstone Biologics Inc., a biotech startup that is developing cancer-fighting viruses. McMaster, Ottawa Hospital and the Children's Hospital of Eastern Ontario pooled their patents to form the new immune-oncology company, which has so far raised $50 million in venture capital financing.

McMaster generated more than $22 million in licensing revenues over the past five years, much of that from its quality of life questionnaires in fields such as irritable bowel syndrome and congestive heart failure. The questionnaires are used by academic researchers, government agencies and pharmaceutical companies around the world. Many of these are non-exclusive licenses with small, one-time fees ranging from $50 to $20,000. Exclusive licences often have higher, ongoing royalty and milestone payments.

"I don't think any university is trying to generate big revenue based on the IP," adds Yuyitung. "We're trying to maximize benefit and encourage researchers and companies to work together."

SOMETIMES YOU STRIKE GOLD

Every so often an academic invention comes along that turns out to be a revenue blockbuster. For the University of Saskatchewan, it was a vaccine (PCV2) licensed to Merial that protects pigs from a devastating wasting

Continued on page 14

SPOTLIGHT ON Canada's Patent Leaders 2013-2017

Research Infosource shines the spotlight on Canada's university, public sector, hospital and corporate patent leaders as measured by ownership of patents granted between 2013-2017.

University Patent Leaders

Rank	Medical	# of Patents
1	University of British Columbia	171
2	McGill University	114
3	University of Alberta	108
4	University of Toronto	81
5	Université Laval	68
6	McMaster University	59
7	Western University	51
8	University of Saskatchewan	42
9	Queen's University	41
10	University of Manitoba	40
10	University of Ottawa	40
Rank	**Comprehensive**	**# of Patents**
1	Simon Fraser University	44
2	University of New Brunswick	26
3	Institut National de la Recherche Scientifique+	25
4	University of Guelph	22
5	University of Windsor	17
Rank	**Undergraduate**	**# of Patents**
1	École de technologie supérieure+	29
2	Brock University	17
3	Trent University	9
4	University of Regina	7
5	University of Ontario Institute of Technology	5

Public Sector Patent Leaders

Rank	Public Sector	# of Patents
1	National Research Council of Canada	183
2	Hydro-Québec	51
3	BC Cancer Agency	29
4	Atomic Energy of Canada Limited	25
4	National Defence	25
6	Agriculture and Agri-Food Canada	20
7	Communications Research Centre Canada (Innovation, Science and Economic Development Canada)	18
7	Natural Resources Canada	18
9	Alberta Health Services	12
10	Health Canada [a]	9
11	Royal Canadian Mint	8
12	Alberta Innovates [b]	7
13	Canada Post Corporation	5
13	Canadian Space Agency	5
15	Environment and Climate Change Canada	4

Hospital Patent Leaders

Rank	Hospital	# of Patents
1	University Health Network	79
2	Hospital for Sick Children	47
3	Sunnybrook Health Sciences Centre	33
4	Centre for Addiction and Mental Health	18
4	Ottawa Hospital	18
6	Lawson Health Research Institute – London Health Sciences Centre/ St. Joseph's Health Care London	13
7	Sinai Health System	8
8	St. Michael's Hospital	6
9	Holland Bloorview Kids Rehabilitation Hospital	5
10	Children's Hospital Of Eastern Ontario	3
10	Montreal Heart Institute	3

Corporate Patent Leaders

Rank	Company	# of Patents
1	BlackBerry Limited++	5,660
2	Pratt & Whitney Canada Corp.	435
3	AMD Canada	281
4	Magna International Inc.++	271
5	CNH Industrial Canada, Ltd.	199
6	ViXS Systems Inc.	163
7	BRP Inc.	156
8	IGNIS Innovation Inc.	114
9	SMART Technologies	99
10	Avigilon Corporation++	97
10	Cooledge Lighting Inc.	97
12	Mitel Networks Corporation	93
13	Husky Injection Molding Systems Ltd.	89
14	BCE Inc.	86
15	Open Text Corporation++	85
16	GuestTek Interactive Entertainment Ltd.	77
17	Omachron Science Inc.	73
18	D-Wave Systems Inc.	69
19	Medtronic CryoCath LP	68
20	Litens Automotive Partnership	61
21	MEGA Brands Inc.	60
22	Accedian Networks Inc.	58
23	Trudell Medical International	54
24	Psion Inc.	53
25	MacDon Industries Ltd.	50

Notes:
1. Based on companies/organizations that were domiciled in Canada and listed as an assignee (owner) on patents granted between calendar years 2013-2017. When more than one owner was listed on a patent, each Canada-based company/organization was counted separately.
2. Counts reported are for the total patents granted for calendar years 2013-2017. Patent types included were utility patents (patents for invention), design and plant.
3. Some universities have inventor-owned or hybrid IP policies. In these instances patents may be held by the professor and not the university, in which case it was not possible to attribute the patent to the inventor's institution. Thus, a number of universities are under-represented on the list.
4. Public sector counts were based on all orders of government departments/agencies/ministries and crown corporations.
5. Corporate sector counts were based on companies whose patents resulted from their own research.
6. Organization/corporate names are shown as listed on the patent when the patent was granted, unless otherwise noted. Exceptions where applicable: the most current version of the owner name is used; patents that were assigned to a legal corporation that holds their patents are reported under the main university, hospital or company name respectively; in most cases if a university or hospital research centre or an affiliated institution was listed as the owner, these patents are reported with the main university or hospital. Federal government public sector patents owners are reported under their government agency/department name.
7. Sources: United States Patent and Trademark Office (USPTO) and PatentsView databases.

+Not a full-service university

++We have attempted wherever possible to include any patents that were also granted to main subsidiaries, divisions, departments, affiliated companies when the respective assignee was domiciled in Canada

(a) Includes patents also assigned to Public Health Agency of Canada.

(b) Includes patents assigned to Alberta Innovates Technology Futures and Alberta Research Council.

PARTNER PERSPECTIVE

The regional impact of university research

Dr. Andrew P. Dean
Vice-President, Research and Innovation,
Lakehead University

Lakehead University is a comprehensive and research-intensive institution with campuses in Thunder Bay and Orillia, Ontario. Like other universities throughout Canada, Lakehead brings great social, cultural, and economic value to the communities we serve. Many Canadian cities have developed around one or two main industries. Thunder Bay, for example, is known for forestry. Relying on one main industry, however, can be risky for a community's economic sustainability. By supporting diversification, universities can promote sustainability and economic growth. According to a 2017 study, Lakehead University's economic impact in Ontario surpassed $1.4 billion.

Lakehead generates knowledge about locally relevant issues through research and innovation, which, in turn, helps attract new businesses and industries to our region. Dr. Pedram Fatehi, Canada Research Chair in Green Chemicals and Processes, is exploring ways to use leftover materials from the pulping process to create greener products and new revenue streams for paper mills. Dr. Fatehi's work has received $5.4 million in funding and includes Resolute Forest Products, FPInnovations, and mining giant Goldcorp as partners.

FPInnovations, with its funding partners, decided to build the LignoForce pilot plant in Thunder Bay based on the results of an engineering study conducted in 2015. After the first plant was built, Lakehead University invested resources to conduct relevant and critical research on lignin – the material that holds together tree fibre and ends up as pulp waste. According to Jean Hamel, Vice President Industry and Member Relations at FPInnovations, this research encouraged their funding partners to invest in a second plant, TMP-Bio. FPInnovations now has scientists working at two major pilot plants in Thunder Bay. Dr. Fatehi's fundamental research helps make it possible for Northwestern Ontario's forestry industry to adopt greener and more sustainable practices.

For the last decade, Lakehead University has maintained an active partnership with the Thunder Bay Regional Health Research Institute (TBRHRI), the research arm of the Thunder Bay Regional Health Sciences Centre. Research at TBRHRI originally focused on medical imaging. A 28-tonne cyclotron was installed in 2015, enabling TBRHRI to independently produce unique isotopes for medical research and provide immediate care to local residents. TBRHRI has now developed to a point of maturity where fundamental research is being translated into clinical trials and the development of medical devices.

Dr. Alla Reznik is the Canada Research Chair in Physics of Molecular Imaging and is a chief scientific officer at Radialis Medical – the first joint venture between Lakehead University and TBRHRI. Radialis is developing a high-resolution, high-sensitivity positron emission mammography (PEM) detector that could dramatically improve early breast cancer diagnosis. The PEM prototype is a plug-in device the size of a shopping cart, meant to be compact enough for transport to underserviced communities. Clinical trials are expected to start this year.

Another researcher addressing local needs is Dr. Kathryn Sinden, an assistant professor in Lakehead's School of Kinesiology. The broad aim of Dr. Sinden's research is to develop tools to prevent and reduce the human and financial impact of workplace injuries. Since joining Lakehead in 2016, Dr. Sinden's interest in occupational health has extended to the Thunder Bay Fire Rescue Service. Firefighters are uniquely predisposed to increased risk of injury due to high physical loads and wearing "bunker gear" which weighs up to 40 kilograms.

Thunder Bay firefighter participates in Dr. Kathryn Sinden's research on occupational health.

Dr. Sinden's research focuses on firefighters in Thunder Bay, allowing her to find local solutions to local problems. "What's different here is creating knowledge that's specific to Northwestern Ontario," Dr. Sinden says of the initiative, which involves both the fire service and the Thunder Bay Professional Firefighters' Association. "We have a different geography, our environment is different. How does that impact the way Thunder Bay firefighters perform their work?" Dr. Sinden is a member of the newly established Research Institute for Enhancing Prevention of Injury and Disability at Work (EPID@Work). Led by Dr. Vicki Kristman, the institute's aim is to reduce the effects of work-related injury and work disability, including mental health issues.

The institute's philosophy of thinking globally, but acting locally captures the essence of much of our research. Universities like Lakehead contribute to our communities in many ways, including economic expansion and diversification. Whether revolutionizing an industry, individualizing health care, or alleviating workplace injuries, our researchers are exploring local issues that will have a global impact.

PARTNER PERSPECTIVE

Shaping the future of sustainable cities

Dr. Steven N. Liss
Vice-President,
Research and Innovation
Ryerson University

Unprecedented expansion of our cities and population requires a bold vision to answer complex problems through innovative and impactful solutions. Uniquely positioned at the core of Canada's largest, most dynamic urban centre, Ryerson University is taking a strong leadership role in answering today's challenges while planning ahead for the sustainable cities of the future.

Urban energy, clean water, transportation and logistics, immigration and integration, sustainable housing, inclusive democratic engagement of our diverse communities – all aspects of city building can be addressed through robust research. Ryerson researchers go beyond the kind of inward-facing planning that benefits only the immediate city and its current population. They know that their thinking must be aspirational and visionary in order to position urban hubs within the much larger global ecosystem.

Ryerson researchers are exploring ways to optimize existing technologies, improve energy efficiency and create alternative energy resources. Director of the Centre for Urban Energy here at Ryerson, Bala Venkatesh, is transforming Canada's electric power systems by looking at large-scale renewable energy and energy storage technologies. As the head of NEST, a recently formed network of industry partners, government agencies and researchers from 15 universities across Canada, he is helping make Canada a world leader in energy storage.

Ryerson researchers are at the forefront of critical efforts to establish efficient, safe and accessible transit systems. Our award-winning International Hyperloop Team has created a prototype of their transit idea of the future: a new high-speed ground transportation system that sends pods through near-vacuum tunnels at speeds of 970 km/h, the equivalent of travelling from Toronto to Montreal in 35 minutes. Bilal Farooq, Canada Research Chair in Disruptive Transportation Technologies and Services, is developing a system that would monitor traffic and safely direct autonomous vehicles to the fastest routes.

Building the cities of tomorrow requires thoughtful, ecologically responsible design that aligns with the needs and habits of our residents. We are investigating the creation of new building materials that enable reduced greenhouse gas emissions; as well as analyses of urban space and land use. The interdisciplinary team of Alan Fung and Cheryl Atkinson from the fields of engineering and architecture, together with entrepreneurship and business management researcher Philip Walsh, is reaching for the highest goals of low-carbon-footprint, single-family dwellings through ZEROHouse. Architecture pro-fessor Jennifer McArthur is leveraging digital technologies such as machine learning to improve the performance of existing buildings, bolstering occupant health and productivity.

Healthy cities depend on healthy urban water strategies that include conservation and management policy on a municipal and global level. Ryerson Urban Water affiliate scientist Claire Oswald investigates the cumulative impact of climate and land use on our watersheds, and researcher Carolyn Johns is advancing water policy on a local, national and global level. These researchers, together with other Ryerson faculty, are at the forefront of conducting research that informs public health and protects drinking water sources, water quantity and water quality.

We approach complex urban social challenges using the strengths of collaboration, diversity and inclusion. The Yellowhead Institute, the first Indigenous policy think tank in Canada, focuses on policies related to land and governance while training the next generation of First Nation advocates. At the Ryerson Centre for Immigration and Settlement, Harald Bauder and Usha George analyze immigration and settlement issues, from policy to the integration trajectories of Canada's newcomers. The newly inaugurated Jarislowsky Chair in Democracy provides a forum for discussion and debate about democracy at this critical moment in its evolution.

By prioritizing investments in research and innovation, we can continue to support the tools needed to enrich the health and prosperity of our communities. Ryerson's forward-looking researchers are addressing tomorrow's problems today. Their work exemplifies why Canada is a role model to the world in creating stronger and more sustainable cities.

Early career researchers drive tomorrow's innovations

Dr. Mona Nemer
Chief Science Advisor
Government of Canada

Investing in early career researchers is vital to Canada's well-being. They are the next generation of scientists and skilled professionals in varied sectors whose innovations will be key to both propelling our country economically and elevating our capacity to be leaders in tackling global challenges.

Training fundamental scientists fosters research and discoveries that not only advance scientific knowledge, but catalyze technologies that benefit Canadians in countless ways, such as through the development of artificial intelligence or clean energies. Empowering early career researchers to realize their potential is a long-term investment in the Canadian economy and society more broadly. Take for example Donna Strickland from the University of Waterloo, who recently won the Nobel prize in physics for her doctoral work on chirped pulse amplification for lasers alongside her supervisor, Gérard Mourou. Today, this work is used in applications like corrective eye surgery, and her Nobel achievement is a source of great national pride. We need to support the future Donna Stricklands of this country.

Early career researchers also have key roles to play in policy discussions surrounding challenges that transcend borders. Issues such as climate change and clean water are problems that no one nation can tackle in isolation. Countries need to act collaboratively and consider creative strategies. Early career researchers bring diverse and fresh perspectives to the table. Moreover, they are the generation that has to contend with the consequences of the myriad global challenges we face today; it is important that we support international opportunities and research collaboration that will equip them to do so.

I am encouraged by Budget 2018's commitment to early career researchers but it is also incumbent on all of us in the science and research community to be attuned to their needs, and to ensure that we have the programs and infrastructure in place to attract and retain the best talent from Canada and abroad. Engaging early career researchers at the forefront of discovery, innovation, and diplomacy will help drive Canada's continued scientific excellence and leadership on the international stage.

LEADERS' CORNER

As Canada's most research-intensive university, it's incumbent upon us to ensure our wider communities – local, national and global – reap the benefits of our research. That's why our collaborations with industries, organizations, and governments are integral to our research enterprise. These partnerships mean our research findings are placed in the hands of those who can put them to their best use, ultimately, improving the health and well-being of society.
Karen Mossman
Vice-President, Research (Acting), McMaster University

The University of Waterloo brings together world-class academic strength, leading-edge research, experience-rich learning and a highly networked entrepreneurial culture that ignites curiosity and enables bold ventures. The Waterloo culture builds bridges between imagination and industry on a foundation of innovation that matters.
Feridun Hamdullahpur
President and Vice-Chancellor
University of Waterloo

As Canada's #1 College in applied research, Lambton College brings together world class faculty and staff, leading edge infrastructure and a highly collaborative culture to develop exceptional innovations and enable bold ideas. Through research excellence, Lambton stimulates economic growth and improves health and well-being of individuals, communities and environment globally.
Dr. Mehdi Sheikhzadeh
Executive Dean, Applied Research & Innovation
Lambton College

Ryerson continues its trajectory of excellence, impact and research growth. Our leadership in city building, diversity, inclusion, collaboration and partnerships uniquely positions us to innovate for the future and make impact. In our city, across the country and globally, we continue to build upon a solid foundation of research excellence.
Dr. Steven N. Liss
Vice-President, Research and Innovation
Ryerson University

Research intensity at Laurentian is growing by leaps and bounds. We have moved up from 39th to 28th in the national university rankings in 5 years and are now Canada's number one undergraduate university in total sponsored research income. Catalyzed within Northeastern Ontario, and reflecting our unique geographic, cultural and demographic circumstances, our research and innovation activities have global reach.
Dr. Rizwan Haq
Interim Vice-President, Research
Laurentian University

Like Canada's Defence Strategy, L3 remains proud of our strong Canadian workforce, our capable and secure technologies, and our passion to innovate and engage with our Defence and Security partners. As a prime contractor and trusted system provider we are well positioned to generate strong innovative products and solutions today and well into the future.
Matt Richi
President, L3 WESCAM

There are two codes that underlie innovation and growth: the digital code of 0s and 1s that drives technology, and the genetic code of ATCG that governs the biological world. Through investment in genomics, Genome Canada is harnessing the code of life to fuel Canada's growing bioeconomy and benefit Canadians.
Marc LePage
President and CEO, Genome Canada

Applied research at Saskatchewan Polytechnic is where ideas meet reality, delivering practical solutions to everyday challenges. Whether you're an aspiring entrepreneur with a big idea, or an industry professional with a challenge requiring a solution, Sask Polytech has the tools and expertise to help.
Dr. Larry Rosia
President and CEO, Saskatchewan Polytechnic

At Sheridan, we are committed to nurturing and integrating innovative research within our inclusive framework of scholarship, research and creative activities. By fostering a culture of research, we deliver economic and social benefits to our industry and community collaborators, and strengthen Sheridan's academic quality and unique character.
Andrea England
Vice Provost, Research, Sheridan College

Solutions to daunting global challenges – food, water and energy security – will not come from any one government, university or industry but from all of us working together in multi-sectoral partnerships across national and disciplinary boundaries. That's the new paradigm needed to make Canada the most innovative country in the world.
Peter Stoicheff
President, University of Saskatchewan

CCNB-*INNOV* has demonstrated that colleges have a place in the research world. Colleges help companies on the front lines, addressing real-world problems using applied sciences from various fields of study. It's just-in-time research, delivered when the clients need it the most. The socioeconomic impact of such an approach is remarkable.
Mike Doucette, MSc
Research Chemist, CCNB

Carleton University's multidisciplinary research approach has fostered significant impacts on society involving national networks, industry partnerships, and international collaborations. Working together in areas like energy efficiency, accessibility, Big Data, Indigenous communities, autonomous systems, and refugees ensures a brighter future for all.
Rafik Goubran
Vice-President (Research and International)
Carleton University

Dalhousie University's first 200 years have seen it transform from a local centre of learning to an institution with global impact. Our unique, interactive and collaborative environment encourages all researchers to achieve excellence, while expanding on opportunities for pioneering research grounded in the UN's Sustainable Development Goals.
Dr. Alice Aiken
Vice President Research and Innovation
Dalhousie University

Over a century ago, our founding researchers made remarkable discoveries and developed exceptional innovations that transformed disciplines, and improved lives and livelihoods. This tradition inspires University of Guelph research today – we create and mobilize knowledge that promotes the health and well-being of humans, animals, the environment, agriculture and society on a global scale.
Malcolm M. Campbell, PhD
Vice-President (Research), University of Guelph

For the fourth year, Lakehead University is proud to be Canada's #1 research university in our category. Our new Centre for Advanced Studies in Engineering and Sciences (CASES) includes specialized laboratories that will increase the scale and quality of research at Lakehead. As an innovative comprehensive university, we create future leaders who have big ideas for a better world.
Andrew P. Dean, PhD
Vice-President, Research and Innovation
Lakehead University

I am proud of what we have achieved with our outstanding researchers and innovators. We have built a community of innovative thinkers, driven toward ground-breaking research and discovery. It is our deep commitment to connect research and innovation to communities and the greater good that makes York truly stand out.
Dr. Robert Haché
Vice-President Research & Innovation
York University

PARTNER PERSPECTIVE

UNBC research addresses global issues with local innovation

Dr. Geoffrey W. Payne
Vice President of Research and Graduate Programs
University of Northern British Columbia

UNBC continues to transform into a destination university that offers world-class education and leading research, while building a supportive environment for faculty and students that is second to none.

The past few years have been incredibly productive for research at UNBC, making it an exciting period for a vibrant university where research is an integral part of the mission. Our inclusion on this year's list of Canada's leading research universities is a proud moment for our community – realizing a 29.8 per cent increase in research funding in one year is a significant accomplishment. This increase also marked UNBC's rise on the top 50 Research Universities in Canada ranking to number 45. While a big reason for that success is the effort of our students, faculty and staff, UNBC's culture of embracing innovation plays a major role as well.

The projects we develop create local solutions that have global impact:

Hakai Cryosphere Node opens at UNBC

UNBC and Vancouver Island University embarked on a joint $2.4 million research project with the Hakai Institute with a focus on understanding the role that seasonal snow cover and glaciers play in the hydrology of key watersheds along B.C.'s Central and Southern Coast.

Interior University Research Coalition

UNBC, Thompson Rivers University, and UBC Okanagan have created the Interior University Research Coalition (IURC), a partnership that fosters new possibilities for student development, and facilitates research collaboration and co-ordinated joint funding proposals.

International Engineering Partnerships

As a leader in wood engineering innovation, researchers at UNBC are developing sustainable solutions that have the potential to revolutionize the construction industry in Canada and around the world. UNBC and the Faculty of Engineering at the University Santiago de Chile will be co-operating in research and teaching on topics related to wood engineering and wood-frame construction technologies.

UNBC Partners with University of Toronto on Remote Internship Program

UNBC and the Impact Centre at the University of Toronto are creating new national entrepreneurial experiential learning opportunities for post-secondary students. Together they launched a new remote entrepreneurial work integrated learning program (eWIL) that connects UNBC students with Toronto-based startup internships.

UNBC, TeejLab Partner on Centre of Excellence

UNBC and TeejLab Inc. have launched a new Centre of Excellence in Data Privacy, Security and Integrity that will provide thought leadership, best practices, research support and training. The centre is a unique opportunity for TeejLab and UNBC to promote their mutual interest in close industry-academia collaboration while fostering economic opportunities in British Columbia and Western Canada.

Passive House, Active Research

The Wood Innovation Research Laboratory (WIRL) at UNBC stands as proof that an ultra-energy efficient industrial-style building in a northern climate can be done. Home to researchers seeking to discover novel materials and techniques for the next generation of tall wood buildings, the laboratory is itself an engineering marvel. It is a certified Passive House, the first building of its type in North America to exceed the exacting international standard. Certified Passive House buildings use up to 90 per cent less energy for heating and cooling when compared with standard buildings and use up to 70 per cent less energy overall.

Rooting for Clean Water

Harvesting Moringa tree root bark to grind into a powder to be used as a potential water treatment, for use in at-risk communities such as rural First Nations in Northern B.C., which could have significant global impacts.

These are but a small sample of how UNBC continues to embrace innovation.

UNBC is proud to be a vital player in the national post-secondary research culture. We are inspired by our colleagues, and motivated to continue developing leading edge research, discovery and innovation. The university research environment is grounded in the ability to ask the question, 'why?' and then challenge what we think we know. Bold and creative ideas ensure that new knowledge will be developed, but the role of a university is to apply that knowledge and share the results with our communities so the research ultimately has a positive impact.

As we move further into the 21st century, more global issues will emerge that will require consolidated efforts from our collective knowledge bases to address. Only through collaboration, initiative and sheer determination will we rise to overcome these challenges.

Doubling down on impact

Continued from page 1

CO-CONSTRUCTING SCIENCE

"Co-construction" has become the latest buzzword when talk turns to maximizing the impact of research. Dr. Martha Crago, Vice-Principal (Research and Innovation) at McGill University, says applied research involving academics and external partners is becoming the norm.

"This is the way research is done now," she explains. "And it goes beyond consulting with stakeholders. You are constructing the research project with them. They're definitely part of the research team, and are listed on the (research grant) application."

There was little funding in the past for such collaborations. A significant change came in 2012 when SSHRC introduced partnership grants to support new and existing collaborations in the social sciences and humanities. One beneficiary of this new model has been Dr. Elena Bennett, a rising star in the field of environmental sustainability at McGill.

"She develops approaches to measure, map and model ecosystems and ecosystem services the land provides," says Crago. "And she produces these easy-to-use tools and practical information that governments, industry and communities can use to understand the ecosystem impacts of their planning decisions."

Several university tech transfer offices are expanding beyond patents and commercialization to focus more on community engagement. "Some universities now have community liaison officers who help researchers work with non-government organizations and communities," says Crago.

Canada's year-old National Housing Strategy also benefited from grassroots engagement. York University professor Dr. Stephen Gaetz partnered with A Way Home Canada, a national coalition to end youth homelessness in Canada, as well as people who are or have been homeless.

The result was a series of policy briefs that demonstrated how the government could reduce chronic homelessness by 50% over the next decade by focusing on prevention, crisis response and helping people exit homelessness.

"The key differentiator with Steve's work is that it's really based on the needs of the homelessness sector, as opposed to someone who just studies it," says Dr. David Phipps, York's Executive Director, Research and Innovation Services. "He is

Continued on page 14

SPOTLIGHT ON **University Research Partnerships 2013-2017**

Research Infosource shines the spotlight on university research partnerships as measured by grants or contracts received from corporate and not-for-profit sources between FY2013-FY2017 at full-service universities.

Corporate Research Income

Rank	Medical	$000
1	McMaster University	$498,461
2	University of Toronto	$464,169
3	Université de Montréal	$390,030
	Tier Average (16)	$207,576
Rank	**Comprehensive**	**$000**
1	University of Guelph	$99,903
2	University of Waterloo	$78,375
3	Université du Québec à Montréal	$43,902
	Tier Average (11)	$31,076
Rank	**Undergraduate**	**$000**
1	Université du Québec à Chicoutimi	$48,995
2	Laurentian University	$30,543
3	Lakehead University	$15,925
	Tier Average (18)	$8,718

Overall universities average $000 (45) = $84,888

Corporate Research Income as % Total University Research Income

Rank	Medical	%
1	Memorial University of Newfoundland	31.4
2	McMaster University	29.5
3	Western University	20.4
	Tier Average (16)	11.9
Rank	**Comprehensive**	**%**
1	University of Guelph	13.5
2	Université du Québec à Montréal	12.9
3	University of New Brunswick	12.9
	Tier Average (11)	7.5
Rank	**Undergraduate**	**%**
1	Université du Québec à Chicoutimi	38.6
2	Laurentian University	28.0
3	Lakehead University	14.5
	Tier Average (18)	11.6

Overall universities average (45) =11.3%

Corporate Research Income Growth (% Change 2013-2017)

Rank	Medical	%
1	Memorial University of Newfoundland	160.2
2	Queen's University	105.6
3	Université Laval	51.5
	Tier Average (16)	29.3
Rank	**Comprehensive**	**%**
1	York University	354.3
2	University of Victoria	261.0
3	University of New Brunswick	173.6
	Tier Average (11)	13.5
Rank	**Undergraduate**	**%**
1	Laurentian University	95.6
2	Université du Québec à Rimouski	85.8
3	Brock University	69.1
	Tier Average (18)	-6.3

Overall universities average (45) = 26.4%

Not-for-Profit Research Income

Rank	Medical	$000
1	University of Toronto	$1,455,062
2	University of British Columbia	$623,157
3	Université de Montréal	$389,821
	Tier Average (16)	$303,567
Rank	**Comprehensive**	**$000**
1	University of Waterloo	$107,133
2	Simon Fraser University	$94,783
3	University of Guelph	$42,150
	Tier Average (11)	$38,206
Rank	**Undergraduate**	**$000**
1	Lakehead University	$20,658
2	Université de Moncton	$15,367
3	Université du Québec à Trois-Rivières	$10,209
	Tier Average (18)	$6,114

Overall universities average $000 (45) = $119,720

Not-for-Profit Research Income as % Total University Research Income

Rank	Medical	%
1	University of Manitoba	29.1
2	University of Toronto	27.4
3	University of British Columbia	22.5
	Tier Average (16)	17.4
Rank	**Comprehensive**	**%**
1	Simon Fraser University	16.6
2	University of New Brunswick	13.8
3	University of Waterloo	12.2
	Tier Average (11)	9.2
Rank	**Undergraduate**	**%**
1	Université de Moncton	28.8
2	Lakehead University	18.8
3	St. Francis Xavier University	16.0
	Tier Average (18)	8.3

Overall universities average (45) = 16.0%

Not-for-Profit Research Income Growth (% Change 2013-2017)

Rank	Medical	%
1	McMaster University	343.2
2	University of Manitoba	203.7
3	University of Saskatchewan	105.0
	Tier Average (16)	42.5
Rank	**Comprehensive**	**%**
1	Ryerson University	725.9
2	Concordia University	203.3
3	Carleton University	166.8
	Tier Average (11)	49.5
Rank	**Undergraduate**	**%**
1	University of Ontario Institute of Technology	290.2
2	Laurentian University	272.4
3	University of Regina	217.7
	Tier Average (18)	42.5

Overall universities average (45) = 43.0%

Notes:
1. Based on full-service universities on the 2018 Top 50 Research Universities list and reported research income from corporate and not-for-profit sources in the form of a grant or contract for all 5 years FY2013-FY2017.
2. Financial data were obtained from Statistics Canada.
3. Apparent ties due to rounding.
4. See researchinfosource.com for full results.

CANADA'S Innovation

Feeding the population in a way that's sustainable and healthy is one of this century's great challenges. That's where **Food from Thought** comes in.

Food from Thought is a $76.7 million research program at the **University of Guelph** designed to increase our ability to leverage big data to benefit food production and biodiversity. Such research and innovation will help transform food systems' sustainability and productivity.

Food from Thought has more than 30 principal investigators, nearly 100 co-investigators and collaborators, hundreds of graduate students, dozens of partners, and $100 million in in-kind and partner contributions.

The research program includes leading-edge projects in the areas of livestock, crop sciences, pathogens in food and livestock, biodiversity, ecosystem services, and integrated food systems.

Food from Thought is funded in part by the Canada First Research Excellence Fund.

Food from Thought principal investigator Prof. Bonnie Mallard received the Governor General's Innovation Award last year for her work on the High Immune Response technology for improving dairy cattle health.

Navigating through the healthcare system can be challenging and frustrating – but it doesn't have to be.

St. Joseph's Health System (SJHS) is redesigning how care is delivered through an Integrated Comprehensive Care (ICC) program. This pioneering model assigns patients a care coordinator who meets them in the hospital and is available throughout their journey over a hotline 24 hours a day, seven days a week.

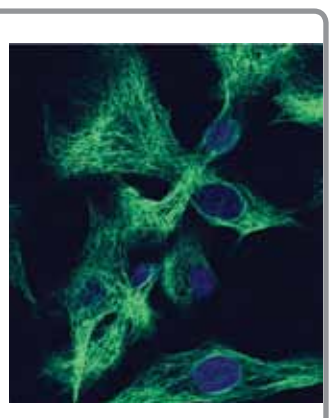
An ICC coordinator can answer questions and dispatch a team of nurses, physicians and other healthcare professionals right to the patient's home. They collaborate with doctors and take charge in booking follow-up visits and referrals. The ICC team works together as one, utilizing one health record, so no matter where our patients' journeys lead them, the frontline staffs are thoroughly aware of all aspects of care.

The ICC program not only allows patients the convenience of personalized attention, it also reduces hospital re-admissions, visits to the ER, and it has proven to be an efficient use of healthcare resources.

Perhaps the most significant achievement from the ICC program at SJHS is that patients and their families leave the hospital happy, with confidence and assurance that they don't have to journey through the system alone.

St. Joseph's HEALTH SYSTEM

In addition to a busy neurosurgery practice, **Dr. Matthew Hebb** maintains a highly productive research program at **Lawson Health Research Institute**, the research institute of London Health Sciences Centre. Dr. Hebb is creating tools to advance Parkinson's Disease research and therapeutics across the globe. Parkinson's Disease is characterized by progressive neurological impairment caused by the death of cells in the nervous system. Dr. Hebb's team provided a novel description of brain-derived progenitor cells (BDPCs) that could protect and stimulate re-growth of disease-affected neurons. This discovery may offer critical insight into the disease process and provide a new personalized source of brain-derived cells for delivering therapy back into the same individual. By using a patient's own BDPCs, Dr. Hebb hopes to slow or halt disease progression and stimulate regeneration of damaged brain circuitry. BDPCs may further advance drug, genetic and functional screening across broad patient populations. This work also resulted in a patent and partnership with STEMCELL Technologies to develop innovative research tools for Parkinson's Disease and other incurable neurological diseases.



In the face of climate change, food and water security are major global challenges. With an unparallelled life sciences cluster – that includes Canada's only synchrotron – and two Canada First Research Excellence Fund programs, the **University of Saskatchewan (USask)** is uniquely equipped to address them.

• The $177-M Global Water Futures network – the largest university-led water research program ever funded worldwide – is transforming the way communities, governments and industries in Canada and other cold regions of the world prepare for and manage increasing water-related threats including floods and droughts. GWF is led by the USask Global Institute for Water Security and three key university partners: McMaster University, University of Waterloo, and Wilfrid Laurier University.

• The $42.7-M "Designing Crops for Global Food Security" program led by the USask Global Institute for Food Security is transforming crop breeding and providing innovative solutions to national and global food security. Building on the university's success in developing more than 400 commercial crop varieti es, the Plant Phenotyping and Imaging Research Centre aims to become a unique global resource for plant breeders to develop new targetted crop varieties and boost crop yields.

USask plant scientist Leon Kochian, Canada Excellence Research Chair in Food Systems and Security, is getting at the roots of food security.

Red River College is driving innovation in Manitoba and around the world. From battery-run buses to sustainable skyscrapers, we work with industry on ground-breaking projects with lasting results.

Consistently ranked as one of Canada's top 10 research colleges, Red River College creates impact in the fields of advanced design and manufacturing, clean technology, digital technology, and health, nutrition and social sciences.

We're growing to meet the needs of industry. The Innovation Centre will be home to the College's business and information technology programs – a site of collaboration between students and their future employers.

The Smart Factory will combine emerging technologies while building on our Technology Access Centre for Aerospace and Manufacturing. Our vehicle test facility MotiveLab™ will be the first of its kind in Western Canada, a space where manufacturers can conduct testing with temperature capabilities between +50° C and -40° C.

A new culinary research and innovation lab will enable researchers, faculty and students to collaborate with the agri-food industry on new products and services.

What we're doing is working. Visit rrc.ca/research.

Camosun College: Applied research is who we are.

Accounting to athletic therapy, carpentry to criminal justice, early childhood learning to engineering technology – applied, real-world learning is woven into everything we do. Practical preparation through industry and community partnerships empowers our graduates to hit the ground running when they enter the workforce. Over the last year, we've accomplished great things – from launching our Babcock Canada Interaction Lab, to breaking ground on the new Alex & Jo Campbell Centre for Health and Wellness, to supporting diversity and inclusion, enhancing the student experience, and so much more.

Located in Victoria, BC's vibrant coastal capital, Camosun College is a national leader in applied research, advanced manufacturing, and technological innovation, and home to the province's only Technology Access Centre. With 19,000 students, 160+ programs, and a strategic direction that prioritizes interdisciplinary education, innovation and community partnerships, Camosun offers students a world-class college experience. We are proud of our students, staff, faculty, and community who have made us one of Canada's Top 50 Research Colleges.

Infectious diseases and drug-resistant infections are a serious global threat to our health and our economy. It's estimated they will kill more people than cancer and cost the world $100 trillion in lost economic output by 2050. To combat this threat, scientists in the Michael G. DeGroote Institute for Infectious Disease Research (IIDR) at **McMaster University** are bridging the divide between basic research and the clinic to develop life-altering drugs, vaccines and prevention strategies. IIDR researchers – an extraordinary and diverse group of world-leading experts – are conducting groundbreaking research in antibiotic resistance mechanisms, new drug discovery, and innovations in therapeutic alternatives to antibiotics. Their work has already resulted in more than 200 filed patents and the launch of three new start-up companies. And, now, they're leading a charge with their partners to establish a first-of-its-kind centre of excellence, designed to propel economic growth, entrepreneurship and job creation; attract further collaborations and partnerships; and position Canada as a global leader in, and exporter of, health technology, research and innovation.

Gerry Wright, director of the IIDR at McMaster University and a global expert in antibiotic resistance research

Ryerson researcher Dr. Victor Yang has shone a light on effective surgical procedures.

His innovation in advanced structured light imaging has allowed surgeons to see below the surface of their patients' anatomy. The new technology, commercialized by 7D Surgical, combines LED surgical light for spine and brain operations. The device captures the light reflected off the surface of the operation site to create a three-dimensional topographical image. Linked with a patient's CT or MRI scans, surgeons can get a better picture of the structures underneath the skin.

With this speedy image generation, surgeons can complete tedious procedures in less time and with improved results. The imaging technology can also reduce risk of complications.

More than 500 procedures have been performed using this technology. Its recent applications won the 2018 Innovator of the Year Award at the Congress of Neurological Surgeons. Both Health Canada and the U.S. Food and Drug Administration have approved the device. To date, it is used in more than a dozen hospitals in North America and New Zealand, with the possibility of further global rollout.

Photo by Nation Wong

Achievements

For the past 10 years, **Huawei Canada** has been investing in research and innovation, positioning Canada as a global 5G leader. Huawei now employs almost 1000 people in Canada, and with a team of 600 researchers and scientists, we are committed to helping drive forward Canada's innovative and competitive ICT ecosystem. Through partnerships with Canadian universities, incubators and small businesses, Huawei has continuously invested into the Canadian economy through research initiatives, and we are helping attract the best and brightest to Canadian schools for advanced communications research. Along with other global ICT players looking to Canada, the result of this investment is a diverse base of skilled technology talent that will help Canadian companies across all industry sectors harness transformative technologies such as 5G. Huawei Canada is proud to again be recognized as one of Canada's leaders in investing in Research & Development in Canada.

Sheridan's Centre for Mobile Innovation (CMI) is focused on developing mobile health solutions, collaborating with a wide range of industry, community and healthcare partners. In Spring 2017, CMI received a five-year $2.3 million NSERC College and Community Innovation Program – Innovation Enhancement Grant, along with an additional $1 million from the Canada Foundation for Innovation (CFI) College-Industry Innovation Fund. This investment provided CMI the dedicated opportunity to continue its collaborative work between professors, students and industry partners in developing innovative mobile solutions and adaptive technologies that benefit our communities.

CMI continues to build on Sheridan's extensive applied computing expertise. Whether through the development of specialized apps, machine learning, the Internet of Things, or augmented/virtual reality, CMI professors and students work closely with industry to develop innovative mobile solutions that will boost their competitiveness and profitability.

New breakthroughs in mobile applications continue to develop through applied research by faculty and students at Sheridan's Centre for Mobile Innovation.

Armed with notable funding and global partnerships, **Carleton University's** James Milner, professor in the Department of Political Science and a team of researchers and practitioners are working with partners in major refugee-hosting states to promote protection and solutions for refugees.

"While Canadians have demonstrated their commitment through the resettlement of Syrian refugees, 86 per cent of the world's refugees remain in the global south. Resettlement opportunities only exist for one per cent of these refugees," says Milner.

The project, Civil Society and the Global Refugee Regime, will study current efforts to implement global refugee policy, identify factors that impact implementation and identify better outcomes. The group will begin with the cases of Jordan, Kenya, Lebanon and Tanzania.

The project will provide hands-on training for 96 graduate students over seven years. They will host annual summer institutes in Canada and affected countries, train refugees and NGO workers in citizen journalism, support fellowships at Carleton for six visiting fellows from the global south and implement professional development programs for NGOs.

Niagara College's Research & Innovation division is comprised of faculty, researchers, students, and an administration team who work on innovative projects helping businesses leap forward in the marketplace. This R&D arm for small- and medium-sized businesses in the Niagara region has been steadily growing in the past decade, evolving business practices and focusing in on specific research areas, including advanced manufacturing, food and beverage, and precision agriculture and environmental technologies. The team works hard to provide meaningful experiences for students and industry, and was delighted by several recent honours, including a silver award for Applied Research and Innovative Excellence from Colleges and Institutes Canada, given out last spring. And just last month, Niagara College earned the 2018 Gold Award of Excellence in Applied Research and Innovation, from the World Federation of Colleges and Polytechnics (WFCP). In each case, the award was made not to one individual project, but to the division itself, validating the gratification the team feels regarding its sustainable growth to date.

To learn more, visit ncinnovation.ca.

Imagine being able to shop at a winery or the LCBO while listening to classical music and savouring the aromas of chardonnay and pinot grigio, all without leaving your seat.

Brock University's Cool Climate Oenology and Viticulture Institute (CCOVI) is establishing the world's first mediated-reality wine laboratory that will create a variety of environments in which people purchase and consume wines.

Researchers will examine how sights, smells and sounds impact the research participants' choices of where and under what conditions they purchase and drink wines. This greater understanding of consumer behaviour will help the industry to best market their wines to potential customers.

The concept of coupling consumer behaviour with technical tools of augmented and virtual reality puts Canadian researchers on the forefront of this research.

CCOVI is also upgrading their winery with 30 stainless steel variable volume tanks controlled by a computerized glycol heating and cooling system, enabling researchers to determine ideal fermentation conditions in each tank for a range of wine styles and varieties.

Brock University President Gervan Fearon, left, and then-Ontario Minister of Research, Innovation and Science Reza Moridi, right, listen as Cool Climate Oenology and Viticulture Institute Director Debbie Inglis explains the virtual reality technology they're trying out at an event held in January 2018.

Lakehead University researchers know how to make a difference for our local, national, and global communities. Dr. Charles Levkoe, our Canada Research Chair in Sustainable Food Systems, believes the right to food is critical for the future. Dr. Levkoe's participatory action research explores how civil society organizations are contributing to the development of the Government of Canada's food policy.

Forest ecologist, Dr. Han Chen studies the effects of global changes – including biodiversity loss, climate change, and forest diversity disturbances – on Canada's boreal forests. Dr. Michael Rennie, Canada Research Chair in Freshwater Ecology and Fisheries, is another champion for ecological sustainability. His research team helps recover overfished populations and lakes impacted by industry to restore freshwater ecosystems.

At Lakehead University, we are proud to train students who are the next generation of changemakers. The opening of the Centre for Advanced Studies in Engineering and Sciences (CASES) will mark the launch of *Ingenuity* – Lakehead's first student business-incubator zone. We look forward to seeing how our student innovators will transform Thunder Bay, Simcoe County, and beyond.

Betting Canada's future prosperity on the "invisible economy"

Continued from page 7

disease. The vaccine hit the market in 2007 and continues to generate about $14 million in annual licensing revenue. While USask owns all IP generated at its institution, any resulting revenues are equally shared between the university and the inventor.

USask has since taken steps to make it easier for companies of all sizes to partner with its researchers. This summer it launched the Fast License program to dramatically reduce the time it takes to acquire a licensing agreement from the university.

"Licences can be negotiated and signed in a day rather than having lengthy, cumbersome negotiations," says Dr. Johannes Dyring, Managing Director of USask's tech transfer unit Innovation Enterprise.

USask has also introduced Academy Industry Meeting Days (AIM-days), a concept borrowed from Sweden that brings dozens of entrepreneurs and researchers together to discuss potential solutions to "real-world" problems in a series of one-hour workshops held in a single day. About one-third of these workshops result in new research partnerships.

"Often it's not about access to the patents, but access to the people who created those inventions – their networks, their knowledge base and their experience in working with those kinds of technology. The patent is just a tool. It's a means to an end," says Dyring.

Sometimes universities will spin off a new company to commercialize its IP. In other cases, it makes sense to license a technology to large firms with established customer relationships, particularly in risk-averse sectors like healthcare.

"To reach the bigger market you really need a vendor to do it for you … someone that can go into any institution, and because of their name, people will listen to them," says Dr. Ting-Yim Lee, Director of PET/CT Imaging Research at Lawson Health Research Institute.

Lee invented CT perfusion, a software that can be used on existing CT scanners to measure blood flow in the body. More than 8,000 hospital imaging departments worldwide now use this sophisticated yet easy-to-use technology, which has transformed the way stroke is assessed and treated around the world.

A 2013 socioeconomic study commissioned by the Canada Foundation for Innovation and the Canadian Institutes of Health Research showed public investment in Lee's work not only expedited this innovation, but also yielded a 2:1 return on public investment.

The software was licensed to GE Healthcare in 1999 and is now available on a non-exclusive basis to companies globally. Lee, along with Lawson and its affiliated institutions (Robarts Research Institute and Western University) share about $2 million annually from some 1,000 copyright licences.

"Some of that value is about improving health, some of it is financial and some is reputational," says Dr. Michael Salter.

SickKids' research blockbusters include the discovery of the cystic fibrosis gene in 1989 which led to new therapeutics, and a device that improves recovery of heart function after a heart attack, which resulted in a new spin-off company, CellAegis Devices.

> Often it's not about access to the patents, but access to the people who created those inventions.
>
> **Dr. Johannes Dyring, Managing Director, Innovation Enterprise, University of Saskatchewan**

"The institution reinvests part of their share back into my research program. That's why we've been able to extend this software beyond stroke to cardiac and now the lung," says Lee.

SUPPORTING ENTREPRENEURIAL INVENTORS

Research hospitals develop a range of healthcare technologies, from medical devices to new drugs. With more than 3,000 employees involved in research, the Hospital for Sick Children in Toronto is ranked the top research hospital in Canada for licensing revenue generated. But as their Chief of Research explains, the bigger priority is creating value from the research.

SickKids works closely with its faculty to help identify and commercialize promising technologies. "We have many junior faculty members who are very entrepreneurial," says Salter, who holds nine patents. "They're interested in seeing their discoveries used to improve health. It's an exciting time to be in this space."

That entrepreneurial spirit is also being cultivated at Queen's University where a new program, the Foundry, pairs researchers who have developed a commercially promising invention, software or idea with entrepreneurial students and recent graduates. Student teams with strong proposals are granted a short-term limited license to develop the technology. Teams also receive training, mentoring, seed funding and an opportunity to fully licence the technology later.

"One of the challenges we see regularly is that the level of technology readiness for early-stage research is often too low for a company to license," says Dr. Jim Banting, Assistant Vice-Principal (Partnerships and Innovation) at Queen's. "This program helps close that gap by having student teams launch start-ups to advance the research to a proof-of-concept stage and beyond."

If Canada wants more IP commercialized, it will need to support more start-ups, adds Banting. He has joined a growing chorus of companies and innovation experts calling for the creation of programs like the Small Business Innovation Research and the Small Business Technology Transfer – perhaps the largest source of early stage/high-risk funding for start-ups and small business in the U.S.

"Figuring out a way to provide that funding to elevate the level of technology readiness will certainly help mobilize and capture the value of early-stage research happening at universities in Canada," says Banting, who worked in the U.S. pharmaceutical sector for several years before moving back to Canada.

The University of Alberta is also supporting students and researchers who want to see their science used in industry and society. The university took an important step in that direction 12 years ago when it partnered with the City of Edmonton to launch a new commercialization arm. U of A has an inventor-owned policy but researchers can opt to split licensing revenues with TEC Edmonton in exchange for training and business services.

"TEC Edmonton creates a supportive environment where researchers can get much closer connections to the end user community so they can see value in what they're doing," says Dr. Matthias Ruth, VP Research at U of A, which has generated many technology successes, including antiviral agents that led to the first oral hepatitis B antiviral Lamivudine that is now licensed in over 200 countries, and black-leg resistant Quantum canola that has contributed over $20 billion to Canada's economy.

While IP has become a hot topic these days within government, industry and academia, Ruth cautions that being fixated on IP unnecessarily narrows perspectives on what it takes to create an innovation ecosystem. Fueling future discoveries and innovations requires that we support the fundamental research from which these discoveries and innovations stem.

"We don't know at the outset if there will be a great product for which there is a market 5, 10 or 20 years down the road so we need to support the research enterprise in a very healthy and sustainable way," says Ruth. "From that will come the benefits for society."

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Dr. Roseann O'Reilly Runte
President and CEO
Canada Foundation for Innovation

Year of science sets Canada on the path for a bright future

This year's Federal budget made 2018 the Year of Science. The three federal research agencies were given a considerable infusion of funds and the Canada Foundation for Innovation received a commitment for ongoing funding, making it possible for researchers, universities, colleges, hospitals, businesses, communities and provinces to better plan for the future. Students will be able to obtain the experience and skills they need and researchers will be able to achieve their goals, allowing Canada to take its place on the global stage.

This Year of Science is an investment in possibilities. Across the country researchers are working to find cures. They are tracing the genomic history of diseases to save precious lives and developing vaccines for use in the next pandemic. Researchers are finding ways to build homes that do not require electricity for heat and safer roads and more fuel-efficient vehicles. Others are creating machines that will function with sensors and artificial intelligence to enable an aging population to remain safely at home for a longer time. The keys to memory, language, and culture are being discovered and will allow us to better understand ourselves and others.

The challenges we face today are many and complex but the knowledge, talents and tools we have at hand are well suited to the tasks before us. Supporting the work of our researchers is both a privilege and a responsibility we all share. In the end, we will all benefit from stronger economic development, better, healthier lives, improved urban and rural environments. Communities flourish around research hubs, and because of the results they produce, we will be able to prosper nationally and compete globally.

The Year of Science is a good beginning. It is positive and progressive. It is a first step on the path to a better future where Canada can play a leading role in the world.

Doubling down on impact

Continued from page 11

alongside the people who are working in it and engaging with people with lived experience of homelessness. It's what I call demand-driven research."

York created its Knowledge Mobilization Unit in 2006 to facilitate such partnerships. Led by Phipps, the office has helped researchers like Gaetz apply for grant funding and develop better ways to share the results of his research with non-academics, including the use of easy-to-understand infographics.

"Our Knowledge Mobilization Unit helps to bridge the all-important gap from new knowledge to real-world application," says Dr. Robert Haché, York's Vice-President Research and Innovation.

MATCHING NEED WITH TALENT

"What keeps you up at night?" It's the first question Mitacs usually asks when determining which post-secondary experts are best equipped to solve your problem.

Supported by both the federal and provincial governments, Mitacs provides matching funds for graduate student internships that help companies and not-for-profits address a particular research challenge. Students, in return, gain valuable on-the-job training and a paid internship.

"Having experience in a company is really a game changer for the students to acquire skills that the university can't provide in the classroom," says Dr. Alejandro Adem, CEO and Scientific Director at Mitacs. "It also gives the best researchers at the university an outlet for impact on the economy."

Many interns end up working with these companies after graduating. Ford Canada, for example, benefited from the University of Windsor's expertise in motion capture technology to make assembly lines more efficient and safer for workers. Some of those interns are now Ford employees.

Mitacs has bold plans for the future. It received $221 million in the last federal budget to provide 10,000 internships annually by 2020-21 and is asking Ottawa for additional funds to extend the program to college students and university undergraduate students.

"The 10,000 internships are just a small piece of a potentially huge market of providing these experiential living opportunities very broadly," says Adem.

ACHIEVING IMPACT AT SCALE

Coming up with a new and improved technology often isn't good enough. Often, the bigger job is translating that technology into a solution that benefits millions of people.

In 1992, for example, Canada established the Micronutrient Initiative, a small pilot program that evolved into Nutrition International, the world's largest supplier of key micronutrients to malnourished infants and children. The program, which began at the International Development Research Centre (IDRC), has been a major contributor to global efforts to ensure that at least 70% of households worldwide have access to iodized salt, which protects millions of newborns from mental impairment.

Building on that success, U of T researchers came up with a simple and cost-effective way to fortify salt with iron, as well as iodine. IDRC support through the Canadian International Food Security Research Fund, jointly funded with Global Affairs Canada, enabled the project's public and private sector partners in India to rapidly scale up the production and local distribution of double fortified salt (DFS). It is now available to more than 50 million people in three Indian states.

> Having experience in a company is really a game changer for the students to acquire skills that the university can't provide in the classroom.
>
> **Dr. Alejandro Adem, CEO and Scientific Director, Mitacs**

"Multiple actors need to be involved to achieve this kind of scale," says IDRC President Jean Lebel. "Now we're seeing demand from Africa for DFS and there's research ongoing to expand beyond two micronutrients," including folic acid, vitamin B12, and zinc.

IDRC research has also translated into diplomatic successes for Canada. Its research with South Africa's exiled democratic movement beginning in the 1980s later helped the government of Nelson Mandela evolve from pro-apartheid technology policies that stifled investment and innovation to ones that facilitated trade, commerce and international collaborations.

Continued on page 20

PARTNER PERSPECTIVE

USask-led Global Water Futures seeks solutions to water threats in era of climate change

Over the past decade, the world has seen record-breaking numbers of extreme weather events such as floods, droughts, storms and forest fires – and Canada is no exception.

In 2018, there was unprecedented flooding in New Brunswick and British Columbia, unrivalled dry conditions and forest fires in British Columbia and the Rocky Mountains, and record drought and heat followed by exceptional fall snow over the southern Prairies. These extreme weather conditions followed on the heels of five years of similar conditions that left millions of Canadians reeling from either insufficient or excessive water.

"We are experiencing chronic water disasters in Canada," said John Pomeroy, Canada Research Chair in Water Resources and Climate Change at the University of Saskatchewan (USask). "We live in a time when climate change and development are threatening the Earth's water security and environmental health."

Pomeroy is director of the $177-million Global Water Futures (GWF) program, the world's largest university-led water research program. Launched with $77.8 million from the Canada First Research Excellence Fund in 2016, the seven-year research program is led by USask and its three key partners – University of Waterloo, McMaster University and Wilfrid Laurier University.

GWF's mission is to prepare Canada and other cold regions to manage risks associated with water-related threats from climate change and increasing development to ensure continued water sustainability and economic prosperity.

"We are providing solutions for avoiding the catastrophic impacts of climate change on Canada's water and are showing a path towards global water security," he said. "This program is making significant scientific contributions nationally and globally."

In its 2018 report, the Intergovernmental Panel on Climate Change (IPCC) warned that even with one more degree Celsius of global warming, the world is headed for serious climate change impacts. The panel found that Western Canada is experiencing some of the world's greatest rates of warming, and this is melting the mountain snow and ice that supply freshwater to several provinces and the United States.

Photo by Mark Ferguson

Researchers John Pomeroy, Phani Adapa and Joe Shea with the Global Water Futures program visit a research station on the Athabasca Glacier.

Pomeroy says that across Canada, climate warming from human actions is altering precipitation patterns, reducing snowpacks, accelerating glacier melt, thawing permafrost, degrading water quality, intensifying floods, and increasing droughts.

"The public needs to understand that the water flows we had in the past are no longer guides to the future," he said. "We need better ways to measure, predict and manage water risks, as well as to improve disaster warning. We're the only G7 country without a national flood-forecasting program, for instance."

With 60 water observation sites across Canada, cutting-edge drone, sensor and modelling technology, and an army of more than 650 researchers, GWF is already addressing some key issues by:

- Developing the first snowpack forecasting in Canada over the Canadian Rockies, available to the public at: www.snowcast.ca,
- Implementing the first flood forecasting system for the Yukon Territory,
- Predicting water flows for the Great Lakes, Saskatchewan and Mackenzie River basins to assess climate change impacts on future water availability,
- Calculating reliable, high-resolution future climate conditions for Canada, and
- Determining, through analysis of DNA gleaned from just a few drops of water, which invasive fish species and contaminants have entered bodies of water and how this affects fish.

Photo by Dave Stobbe for the University of Saskatchewan

Emily Cavaliere, a GWF researcher, studies water cleansing process that keeps lakes "alive" in winter.

With many First Nations communities under long-term boil-water advisories, GWF is engaging with Indigenous communities to co-develop water research strategies that recognize traditional Indigenous knowledge and western science in developing water management solutions.

In April, 60 researchers and Indigenous community partners met at Wanuskewin Heritage Park in Saskatoon to build and enhance existing partnerships. And in June, in what is believed to be the first scientific meeting ever held on a First Nation, 400 GWF researchers were invited by the Six Nations of the Grand River to listen, learn and share on their territory.

"Our goal is to work with communities, Indigenous Nations, governments and industries to transform how they prepare for and manage water challenges," said Pomeroy.

As one of the top universities in the world for water resources research, USask is attracting top international talent. For example, NASA Jet Propulsion Laboratory Senior Water Scientist Jay Famiglietti was recruited this year from the California Institute of Technology to lead the university's Global Institute for Water Security as Canada 150 Research Chair in Hydrology and Remote Sensing.

A *Nature* article co-authored by Famiglietti this year reveals the dramatic impact of climate change and human activities on the availability of freshwater around the globe.

Using GRACE satellites to identify and quantify groundwater depletion from the globe's major aquifers, Famiglietti's team found that wet river basins – both in high latitudes and the tropics – are getting wetter, while the dry regions are getting dryer. For instance, an issue for Western Canada will be decreasing replenishment of water supplies in aquifers and reservoirs as glaciers in British Columbia disappear, he said.

"The world's freshwater resources are under a level of stress unseen before," Famiglietti said, noting that to avoid future conflicts over declining water supplies, groundwater sharing will need to be included in transboundary agreements.

"The need for water-saving technologies and improved management and governance of water will become increasingly clear, and without these, I see a future in which we will be very challenged to produce the food that we need for our growing world population."

Innovative research to improve drinking water

With possible shorter and milder winters due to climate change, the vexing issue of algae blooms in lakes and reservoirs and their impact on drinking water quality is under study by a USask research team.

"We expect lakes to become more vulnerable to nutrient pollution simply as a result of warming water temperatures," says Helen Baulch, a scientist with USask's Global Institute for Water Security who leads one of GWF's 33 research projects. "This means we expect to see more frequent and more severe blooms."

Baulch's PhD student Emily Cavaliere has found that a naturally occurring cleansing chemical process called "denitrification", in which bacteria in lake sediment take up nitrogen, helps maintain water quality of Prairie lakes during winter – a previous scientific unknown. Scientists had previously assumed that cold temperatures would slow down this process.

"My work has debunked scientists' assumption that ice-covered lakes are dormant until spring comes," said Cavaliere. "Where there is water, there is life."

The next step is to study how water nutrient cycling rates will change in the future as winters grow shorter, said Baulch.

CANADA'S TOP 40 RESEARCH HOSPITALS

CANADA'S INNOVATION LEADERS

RESEARCH Infosource Inc.

Baycrest

LAWSON HEALTH RESEARCH INSTITUTE

London Health Sciences Centre

St. Joseph's Healthcare London

St. Joseph's Healthcare Hamilton

Hôpital St-Boniface Hospital RECHERCHE • RESEARCH

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November 15, 2018

Canada's TOP 40 RESEARCH HOSPITALS 2018

Rank 2017	Rank 2016	Hospital/Hospital Network/ Health Authority	Research Spending FY2017 $000	Research Spending FY2016 $000	Research Spending % Change 2016-2017	Research Intensity Researcher $ per Researcher $000	Research Intensity Hospital $ as % of Total Hospital Spending	Prov	Main Affiliated Research Institute(s)/Centre(s)
1	1	University Health Network	$350,080	$332,000	5.4	$601.5	17.3	ON	Princess Margaret Cancer Centre, Toronto General Hospital Research Institute, Krembil Research Institute, Toronto Rehabilitation Institute, Techna Institute
2	2	Hospital for Sick Children	$209,627	$201,484	4.0	$600.7	23.8	ON	SickKids Research Institute
3	4	Hamilton Health Sciences	$206,950	$171,458	20.7	$454.8	14.2	ON	Population Health Research Institute, Escarpment Cancer Research Institute, Thrombosis and Atherosclerosis Research Institute
4	3	McGill University Health Centre (MUHC)	$204,174	$178,823	14.2	$590.1	18.7	QC	Research Institute of the MUHC
5	6	Vancouver Coastal Health Authority	$145,501	$149,987	-3.0	$365.6	4.3	BC	Vancouver Coastal Health Research Institute
6	7	Ottawa Hospital	$136,829	$128,974	6.1	$374.9	9.9	ON	Ottawa Hospital Research Institute, Ottawa Heart Institute Research Corporation
7	5	Provincial Health Services Authority	$133,314	$161,939	-17.7	$164.6	4.9	BC	BC Cancer Agency/Research Centre, BC Children's Hospital Research Institute, BC Centre for Disease Control
8	8	London Health Sciences Centre/St. Joseph's Health Care London [a]	$123,255	$124,304	-0.8	$616.3	7.8	ON	Lawson Health Research Institute
9	9	CHU de Québec - Université Laval	$102,306	$96,788	5.7	$311.0	8.6	QC	Centre de recherche du CHU de Québec - Université Laval
10	10	Sunnybrook Health Sciences Centre	$91,214	$92,872	-1.8	$288.7	9.2	ON	Sunnybrook Research Institute, Sunnybrook Research Academy
11	11	Sinai Health System	$88,878	$84,564	5.1	$753.2	14.8	ON	Lunenfeld-Tanenbaum Research Institute, Bridgepoint Collaboratory for Research and Innovation
12	12	St. Michael's Hospital+	$77,096	$78,149	-1.3	$370.7	11.2	ON	Keenan Research Centre for Biomedical Science, Li Ka Shing Knowledge Institute
13	13	Centre hospitalier de l'Université de Montréal (CHUM)	$73,274	$73,237	0.1	$179.6	7.3	QC	Centre de recherche du CHUM
14	14	Centre for Addiction and Mental Health	$68,269	$66,806	2.2	$555.0	16.9	ON	Campbell Family Mental Health Research Institute, Krembil Centre for Neuroinformatics, Azrieli Centre for Neuro-Radiochemistry
15	15	CIUSSS du Centre-Ouest-de-l'île de Montréal	$59,584	$54,828	8.7	$272.1	6.8	QC	Lady Davis Institute at the Jewish General Hospital
16	16	Alberta Health Services - Edmonton Zone	$53,969	$51,000	5.8	$148.3	na	AB	
17	17	Montreal Heart Institute	$48,644	$49,329	-1.4	$579.1	23.3	QC	Montreal Heart Institute Research Centre
18	18	CHU Sainte-Justine	$38,837	$38,201	1.7	$185.8	8.3	QC	Centre de recherche du CHU Sainte-Justine
19	20	Winnipeg Regional Health Authority (WRHA) [b]	$37,148	$29,211	27.2	$199.7	1.8	MB	Children's Hospital Research Institute of Manitoba, Health Sciences Centre Department of Research, Concordia Joint Replacement Group/Orthopaedic Innovation Centre
20	23	CIUSSS de la Capitale-Nationale - site IUSMQ	$33,856	$26,545	27.5	$490.7	19.2	QC	Centre de recherche CERVO
21	22	CIUSSS de l'Ouest-de-l'Île-de-Montréal	$32,554	$27,861	16.8	$561.3	3.6	QC	Douglas Hospital Research Centre
22	21	Institut universitaire de cardiologie et de pneumologie de Québec - Université Laval	$29,023	$28,050	3.5	$273.8	9.9	QC	Centre de recherche de l'Institut universitaire de cardiologie et de pneumologie de Québec - Université Laval
23	19	Alberta Health Services - Calgary Zone	$28,947	$32,021	-9.6	$391.2	na	AB	
24	25	Children's Hospital of Eastern Ontario	$26,350	$24,156	9.1	$112.1	8.7	ON	Children's Hospital of Eastern Ontario Research Institute
25	24	St. Joseph's Healthcare Hamilton	$25,684	$26,116	-1.7	$171.2	4.4	ON	Research St. Joseph's - Hamilton, Firestone Institute for Respiratory Health, Michael G. DeGroote Centre for Medicinal Cannabis Research
26		CIUSSS de l'Est-de-l'Île-de-Montréal	$25,252	$25,201	0.2	$135.8	2.1	QC	Centre de recherche de l'Hôpital Maisonneuve-Rosemont, Centre de recherche de l'Institut universitaire de santé mentale de Montréal
27	26	CIUSSS de l'Estrie - Centre Hospitalier Universitaire de Sherbrooke (CHUS)	$24,832	$23,732	4.6	$97.4	1.9	QC	Centre de recherche du CHUS, Centre de recherche sur le viellissement, Institut universitaire de premiere ligne en sante et services sociaux
28	27	Nova Scotia Health Authority	$22,798	$22,468	1.5	$77.3	1.1	NS	Maritime SPOR Support Unit, Biomedical Translation Imaging Centre, Atlantic Canada Cancer Research Unit
29	28	CIUSSS du Nord-de-l'Île-de-Montréal	$19,944	$16,376	21.8	$181.3	3.8	QC	Centre de recherche du CIUSSS du Nord-de-l'île-de-Montréal
30	30	Kingston Health Sciences Centre - KGH Site	$17,363	$15,813	9.8	$65.0	3.8	ON	Kingston General Health Research Institute
31	29	CIUSSS du Centre-Sud-de-l'Île-de-Montréal	$15,338	$15,987	-4.1	$62.6	1.3	QC	CRIUGM, URDPM, IUJD, CREMIS, CREDITSA, IUD
32	33	IWK Health Centre	$14,639	$13,915	5.2	$127.3	5.5	NS	Centre for Research in Family Health, Centre for Pediatric Pain Research, MicroResearch International
33	32	Baycrest	$14,584	$14,456	0.9	$560.9	9.1	ON	Rotman Research Institute
34	34	St. Boniface Hospital	$12,931	$12,044	7.4	$380.3	3.5	MB	Albrechtsen Research Centre
35	31	Women's College Hospital	$12,655	$14,673	-13.8	$316.4	8.3	ON	Women's College Research Institute, Women's College Hospital Institute for Health Solutions and Virtual Care
36	35	Holland Bloorview Kids Rehabilitation Hospital	$11,864	$11,319	4.8	$312.2	13.4	ON	Bloorview Research Institute
37	36	The Royal	$10,588	$8,956	18.2	$165.4	6.2	ON	University of Ottawa Institute of Mental Health Research
38	37	Hôpital Montfort	$7,438	$7,706	-3.5	$121.9	3.4	ON	Institut du Savoir Montfort
39	39	Health Sciences North	$7,143	$7,131	0.2	$89.3	1.5	ON	Health Sciences North Research Institute
40	38	Thunder Bay Regional Health Sciences Centre	$6,769	$7,618	-11.1	$75.2	2.2	ON	Thunder Bay Regional Health Research Institute

Notes:
1. Data were obtained through a survey or from financial statements. Information for Ontario was coordinated in part through CAHO (Council of Academic Hospitals of Ontario).
2. Research spending includes all funds (direct and indirect) spent on all sources (internal and external) to support research.
3. Researchers include full/part-time researchers/scientists/investigators/clinician-researchers with a faculty appointment who actively conduct research.
4. FY2016 figures may have been adjusted as more accurate information became available.
5. Data are provided for the main hospital/health network/health authority including their affiliated hospitals and research institutes/centres, where applicable.

+Not current name
na = not available
[a] Research spending amounts were combined as these hospitals have one research institute.
[b] Data for St. Boniface Hospital were not included with WRHA.

CANADA'S TOP 40 Research Hospitals

HOSPITAL RESEARCH SPENDING ADVANCES

Canada's Top 40 Research Hospitals posted a modest 4.1% gain in research spending in Fiscal 2017 and combined research spending increased to $2.65 billion from $2.55 billion in Fiscal 2016. Research spending increased at 28 Hospitals, Hospital Networks and Health Authorities and declined at 12 others. Average research spending rose to $66.2 million in Fiscal 2017 from $63.7 million the prior year. The number of health researchers was 8,667 – nearly the same as 8,657 in Fiscal 2016.

Toronto's University Health Network remained the largest health research enterprise, reporting $350.1 million of research spending (up 5.4%). Hospital for Sick Children ($209.6 million, up 4.0%) was next on the Top 40 list. Hamilton Health Sciences moved into the 3rd position nationally with nearly $207 million of research spending (up 20.7%). McGill University Health Centre (MUHC) was in 4th place with $204.2 million of research spending (up 14.2%). Despite a decline of -3.0%, Vancouver Coastal Health Authority moved into 5th place on the list with $145.5 million of research spending. New to the Top 40 this year is CIUSSS de l'Est-de-l'Île-de Montréal, which debuted in the 26th position.

THE $100 MILLION CLUB

In Fiscal 2017, 9 institutions – up from 8 last year – each recorded research spending in excess of $100 million. New to the $100 Million Club is CHU de Québec - Université Laval ($102.3 million). With a combined research spending of $1.61 billion, the $100 Million Club accounted for 60.8% of total national research spending in Fiscal 2017, up from 56.9% in Fiscal 2016.

The $100 Million Club

2017 Rank	Research Hospital	Research Spending $000
1	University Health Network	$350,080
2	Hospital for Sick Children	$209,627
3	Hamilton Health Sciences	$206,950
4	McGill University Health Centre (MUHC)	$204,174
5	Vancouver Coastal Health Authority	$145,501
6	Ottawa Hospital	$136,829
7	Provincial Health Services Authority	$133,314
8	London Health Sciences Centre/ St. Joseph's Health Care London	$123,255
9	CHU de Québec - Université Laval	$102,306

PROVINCIAL PERFORMANCE

In Fiscal 2017, Ontario's 19 health research organizations on the Top 40 list, accounted for $1.49 billion of total national research spending, or 56.3% of the total (up 5.2%). Quebec's 13 institutions accounted for $707.6 million, representing 26.7% of the national total (up 8.0%). Two health organizations from British Columbia posted $278.8 million of research spending, or 10.5% of the national total (down -10.6%).

Top 40 – Leading Provinces

Province	% of Total
Ontario (19)	56.3
Quebec (13)	26.7
British Columbia (2)	10.5

PERFORMANCE BY TYPE

Research Infosource's Top 40 Research Hospitals list is an amalgam of 3 types of institutions: stand-alone Hospitals, Hospital Networks and Health Authorities. This year, there were 21 Hospitals on the Top 40 list, accounting for $1.03 billion of research spending or 38.8% of the national total (up 4.5%). Twelve Hospital Networks spent $1.19 billion on research or 44.8% of the national total (up 7.6%). Seven Health Authorities spent $436.3 million, which represented 16.5% of the national total (down -5.3%).

RESEARCH SPENDING GROWTH

Compared with an overall gain of 4.1% in national spending, 7 organizations recorded increases of more than 10% in their research activity. CIUSS de la Capitale-Nationale – site IUSMQ posted an impressive 27.5% gain in research spending, followed closely by Winnipeg Regional Health Authority (WRHA) (up 27.2%). Research spending at CIUSSS du Nord-de-l'Île-de-Montréal rose by 21.8%, while research spending at Hamilton Health Sciences increased by 20.7% and research spending at The Royal grew by 18.2%. CIUSSS de l'Ouest-de-l'Île-de-Montréal increased their research spending by 16.8%, while McGill University Health Centre (MUHC) increased their research spending by 14.2%.

RESEARCHER INTENSITY

Research Infosource measures research intensity in two ways: by researcher (research spending per researcher), and by hospital (hospital research spending as a percent of total hospital spending). At the national level, researcher intensity expanded by 3.9% to an average of $305,700 of spending per researcher.

At $616,300 of spending per researcher, London Health Sciences Centre/St. Joseph's Health Care London led its large hospital peers, followed by University Health Network ($601,500 per researcher) and McGill University Health Centre (MUHC) ($590,100). Among the medium hospitals, Sinai Health System was the most researcher-intensive institution ($753,200 of spending per researcher) and also led the national results, followed by Hospital for Sick Children ($600,700 spending per researcher) and in third CIUSSS de l'Ouest-de-l'Île-de-Montréal ($561,300 spending per researcher). At the smaller institutions, Montreal Heart Institute led with $579,100 of spending per researcher), in second was Baycrest ($560,900 spending per researcher), followed by CIUSSS de la Capitale Nationale – site IUSMQ ($490,700 spending per researcher).

Measured by hospital intensity (proportion of total hospital spending accounted for by research), McGill University Health Centre (MUHC) led the large hospital category, devoting 18.7% of its total hospital spending to research. However, Hospital for Sick Children, a medium-size hospital, posted the highest portion of research spending of all institutions (23.8%), narrowly ahead of Montreal Heart Institute, a small-size hospital (23.3%).

THIS YEAR AND NEXT

Fiscal 2017 was essentially a year of stability for health research spending. The total national research spending increased by a modest 4.1%, compared with 4.8% growth in Fiscal 2016. Additionally, researcher numbers were essentially flat. However, a number of institutions did record impressive gains in their individual research spending.

Prospects for next year remain muted. Although the Federal Government's 2018 budget promised to "provide the single largest investment in fundamental research in Canadian history", the timing of the new spending means that any results are still a year – or more likely two years away. Only a portion of a planned $354.7 million of new spending over five years ($90.1 million per year ongoing) through the Canadian Institutes of Health Research will flow through to the Top 40 Research Hospitals, so in the grand scheme of things, overall gains will be muted.

Spotlight on Hospital Research Activity FY2017

Top Researcher-Intensive Organizations (Research Spending per Researcher)

Rank	Large	$000	Rank	Medium	$000	Rank	Small	$000
1	London Health Sciences Centre/St. Joseph's Health Care London	$616.3	1	Sinai Health System	$753.2	1	Montreal Heart Institute	$579.1
2	University Health Network	$601.5	2	Hospital for Sick Children	$600.7	2	Baycrest	$560.9
3	McGill University Health Centre (MUHC)	$590.1	3	CIUSSS de l'Ouest-de-l'Île-de-Montréal	$561.3	3	CIUSSS de la Capitale-Nationale - site IUSMQ	$490.7

Top Hospital-Intensive Organizations (Research Spending as % of Total Hospital Spending)

Rank	Large	%	Rank	Medium	%	Rank	Small	%
1	McGill University Health Centre (MUHC)	18.7	1	Hospital for Sick Children	23.8	1	Montreal Heart Institute	23.3
2	University Health Network	17.3	2	Centre for Addiction and Mental Health	16.9	2	CIUSSS de la Capitale-Nationale – site IUSMQ	19.2
3	Hamilton Health Sciences	14.2	3	Sinai Health System	14.8	3	Holland Bloorview Kids Rehabilitation Hospital	13.4

Note: Hospital size categories are based on Fiscal 2017 total hospital spending: Large = more than $1 billion; Medium = $400 million to $1 billion; Small = less than $400 million.

Top 10 Research Hospitals by Growth

2017 Rank Spending Growth	Overall	Research Hospital	% Change 2016-2017
1	20	CIUSSS de la Capitale-Nationale - site IUSMQ	27.5
2	19	Winnipeg Regional Health Authority (WRHA)	27.2
3	29	CIUSSS du Nord-de-l'Île-de-Montréal	21.8
4	3	Hamilton Health Sciences	20.7
5	37	The Royal	18.2
6	21	CIUSSS de l'Ouest-de-l'Île-de-Montréal	16.8
7	4	McGill University Health Centre (MUHC)	14.2
8	30	Kingston Health Sciences Centre - KGH Site	9.8
9	24	Children's Hospital of Eastern Ontario	9.1
10	15	CIUSSS du Centre-Ouest-de-l´île de Montréal	8.7

PARTNER PERSPECTIVE

Leading the charge to improve aging brain health

Dr. Allison Sekuler
Vice-President Research, Baycrest,
Sandra A. Rotman Chair in
Cognitive Neuroscience

We're in a race against time to tackle dementia and transform the aging experience.

As the world's population ages, a new case of dementia is diagnosed every three seconds with 7.7 million new cases per year worldwide. Currently, about 50 million people around the globe live with the neurodegenerative disorder and this number is expected to surge to 75 million by 2030.

The statistics may appear bleak, but there are opportunities to intervene. Baycrest researchers are leading the charge in the fight against dementia, as we work towards a world where every older adult enjoys a life of purpose, inspiration and fulfilment.

In 2018, Baycrest celebrated its centennial anniversary and this coming year, the Rotman Research Institute will celebrate its 30th anniversary. While we reflect on our successes, we also continue to move forward. This year, we launched a number of exciting new initiatives that will ultimately lead to better health for older adults.

The future of brain research: Stopping dementia before it develops

People commonly think of Alzheimer's as an "old person's disease," but our researchers have shown that dementia starts decades before any symptoms appear. The key to dementia prevention may be to maintain brain health throughout adulthood.

Building on decades of scientific discoveries, Baycrest is building the Kimel Family Centre for Brain Health and Wellness, a one-of-a-kind, research and care facility combining community wellness programming, specialized clinics, and integrated research aimed at enhancing wellness and preventing cognitive decline among older adults.

Under the direction of Dr. Howard Chertkow, Baycrest's new Chair in Cognitive Neurology and Innovation and Senior Scientist at the Rotman Research Institute (RRI), this new centre will spearhead the unprecedented convergence of scientific research and evidence-based interventions that will impact the brain health and wellness of older adults in our community, across Canada and around the world. It will incorporate innovations from the Baycrest-led Centre for Aging + Brain Health Innovation, as well as novel interventions and research programs developed by our researchers.

The Kimel Family Centre for Brain Health and Wellness' unique environment will allow clinicians and researchers to closely track the effectiveness of prevention regimens and bring us closer to discovering how to prevent dementia and minimize cognitive decline.

Clinical Trials Unit: Exploring promising dementia treatments

To complement this cutting-edge facility, Baycrest is also developing a formal Clinical Trials Unit to continue providing our clients and community members access to groundbreaking drug and non-drug interventions.

After decades of studying the brain, promising prevention and treatment options are finally emerging.

Some of the upcoming clinical trials that our researchers, clinicians and industry partners are planning at Baycrest include:

- Mindfulness meditation training for clients with cognitive impairment and their caregivers
- Real-time fall detection and prevention technology for clients with dementia
- Combined brain stimulation and group interventions to boost treatment effects
- Utilizing artificial intelligence-enabled robots to decrease loneliness and enhance quality of life among older adults living alone

The Clinical Trials Unit will enable Baycrest researchers to bring ideas to life and provide the latest dementia research, care and innovative solutions to our clients and the broader community.

Bridging the gap between research and care

To reach a point where we can start effectively preventing, detecting and treating dementia, various disciplinary approaches need to come together.

Baycrest has designed its campus to bring together researchers involved in work across the brain health spectrum, from basic science to uncover the mysteries of the human brain, to clinical studies to improve care at the bedside to innovative ideas to develop the latest technological tools to transform the aging experience.

The Ben & Hilda Katz Inter-Professional Research Program in Geriatric and Dementia Care, led by RRI Senior Scientist, Dr. Nicole Anderson, unites Baycrest's scientists, clinicians and front-line staff to engage in research that will address the unique challenges of older adults, particularly those with dementia, and develop new programs to maintain brain health and wellness.

Scientists from Baycrest's Rotman Research Institute, Drs. Morris Freedman and Allison Sekuler, are exploring the effectiveness of a brain-sensing headband for mindfulness meditation among individuals with cognitive impairment and their caregivers.

As our centennial comes to a close, Baycrest is proud to maintain its status as one of Canada's most research-intensive hospitals. We look forward to continuing to push the boundaries of aging and brain health research in our second century. Visit www.baycrest.org/research to find out how we can work together to not just add years to life, but to add life to years.

G7 meetings show benefits of Canada's support for research as a public good

Chad Gaffield
President,
Royal Society of Canada

A half-century ago, Canada's centennial events celebrated political independence amidst growing concern about continued intellectual and cultural dependence on other countries.

Today, scientists and scholars in Canada have graduated from world-class domestic as well as international universities; they include leaders in many fields and teach students using up-to-date and relevant curricula.

This dramatic transformation has been primarily enabled since the 1960s by federal government leadership in cultivating research excellence as a public good at home and abroad. This year's federal budget enthusiastically strengthened this leadership at an ideal time for Canada's hosting of the G7 countries.

As host for the G7 Science Academies, Canada's national representative, the Royal Society of Canada (RSC), seized this opportunity with its partners by selecting two topics for specific attention: (1) The Global Arctic: the sustainability of northern communities in the context of changing ocean systems; and (2) Our digital future and its impact on knowledge, industry and the workforce.

The G7 Science Academies developed formal G7 Science Academy statements to identify key challenges, recommendations and principles for action on these two topics. Moreover, the statements have provided the framework for successive G7 Research Summits, organized in collaboration with federal, provincial and international partners.

Many of the Academy recommendations were reflected in the G7 Summit Communiqué as well as the seven Charlevoix commitments. These documents included, for example, our recommendations on ensuring ethical and human-centered approaches to AI, promoting lifelong learning and digital literacy and promoting research and development in ocean science.

Many countries are beginning to truly confront the global challenges of our era. In keeping with Canada's leadership of research excellence as a public good, we must continue to act boldly and collaboratively to help make a better a future.

The bigger picture: Canada's commitment to science and innovation

Eric M. Meslin
President and CEO
Council of Canadian Academies

Canada has been stepping up its science and innovation game. The 2018 Global Innovation Index ranks Canada #18 out of 126 countries, up one spot from last year. With historic investments in research and infrastructure, an Innovation and Skills Plan, the Innovation Superclusters Initiative, and the appointment of a Chief Science Advisor, the Government of Canada is starting to paint the outlines of a future self-portrait of our country – one in which knowledge becomes a resource every bit as valuable as the natural resources that helped build Canada.

Many can point to these policy and financial investments as particularly impressive pieces of that painting: without basic research we might not know a world where insulin, the pacemaker, or the Canadarm exist, nor would we know some of the secrets of the cosmos. Just as a painter needs brushes, oils and palettes, the Government of Canada is providing researchers with the tools they need. As the Council of Canadian Academies' (CCA) recent report on the state of Canada's performance in S&T and IR&D showed, Canada's researchers compare most favorably on the world stage. We have leading scientists producing research of high impact, and the highest levels of educational attainment compared to our peers. Yet as CCA and others have noted, Canada still has a scale-up and prosperity problem that money alone will not fix.

Investment decisions in S&T, the economy, or health also offer a glimpse into the type of society we want to live in. The metaphor of a self-portrait breaks down if we believe that only one person paints it from their perspective. Canada is now collectively painting its science, technology, and innovation future: bench scientists and social scientists; clinical researchers and bioengineers; computer programmers and linguists; granting councils and small start-ups; provinces and territories each fill in pieces of the picture, and the many publics hold a brush.

What might we expect the finished portrait look like? Time will tell.

CANADA'S TOP 50 RESEARCH COLLEGES

CANADA'S INNOVATION LEADERS

RESEARCH Infosource Inc.

Niagara College Canada
APPLIED DREAMS.

Sheridan | Get Creative

HUMBER

RED RIVER COLLEGE
RESEARCH PARTNERSHIPS & INNOVATION

CENTENNIAL COLLEGE

Lambton College

CAMOSUN COLLEGE

CCNB INNOV

SASKATCHEWAN POLYTECHNIC

Ontario Centres of Excellence
Centres d'excellence de l'Ontario
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November 15, 2018

Canada's TOP 50 RESEARCH COLLEGES 2018

Rank 2017	Rank 2016	College	Research Income FY2017** $000	Research Income FY2016 $000	Research Income % Change 2016-2017+	Researchers* 2016-2017 #	Research Intensity $ per Researcher $000	Prov	Main Research Institute/ Centre/Facility
1	3	Lambton College	$11,397	$11,038	3.3	71	$160.5	ON	Centre of Excellence in Energy and Bio-Industrial Technologies
2	1	George Brown College	$11,060	$13,217	-16.3	128	$86.4	ON	Food Innovation & Research Studio, Product Development, Digital Experience, Green Building
3	15	NAIT - Northern Alberta Institute of Technology	$9,925	$5,205	90.7	48	$206.8	AB	
4	11	Cégep de Trois-Rivières	$8,290	$5,975	38.7	78	$106.3	QC	Centre de métallurgie du Québec
5	6	Sheridan College	$8,280	$8,297	-0.2	104	$79.6	ON	Sheridan Centre for Elder Research
6	5	Cégep de la Gaspésie et des Îles	$8,192	$9,951	-17.7	108	$75.9	QC	CIRADD, Merinov, Nergica
7	8	Centennial College	$7,004	$6,364	10.1	196	$35.7	ON	Wearable, Interactive, and Mobile Technologies Access Centre in Health
8	7	Niagara College	$6,517	$6,942	-6.1	63	$103.4	ON	Canadian Food & Wine Institute Innovation Centre
9	2	Fanshawe College	$6,237	$12,332	-49.4	55	$113.4	ON	Canadian Centre for Product Validation
10	9	Red River College	$6,205	$6,172	0.5	48	$129.3	MB	BETAC - Building Envelope Technology Access Centre
11	10	British Columbia Institute of Technology	$6,100	$6,000	1.7	120	$50.8	BC	Centre for Applied Research and Innovation
12	13	Cégep de La Pocatière	$5,970	$5,674	5.2	73	$81.8	QC	Solutions Novika, Biopterre, OPTECH
13	12	Cégep Édouard-Montpetit	$5,938	$5,737	3.5	87	$68.3	QC	Centre technologique en aérospatiale
14	14	Southern Alberta Institute of Technology (SAIT)	$5,495	$5,487	0.1	67	$82.0	AB	Centre for Innovation and Research in Unmanned Systems
15	16	Yukon College	$4,991	$4,803	3.9	43	$116.1	YT	Yukon Research Centre
16	23	Mohawk College	$4,865	$3,137	55.1	129	$37.7	ON	IDEAWORKS
17	20	Nova Scotia Community College	$4,675	$3,719	25.7	90	$51.9	NS	NSCC Applied Oceans Research Group
18	4	Cégep de Saint-Hyacinthe	$4,401	$10,792	-59.2	117	$37.6	QC	CTT Group, Cintech Agroalimentaire, Eklor
19	19	Cégep de Thetford	$3,664	$3,866	-5.2	42	$87.2	QC	OLEOTEK, Centre de Technologie Minérale et de Plasturgie
20	30	Humber College	$3,303	$2,275	45.2	302	$10.9	ON	Centre for Entrepreneurship
21	22	Cégep de Sept-Îles	$3,252	$3,190	1.9	25	$130.1	QC	ITMI, INREST
22	37	Cambrian College	$3,220	$1,856	73.5	27	$119.3	ON	Glencore Centre for Innovation
23	24	Conestoga College	$3,129	$2,825	10.8	168	$18.6	ON	Centre for Advancing Seniors' Care, Centre for Smart Manufacturing, Technology Recycling Lab
24	25	Collège communautaire du Nouveau-Brunswick	$3,000	$2,709	10.7	30	$100.0	NB	CCNB-*INNOV* Network
25	21	Cégep de Victoriaville	$2,894	$3,292	-12.1	48	$60.3	QC	CETAB+, CISA, INOVEM
26	41	Camosun College	$2,766	$1,635	69.2	15	$184.4	BC	Camosun Technology Access Centre
27	33	Algonquin College	$2,734	$2,072	31.9	79	$34.6	ON	Data Analytics Research Centre
28	29	Collège Shawinigan	$2,733	$2,308	18.4	28	$97.6	QC	CNETE (Centre National en Électrochimie et en Technologies Environnementales)
29	36	Collège d'Alma	$2,716	$1,904	42.6	19	$142.9	QC	Agrinova
30	27	Aurora College	$2,635	$2,485	6.0	11	$239.5	NT	Aurora Research Institute
31	18	Cégep André-Laurendeau	$2,628	$4,100	-35.9	30	$87.6	QC	OPTECH, Institut international de logistique de Montréal
32	26	Cégep de l'Abitibi-Témiscamingue	$2,448	$2,701	-9.4	23	$106.4	QC	Centre technologique des résidus industriels
33	47	College of the North Atlantic	$2,415	$1,474	63.8	18	$134.2	NL	Applied Mineralogy and Chemistry Lab
34	38	Collège de Maisonneuve	$2,410	$1,800	33.9	40	$60.3	QC	CÉPROCQ, ITEGA, IRIPI
35	31	Cégep de Lévis-Lauzon	$2,238	$2,239	-0.04	28	$79.9	QC	TransBIOTech, CRVI
36	49	Saskatchewan Polytechnic	$2,063	$1,404	46.9	65	$31.7	SK	Digital Integration Centre of Excellence
37	28	Seneca College	$1,990	$2,430	-18.1	71	$28.0	ON	Centre for Development of Open Technology
38	39	Dawson College	$1,945	$1,725	12.8	32	$60.8	QC	Centre de recherche pour l'inclusion scolaire et professionnelle des étudiants en situation de handicap
39	34	Red Deer College	$1,808	$2,001	-9.6	106	$17.1	AB	Centre for Innovation in Manufacturing
40	46	Cégep de Rimouski	$1,692	$1,506	12.4	32	$52.9	QC	SEREX, Innovation Maritime
41	40	Cégep de Saint-Laurent	$1,645	$1,704	-3.5	17	$96.8	QC	Centre des technologies de l'eau
42	44	Grande Prairie Regional College	$1,627	$1,531	6.3	44	$37.0	AB	National Bee Diagnostic Centre - Technology Access Centre
43	43	Durham College	$1,618	$1,575	2.7	32	$50.6	ON	Centre for Craft Brewing Innovation, Artificial Intelligence Hub
44	48	Olds College	$1,546	$1,427	8.3	28	$55.2	AB	OCCI - Olds College Centre for Innovation
45	45	Cégep de Sainte-Foy	$1,534	$1,512	1.5	37	$41.5	QC	Centre en imagerie numérique et medias interactifs
46	32	Holland College	$1,396	$2,210	-36.8	29	$48.1	PE	Canada's Smartest Kitchen
47	17	Cégep de Saint-Jérôme	$1,382	$4,326	-68.1	37	$37.4	QC	CDCQ, IVI
48		Cégep de Jonquière	$1,364	$1,094	24.7	62	$22.0	QC	CPA, ÉCOBES
49		St. Lawrence College	$1,316	$964	36.5	5	$263.2	ON	Sustainable Energy Applied Research Centre
50	42	Lethbridge College	$1,286	$1,628	-21.0	18	$71.4	AB	Aquaculture Centre of Excellence

Notes:
1. Data were obtained through a survey of publicly-funded colleges and from financial statements.
2. Research income includes all funds (direct and indirect) to support applied and scholarly research received from all sources (internal and external).
3. FY2016 figures may have been adjusted as more accurate information became available.
4. Data are provided for the main college including affiliated research institutes/centres, where applicable.

*Head count of full or part-time faculty/teaching staff/technicians and/or dedicated researchers conducting research. Does not include support staff or student researchers

**FY2017 research income excludes in-kind contributions, income received from Post-Secondary Institutions Strategic Investment Funds (PSI-SIF) and technical service/fee-for service agreements

+Caution should be used when comparing 2016-2017 research income growth results as definitions changed between years

Research Infosource Inc. is Canada's source of R&D intelligence.
For further information, please visit researchinfosource.com

CANADA'S TOP 50 **Research Colleges**

STEADY YEAR FOR COLLEGE RESEARCH

Canada's Top 50 Research Colleges posted combined research income of $197.9 million in Fiscal 2017. However, when additional research infrastructure funding of $61.7 million from the Federal Government's Post-Secondary Institutions Strategic Investment Fund (PSI-SIF) was included, combined research income increased to $259.6 million. (Twenty-seven of the 50 research colleges reported receiving PSI-SIF funding.)

Ontario's Lambton College led the Top 50 with research income of $11.4 million, while George Brown College ($11.1 million), NAIT - Northern Alberta Institute of Technology ($9.9 million), Cégep de Trois-Rivières ($8.3 million) and Sheridan College ($8.3 million) rounded out the five leading research colleges. Research Infosource welcomes Cégep de Jonquière and St. Lawrence College to this year's Top 50 list.

PROVINCIAL PERFORMANCE

Fourteen Ontario colleges attracted a total of $72.7 million of research income, representing 36.7% of the Top 50 total in Fiscal 2017. Twenty Quebec colleges posted $67.3 million of research income, accounting for 34.0% of the national total. Six Alberta colleges posted combined research income in Fiscal 2017 of $21.7 million, or 11.0% of the national total. Two British Columbia colleges reported combined research income of $8.9 million, or 4.5% of the national total.

Among the four leading provinces with more than one college reporting, the average provincial per-college research income was highest in Ontario ($5.2 million), British Columbia ($4.4 million), Alberta ($3.6 million) and Quebec ($3.4 million).

Top 50 – Leading Provinces

Province	% of Total
Ontario (14)	36.7
Quebec (20)	34.0
Alberta (6)	11.0
British Columbia (2)	4.5

Top 10 Research Intensive Colleges

2017 Rank Research Intensity	Overall	Research College	Research Intensity ($ per Researcher) $000
1	49	St. Lawrence College	$263.2
2	30	Aurora College	$239.5
3	3	NAIT - Northern Alberta Institute of Technology	$206.8
4	26	Camosun College	$184.4
5	1	Lambton College	$160.5
6	29	Collège d'Alma	$142.9
7	33	College of the North Atlantic	$134.2
8	21	Cégep de Sept-Îles	$130.1
9	10	Red River College	$129.3
10	22	Cambrian College	$119.3

Top 10 Research Colleges by Growth++

2017 Rank Income Growth	Overall	Research College	% Change 2016-2017
1	3	NAIT - Northern Alberta Institute of Technology	90.7
2	22	Cambrian College	73.5
3	26	Camosun College	69.2
4	33	College of the North Atlantic	63.8
5	16	Mohawk College	55.1
6	36	Saskatchewan Polytechnic	46.9
7	20	Humber College	45.2
8	29	Collège d'Alma	42.6
9	4	Cégep de Trois-Rivières	38.7
10	49	St. Lawrence College	36.5

++Caution should be used when comparing 2016-2017 research income growth results as definitions changed between years

RESEARCH INCOME GROWTH

A number of colleges posted strong gains in research income in Fiscal 2017, led by NAIT - Northern Alberta Institute of Technology, which reported an increase of research income of 90.7%. Additional college leaders for research income growth included Cambrian College (73.5% growth), Camosun College (69.2%), College of the North Atlantic (63.8%) and Mohawk College (55.1%). A total of twenty colleges reported research income growth in excess of 10% in Fiscal 2017.

RESEARCH INTENSITY

The total Top 50 research intensity (research income per researcher) was $62,400 in Fiscal 2017. This total was derived from a combined $197.9 million of research income and a total of 3,173 researchers (including faculty, researchers and technicians). Research intensity was highest at St. Lawrence College ($263,200 per researcher), Aurora College ($239,500) and NAIT - Northern Alberta Institute of Technology ($206,800). Overall, 28 of the 50 research colleges posted research intensities higher than the national average.

RESEARCH PARTNERSHIPS AND PROJECTS

Research Infosource focuses on two key college research indicators: the number of active formal research partnerships and the number of completed research projects. In Fiscal 2017, colleges reported a total of 4,219 active research partnerships associated with their research contracts, collaborative research agreements and partnership grants. Colleges also reported that they had completed a total of 2,309 research projects, excluding projects associated with technical service/fee for service agreements.

Among large colleges, Algonquin College reported 300 active research partnerships. Cégep de Saint-Hyacinthe was the medium college leader – and overall national leader – with 553 reported research partnerships. Cégep de la Gaspésie et des Îles was ahead in the small college grouping with 169 partnerships. Sheridan College completed 180 research projects to lead its large college counterparts, while Cégep de Saint-Hyacinthe completed 357 research projects, leading the medium colleges and capturing the national lead. Collège d'Alma headed the small college category with 77 completed research projects.

Spotlight on College Research Activity FY2017

Number of Research Partnerships*

Rank	Large	#	Rank	Medium	#	Rank	Small	#
1	Algonquin College	300	1	Cégep de Saint-Hyacinthe	553	1	Cégep de la Gaspésie et des Îles	169
2	Sheridan College	257	2	Cégep de Trois-Rivières	139	2	Collège d'Alma	157
3	Humber College	226	3	Lambton College	125	3	Cégep de La Pocatière	131

Number of Completed Research Projects*

Rank	Large	#	Rank	Medium	#	Rank	Small	#
1	Sheridan College	180	1	Cégep de Saint-Hyacinthe	357	1	Collège d'Alma	77
2	Algonquin College	170	2	Cégep de Trois-Rivières	195	2	Cégep de La Pocatière	76
3	Niagara College	131	3	Cégep Édouard-Montpetit	103	3	Cégep de Thetford	30

Number of Paid Student Researchers**

Rank	Large	#	Rank	Medium	#	Rank	Small	#
1	George Brown College	399	1	Lambton College	144	1	Cégep de la Gaspésie et des Îles	50
2	Centennial College	274	2	Cégep de Saint-Hyacinthe	101	2	Cégep de Jonquière	41
3	Humber College	182	3	Cambrian College	74	3	Yukon College	38
			3	Dawson College	74			

Industry Research Income+

Rank	Large	$000	Rank	Medium	$000	Rank	Small	$000
1	Mohawk College	$2,732	1	Cégep de Trois-Rivières	$3,429	1	Cégep de La Pocatière	$4,278
2	NAIT - Northern Alberta Institute of Technology	$2,638	2	Cégep de Saint-Hyacinthe	$2,384	2	Cégep de la Gaspésie et des Îles	$3,657
3	Sheridan College	$1,465	3	Cégep Édouard-Montpetit	$1,995	3	Cégep de Lévis-Lauzon	$1,605

Industry Research Intensity (Industry Research Income as % of Total Research Income)

Rank	Large	%	Rank	Medium	%	Rank	Small	%
1	Mohawk College	56.2	1	Cégep de Saint-Hyacinthe	54.2	1	Cégep de Lévis-Lauzon	71.7
2	Camosun College	30.6	2	Cégep de Saint-Jérôme	48.6	2	Cégep de La Pocatière	71.7
3	NAIT - Northern Alberta Institute of Technology	26.6	3	Cégep de Trois-Rivières	41.4	3	Cégep de Jonquière	69.5

Notes:
1. College size categories are based on Fiscal 2017 total college income: Large = more than $100 million; Medium = $50 million to $100 million; Small = less than $50 million.
2. Apparent ties due to rounding.

*Research partnerships and completed research projects with external organizations governed by formal written agreements
**Students that were involved in applied research projects that were paid for their work
+Research income from industry sources in the form of grants or contracts; excludes in-kind contributions/donations

INTERACTION WITH INDUSTRY

Total industry research income reported from grants and contracts in Fiscal 2017 was $42.8 million. Among the large colleges, Mohawk College reported $2.7 million from industry research contracts and grants in Fiscal 2017. Cégep de Trois-Rivières led its medium-sized peers, garnering $3.4 million of industry research income. Cégep de La Pocatière led the small colleges and captured the national lead, attracting $4.3 million of industry research income.

Another key indicator is industry research intensity – industry research income as a proportion of a college's total research income. Mohawk College led the large colleges with 56.2% of its research income coming from industry grants and contracts. Cégep de Saint-Hyacinthe (54.2%) topped the medium category and Cégep de Lévis-Lauzon (71.7%) led in the small college category.

THIS YEAR AND NEXT

Changes to this year's reporting format make it difficult to compare some Fiscal 2017 results with those of Fiscal 2016. Our overall impression is that with total research income of about $198 million, the college research enterprise is holding its own. About one-fifth of research income – $42.8 million – came from industry sources, an average of $872,694 per college. (For comparison, about 14% of university research income comes from corporate sources.) However, the college total industry research income was driven by 15 colleges where industry research income was particularly high, implying that activity is lower at a majority of colleges.

A total research workforce of 3,173 faculty, researchers and technicians signifies that, on average, 63 personnel are engaged at research at each institution. The total number of students paid to engage in research was 2,653 or an average of 53 per college.

Many colleges have begun to emulate the success of Quebec's CCTTs (Centres collégiaux de transfert de technologie) by establishing Technology Access Centres (TACs). The mission of the CCTTs and TACs is to help companies across the country gain access to the expertise, equipment and facilities of publicly-funded cégeps and colleges. Future engagement with industry, which is the raison d'être for college research, will rely heavily on their success.

PARTNER PERSPECTIVE

The cost of doing (applied research) business

Dr. Marc Nantel
Associate Vice-President, Research & Innovation, Niagara College, and Chair, National Research Advisory Committee (NRAC, CICan)

Canada's colleges, cégeps, polytechnics and institutes ("colleges") are deservedly lauded for their role in training the next generation of dental assistants, nurses, pipe-fitters, and computer programmers, amongst others. According to Colleges & Institutes Canada (CICan), there are over 670 college locations across Canada, and 95% of Canadians live within 50 km of them. Colleges add over $190B annually to Canada's economy and contribute to inclusive growth by working with employers to offer programs in urban, rural, remote, and northern communities. This is a well understood role of the colleges.

One crucial contribution that is newer and often forgotten, is that of applied research and economic development. For the past 10 years, thanks to funding from NSERC, CFI, and other federal and provincial agencies, colleges have greatly enhanced their engagement with industry – especially small and medium enterprises (SMEs) – by essentially becoming their research department. Universities and national laboratories research is generally centered on the discovery of new knowledge and far-reaching technology platforms. Colleges are focussed on providing faster, closer-to-market solutions for SMEs that need solutions now. And we've been very successful at it. According to reported numbers (so, likely underestimating), more than 7,300 research partnerships resulted in the development of more than 1,400 prototypes, 500 processes, and 350 services last year alone. The vast majority were collaborations with SMEs, which will commercialize the new products.

What types of products and services? Things that make a difference in the lives of ordinary Canadians: New web-based software to improve electronic medical records, and the connected hardware to facilitate aging at home; a new type of asphalt made of 98% recycled industrial waste; a new process to obtain purer lithium for better rechargeable batteries in electric cars; and a panoply of new beverages to please all palates, from light ciders to non-alcoholic beers to, soon, cannabis-infused anything! Colleges enable the creation of thousands of jobs every year, at small companies, but also at larger firms like Ferrero, Airbus, John Deere, IBM, and SONY.

All great news. What's the catch? We're coming to it. All this activity by colleges is managed and orchestrated by the institutions' research offices. Because funding for colleges is usually institution-based, the task of outreach to industry, as well as the strategic direction followed by the college, is the purview of those research offices, which have a huge impact on the successes exemplified above.

So here it is: None of the great results college applied research achieves across the country could happen without the work of the research offices, and yet they are run on inadequate resources, often on a shoestring budget. This is because, unlike our university cousins, colleges are not sufficiently supported for their non-project costs of research. While the provinces typically supply the building/electricity/heating infrastructure, and specific project grants provide some of their budgets (20% at most, often less) toward administration directly related to said projects, there is no provision for the support of the indirect – but very real – costs of research. These include such critical items as project scoping, financial and compliance monitoring, outcomes reporting, research data and research ethics board management, and human resource processes to hire students for the projects. All of these activities are necessary and mandated by government – not optional – but are not explicitly supported by the research funding.

The college applied research endeavour has grown greatly in the past 10 years, mostly organically. It was bootstrapped by those pioneering institutions – such as Niagara College – that got into this adventure early, and is now a serious contributor to Canada's innovation landscape, creating jobs and vital products to improve the lives of all Canadians. But we're hitting a wall. There is so much more demand from industry to grow through innovation and exports, but our system is reaching a breaking point. It cannot grow anymore to answer this demand and deliver great outcomes without serious support for the indirect costs of research.

Partnerships rule the college applied research system. We have made good on the outcomes we provide to our partners; it's time our most significant stakeholder – government – awarded the delivery of these amazing outcomes by investing in the funding of indirect costs of research. Imagine how much more we can accomplish together.

PARTNER PERSPECTIVE

Humber's Advanced Manufacturing Skills Consortium sets students and industry up for success

Darren Lawless, PhD
Dean, Applied Research & Innovation
Humber College

According to the Conference Board of Canada, Ontario's skills shortages are costing us as much as $24.3 billion in GDP – and as things stand now, the skills gaps will only grow if we don't start taking different approaches.

At Humber College, we are taking bold steps to help shape the future of industry through our unique model of polytechnic education and respond to the needs of business.

A few years ago, we began to implement our vision of bringing a technology and innovation hub to Humber. To be successful, we knew we had to accomplish two things right away. One was to be different in our approach to innovation. The other was to emphasize partnerships and seize the opportunity to work with and learn from industry leaders.

The result is our groundbreaking Barrett Centre for Technology Innovation (Barrett CTI), which is scheduled to open in early 2019. Within it, we will pioneer new solutions to technological and innovation challenges in advanced manufacturing and Industry 4.0.

Once complete, the five-storey, 93,000 square-foot space will feature a state-of-the-art data centre, cyber-physical factory, automated guided vehicles, prototyping labs, makerspaces, interactive technology zones and digital media studios.

The centre, which is located at Humber's North Campus in Toronto, will enable industry to work with faculty and students to drive adoption of new technologies Canadian companies need to succeed in a rapidly changing economy.

In 2016, Humber received the largest donation in its history from the Barrett Family Foundation, enabling the college to start work on the Barrett CTI. The federal and provincial government also provided funding through the Post-Secondary Institutions Strategic Investment Fund.

Humber's vision is resonating with industry who are also providing significant resources to support the initiative. As of October, we have signed five-year agreements with seven of the country's leading technology and innovation companies. These partnerships will create new learning pathways and opportunities for students, faculty, and industry experts to work together using the latest technology to solve real-world business challenges. Partners are providing Humber with the latest technology and equipment and our students and graduates with scholarships, and internship and job opportunities.

Cimetrix, Cisco Canada, Festo Didactic, SEW-EURODRIVE, DMG MORI Canada Inc., Kuka Canada and Rockwell Automation have become founding members of Humber's Advanced Manufacturing Skills Consortium. Through experiential learning, applied research projects, exposure to the latest technologies and interactions with our partners, we will be equipping our students with the skills necessary to succeed in an ever-changing global economy – the skills in demand by employers across the board.

Like all Canadian polytechnics and colleges, Humber has always valued and relied on the expertise of our industry partners. The Barrett CTI and the Advanced Manufacturing Skills Consortium are now raising the bar when it comes to how we build multi-faceted partnerships. They also provide a new platform to engage local companies in discussions about technology adoption and space for them to come and interact first-hand with cutting-edge equipment. Not only can we assist them in future-proofing their operations, as an educational provider, we can help them with a plan to train and upskill their current workforce.

In coming together as the Advanced Manufacturing Skills Consortium, I'm confident that we will teach and learn from each other, in turn, enhancing future opportunities for both employers, employees and students.

We believe that applied research projects and collaborative work between polytechnic institutions and private and public sector partners is the best way to put our students ahead of the curve in a competitive knowledge and skills driven economy.

As we collaborate, our industry partners have new ways to introduce their technologies to the next generation of employees. They in turn benefit from fresh, innovative ideas from aspiring professionals who are looking for real-world, work-integrated learning experiences. We think it is the best of both worlds. While there may be no traditional classrooms in the Barrett CTI, there's no doubt that the amount of learning that will occur in it will be immense.

Doubling down on impact

Continued from page 14

More than half of Mandela's cabinet members had been recipients of IDRC funding in such fields as health, urban issues, and economic and industrial policy.

"The big outcome of this is that it has strengthened ties between Canada and South Africa," says Lebel.

COMBATTING CLIMATE CHANGE

While bureaucrats from Canada, the United States and Mexico were toiling over the intricacies of a new free trade agreement, scientists from the three countries were working on an even more formidable challenge: to dramatically accelerate the world's transition to a low-carbon economy.

That effort is part of Canada's commitment to Mission Innovation, an initiative of 22 countries and the European Union to double public investment in in clean energy innovation. Leading scientists and thought leaders from around the world met September 2017 in Mexico City to identify opportunities to fast-track the discovery of high-performance, low-cost materials for new clean energy technologies. The workshop was sponsored by the Canadian Institute for Advanced Research (CIFAR), the Mexican Ministry of Energy and the U.S. Department of Energy.

The group later produced a 108-page roadmap for an automated platform for the chemical and materials lab of the future – one that integrates artificial intelligence, robotics and materials science to cut the time to develop new materials for clean energy from 20 years down to one or two years.

"This document is the only substantial research roadmap to come out of Mission Innovation to date and CIFAR is very proud of that," says John Hepburn, Vice-President, Research at CIFAR. "This is a basic research program that's also cutting-edge science. The idea is that this would revolutionize materials discovery."

Much of that groundbreaking work is happening at the University of British Columbia, which received about $10 million from Natural Resources Canada to establish the Ada lab, led by CIFAR Fellow Dr. Curtis Berlinguette and Dr. Jason Hein. The lab's robots are made by North Robotics of Victoria BC.

The Ada lab will work closely with another CIFAR Fellow, Dr. Alán Aspuru-Guzik, a Mexican-American scholar in theoretical and computational chemistry and the lead author on the roadmap report. This summer Aspuru-Guzik moved his lab and team from Harvard University to accept a Canada 150 Research Chair at U of T.

"This is an opportunity for a Canadian-based company and for Canadian researchers to lead in a field that is relevant to climate change and clean energy," says Hepburn. "We're talking about real impact, not just on the potential for materials discovery but also on how research is done."

BUILDING ON OUR STRENGTHS

The automotive industry is Ontario's largest manufacturing sector. It is also the single largest auto jurisdiction on the continent, producing one in every six North American-built vehicles. But the industry is facing strong headwinds, including disruptive technologies, global competition and shifting trade patterns.

To help prepare for those changes, the Ontario Centres of Excellence (OCE) received $80 million in provincial funding to support a new Autonomous Vehicle Innovation Network. The AVIN includes six demonstration sites where companies can partner with academic researchers and local municipalities to develop and test new technologies, access specialized equipment and obtain technical and business advice.

"We need to build on Ontario's strengths in the auto sector because the business is changing," says Dr. Tom Corr, President and CEO of the OCE, which connects industry with academic research. "Facilitating these transactions and pulling the players together – the researchers, big companies, small companies – that's the secret sauce we bring to the table."

The OCE also manages Ontario's participation in an ultra-high-speed fifth-generation (5G) wireless corridor extending from Quebec City to Windsor. Industry heavyweights Ericsson, Ciena Canada, Thales Canada, IBM Canada and CGI have invested in the $400-million ENCQOR (Evolution of Networked Services through a Corridor in Quebec and Ontario for Research and Innovation), which aims to unlock the massive potential of smart cities, e-health, e-education, connected and autonomous vehicles, on-demand entertainment and media, and the Internet of Things.

> Our projects are now more problem-driven.
>
> **Marc LePage, President and CEO, Genome Canada**

"The program will allow small- and medium-sized enterprises and start-ups to access this technology and build applications that can be exported around the world," says Corr.

SUPPORTING START-UPS

Ryerson University likes to boast that "entrepreneurship is in our DNA". The downtown Toronto campus is home to DMZ (aka Digital Media Zone), the top university-based business incubator in the world according to UBI Global. Since its launch in 2010, the space has nurtured 357 start-ups that have raised nearly $518 million in seed funding and created more than 3,400 jobs.

"The zones support experiential learning and engagement," says Dr. Steven Liss, Vice-President Research and Innovation at Ryerson. "One of the nice things about the Ryerson model is the zones are open and permeable to external participants and partners. It's not solely focused on things arising from Ryerson."

One successful DMZ graduate is the incubator's own co-founder, Dr. Hossein Rahnama, a former Ryerson student whose research into artificial intelligence and contextual computing led to the creation of Flybits. The company uses these advanced technologies to empower enterprises to connect with their customers more meaningfully through micro-personalized experiences. In addition to technology support, DMZ provided Flybits with seed funding through its venture arm, Ryerson Futures.

"Ryerson Futures was launched as a vehicle to draw venture capital for companies that may be coming out of Ryerson or ones we engage with globally," says Liss. "Ryerson Futures is now global with hubs from South Africa to Asia, including the Bombay Stock Exchange, as well as in Europe and the U.S. It exposes Ryerson to a global range of opportunities."

HELPING CHILDREN WITH RARE DISEASES

Nowhere is the demand for real-world results more pressing than in the area of human health and disease. Canada achieved a global first this year with a nation-wide initiative in precision medicine. Led by Genome Canada, the initiative will initially establish clinical sites across Canada for genetic testing for rare diseases, a field where Canada excels internationally. Rare genetic diseases impact about one million Canadians, mostly children, and are notoriously difficult to diagnose and treat.

"In health research the Holy Grail is to get into the clinic," says Marc LePage, President and CEO, Genome Canada. "Yet genomic testing to identify rare diseases is not applied anywhere in Canada. It is not a standard of care and rare diseases are really difficult to diagnose. We have all these young kids going around for months, if not years, without getting a proper diagnosis."

Increasingly, Genome Canada is expanding beyond health care to develop genomics-based solutions for diverse sectors, including agriculture, forestry, fisheries, the environment, and more recently, oil, gas and mining.

"Our projects are now more problem-driven," adds LePage. "We've had agricultural projects that deal with seed performance, animal genetics or antibiotic resistance. In fact, our funding in agricultural and natural resources, taken together, is now bigger than our funding on health."

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PARTNER PERSPECTIVE

Social innovation in research

John Helliker
Dean, Innovation & Engagement,
Sheridan College

Curiosity, innovation and creativity are hallmarks of Sheridan's character – and they fuel research across our campuses. Sheridan is committed to supporting diverse forms of research through our inclusive framework of scholarship, research and creative activities. Our research provides valuable experiences to students and faculty that contribute to economic and social benefits for our industry and community partners.

Social innovation is a significant area of focus and opportunity at Sheridan, and it aligns well with our commitment to research. Through our research, we continue to explore new strategies and ideas to help develop sustainable solutions from the ground up. Whether it's through working with community organizations to apply creative problem-solving to address social issues, or applying a technology innovation such as virtual and augmented reality or mobile application, the creation of new concepts, systems and practices in social innovation is driven by collaborative efforts with external partners. Social innovation in research thrives with external engagement and support, and Sheridan values that partnership and its impact to the economy and our communities. Our dedication to social innovation places us on a transformative path as we create, build and shape exciting new opportunities in research.

For our partners in industry and in the community, engaging in research with Sheridan provides an opportunity to join us on that transformative journey. Collaboration with our faculty, staff and students can provide access to infrastructure, training, skills and expertise. These resources can often be found in our Research Centres and our Entrepreneurial Hub: the Screen Industries Research and Training Centre (SIRT) at Pinewood Toronto Studios; the Centre for Advanced Manufacturing and Design Technologies (CAMDT) at our Davis Campus in Brampton; the Centre for Mobile Innovation (CMI), the Canadian Music Theatre Project (CMTP), and the Centre for Elder Research at the Trafalgar Campus in Oakville; and EDGE Entrepreneurship Hub located at our Hazel McCallion Campus in Mississauga.

Social innovation in research and entrepreneurship

Sheridan's Centre for Elder Research has a proud tradition of social innovation at work with colleagues on campus and out in the community. Elder Research recently celebrated its 15th anniversary of Lab to Life® research, offering innovative ways of enhancing the well-being of older adults and the environments that support them. Over the last 15 years, Elder Research has conducted nearly 100 research, evaluation and design projects that have directly benefited older adults and their families; developed over 40 formal relationships with businesses, community organizations and service providers; and hosted over 150 events for older adults, the Sheridan community and industry leaders, not-for-profit organizations and the general public. Through their interdisciplinary approach, the Centre for Elder Research is a leader in the integration of new ideas, methods and technologies in the field of aging.

Since opening its doors in September 2017, Sheridan's EDGE Entrepreneurship Hub has become an influential driver in entrepreneurial innovation. The Hub is a place for changemakers and entrepreneurs of all backgrounds to meet, learn and work together on an innovative business or social enterprise idea and turn it into reality. EDGE now supports approximately 40 start-up businesses across a variety of sectors. A notable example of social innovation at EDGE is Motify. Motify is a virtual assistant for students on the autism spectrum, and this start-up recently secured a competitive opportunity to pitch their venture at RISE, Asia's largest tech conference in Hong Kong.

Social innovation is a core element of research and entrepreneurship at Sheridan. Our people, our creativity, and our commitments drive our work to deliver both social and economic value to our partners through research.

To learn more about how you can partner with research at Sheridan, please visit research.sheridancollege.ca.

CANADA'S TOP 100 CORPORATE R&D SPENDERS

November 15, 2018

Canada's TOP 100 CORPORATE R&D SPENDERS 2018

Rank 2017	Rank 2016	Company	R&D Spending FY2017 $000	R&D Spending FY2016 $000	R&D Spending % Change 2016-2017	Revenue FY2017 $000	R&D Intensity R&D Spending as % of Revenue**	Industry
1	1	Bombardier Inc.*	$1,603,771	$1,968,653	-18.5	$21,060,695	7.6	Aerospace
2	2	Magna International Inc.*	$677,869	$662,400	2.3	$47,513,177	1.4	Automotive
3	8	IBM Canada Ltd. (fs)	$525,000	$478,000	9.8	nd		Software & Computer Services
4	5	BCE Inc.	$514,300	$518,900	-0.9	$22,719,000	2.3	Telecommunications Services
5	6	Pratt & Whitney Canada Corp. (fs)	$513,000	$511,000	0.4	nd		Aerospace
6	9	Constellation Software Inc.*	$475,473	$415,645	14.4	$3,219,776	14.8	Software & Computer Services
7	3	Valeant Pharmaceuticals International, Inc.*	$468,795	$557,741	-15.9	$11,328,986	4.1	Pharmaceuticals/Biotechnology
8	7	Rogers Communications Inc.	$459,143	$480,555	-4.5	$14,143,000	3.2	Telecommunications Services
9	15	Open Text Corporation*	$365,790	$257,087	42.3	$2,975,167	12.3	Software & Computer Services
10	12	Apotex Inc.	$363,688	$311,870	16.6	$2,202,789	16.5	Pharmaceuticals/Biotechnology
11	17	Suncor Energy Inc.	$350,000	$200,000	75.0	$32,176,000	1.1	Energy/Oil & Gas
12	4	Canadian Natural Resources Limited	$345,000	$549,000	-37.2	$16,651,000	2.1	Energy/Oil & Gas
13	10	BlackBerry Limited* ++	$310,365	$405,389	-23.4	$1,210,295	25.6	Software & Computer Services
14	11	Ericsson Canada Inc. (fs)	$310,000	$315,000	-1.6	nd		Comm/Telecom Equipment
15	13	CGI Group Inc.	$271,127	$267,082	1.5	$10,845,066	2.5	Software & Computer Services
16	16	AMD Canada (fs)	$248,362	$218,807	13.5	nd		Electronic Systems & Parts
17	20	TELUS Corporation	$240,000	$184,000	30.4	$13,304,000	1.8	Telecommunications Services
18	19	BRP Inc.++	$198,600	$184,100	7.9	$4,486,900	4.4	Other Manufacturing
19	21	CAE Inc.	$186,000	$150,000	24.0	$2,704,500	6.9	Aerospace
20	28	Shopify Inc.*	$176,606	$98,480	79.3	$874,353	20.2	Software & Computer Services
21	18	Imperial Oil Limited	$154,000	$195,000	-21.0	$29,125,000	0.5	Energy/Oil & Gas
22	25	Huawei Canada (fs)	$142,882	$127,479	12.1	nd		Comm/Telecom Equipment
23	24	Mitel Networks Corporation*	$135,704	$127,843	6.1	$1,375,347	9.9	Comm/Telecom Equipment
24	27	Hydro-Québec	$132,000	$122,000	8.2	$13,468,000	1.0	Electrical Power & Utilities
25	22	Cisco Canada (fs)	$130,175	$133,968	-2.8	nd		Comm/Telecom Equipment
26	23	Sanofi (fs) (a)	$123,000	$130,000	-5.4	$758,587	16.2	Pharmaceuticals/Biotechnology
27	29	Sierra Wireless, Inc.*	$109,402	$97,631	12.1	$898,731	12.2	Comm/Telecom Equipment
28	34	Ontario Power Generation Inc.	$106,000	$82,000	29.3	$5,158,000	2.1	Electrical Power & Utilities
29	31	Bayer Inc. (fs)	$104,861	$92,202	13.7	$1,142,883	9.2	Pharmaceuticals/Biotechnology
30	32	ProMetic Life Sciences Inc.	$101,946	$89,744	13.6	$39,115	260.6	Pharmaceuticals/Biotechnology
31	26	Maxar Technologies*	$100,969	$126,452	-20.2	$2,118,248	4.8	Software & Computer Services
32	30	Pfizer Canada Inc. (fs)	$97,865	$97,121	0.8	$1,199,741	8.2	Pharmaceuticals/Biotechnology
33	33	Linamar Corporation	$86,605	$85,292	1.5	$6,546,458	1.3	Automotive
34	35	Arbutus Biopharma Corporation*	$81,391	$81,148	0.3	$13,895	585.8	Pharmaceuticals/Biotechnology
35	38	Novelis Inc.* (fs)	$75,319	$71,539	5.3	$12,454,873	0.6	Mining & Metals
36	41	Evertz Technologies Limited	$73,699	$66,892	10.2	$384,432	19.2	Comm/Telecom Equipment
37	43	EXFO Inc.*	$68,987	$63,425	8.8	$315,951	21.8	Comm/Telecom Equipment
38	44	GlaxoSmithKline Inc. (fs)	$68,271	$62,452	9.3	$729,426	9.4	Pharmaceuticals/Biotechnology
39	45	Syncrude Canada Ltd.	$67,933	$61,886	9.8	nd		Energy/Oil & Gas
40	36	Westport Fuel Systems Inc.*	$66,303	$78,710	-15.8	$320,836	20.7	Other Manufacturing
41	82	Novelion Therapeutics Inc.*	$63,642	$19,586	224.9	$179,776	35.4	Pharmaceuticals/Biotechnology
42	42	Stars Group Inc.*	$62,842	$64,414	-2.4	$1,704,172	3.7	Software & Computer Services
43	47	Microsemi Storage Solutions Ltd.* (fs)	$61,358	$54,229	13.1	$1,660		Electronic Systems & Parts
44		Amgen Canada Inc. (fs)	$60,600	$66,500	-8.9	nd		Pharmaceuticals/Biotechnology
45	66	Teck Resources Limited	$55,000	$30,000	83.3	$12,048,000	0.5	Mining & Metals
46	46	Optiva Inc.*	$54,468	$60,273	-9.6	$179,108	30.4	Software & Computer Services
47	55	Descartes Systems Group Inc.* ++	$54,287	$47,105	15.2	$308,338	17.6	Software & Computer Services
48	53	Zymeworks Inc.*	$54,215	$48,774	11.2	$67,218	80.7	Pharmaceuticals/Biotechnology
49	51	Novartis Pharmaceuticals Canada Inc. (fs)	$51,000	$49,000	4.1	nd		Pharmaceuticals/Biotechnology
50	50	AstraZeneca Canada Inc. (fs)	$47,071	$50,065	-6.0	$626,933	7.5	Pharmaceuticals/Biotechnology
51	56	Enghouse Systems Limited	$45,890	$46,339	-1.0	$325,368	14.1	Software & Computer Services
52	90	Lockheed Martin Canada (fs)	$44,968	$16,244	176.8	$460,920	9.8	Aerospace
53	59	Cascades Inc.	$44,964	$38,197	17.7	$4,321,000	1.0	Forest & Paper Products
54	83	Aurinia Pharmaceuticals Inc.*	$44,061	$19,255	128.8	$545		Pharmaceuticals/Biotechnology
55	57	Avigilon Corporation*	$43,376	$43,121	0.6	$530,646	8.2	Computer Equipment
56	51	Pharmascience Inc.	$42,947	$49,000	-12.4	$525,647	8.2	Pharmaceuticals/Biotechnology
57		Eli Lilly Canada Inc. (fs)	$42,194	$40,726	3.6	nd		Pharmaceuticals/Biotechnology
58	48	Concordia International Corp.*	$40,883	$53,836	-24.1	$813,143	5.0	Pharmaceuticals/Biotechnology
59	60	Martinrea International Inc.	$40,808	$37,477	8.9	$3,690,499	1.1	Automotive
60	49	Dorel Industries Inc.*	$40,341	$51,789	-22.1	$3,347,360	1.2	Other Manufacturing
61	80	Resverlogix Corp.*	$38,884	$20,839	86.6	$0		Pharmaceuticals/Biotechnology
62	65	Trillium Therapeutics Inc.	$38,420	$30,030	27.9	$0		Pharmaceuticals/Biotechnology
63	61	Monsanto Canada Inc. (fs)	$37,528	$35,297	6.3	$1,010,063	3.7	Agriculture & Food
64	72	Canadian Solar Inc.*	$37,370	$23,061	62.0	$4,402,764	0.8	Energy/Oil & Gas
65	64	Northland Power Inc.	$36,785	$31,255	17.7	$1,376,256	2.7	Electrical Power & Utilities
66	76	Clementia Pharmaceuticals Inc.*	$35,589	$22,326	59.4	$0		Pharmaceuticals/Biotechnology
67	58	Thales Canada Inc. (fs)	$34,215	$38,700	-11.6	$692,000	4.9	Electronic Systems & Parts
68	63	Celestica Inc.*	$34,023	$32,988	3.1	$7,935,095	0.4	Electronic Systems & Parts
69	68	Kinaxis Inc.*	$33,532	$29,299	14.4	$173,125	19.4	Software & Computer Services
70	70	Ballard Power Systems Inc.*	$32,494	$26,267	23.7	$157,505	20.6	Machinery
71	79	IMAX Corporation*	$27,082	$21,614	25.3	$494,464	5.5	Other Services
72	81	L3 WESCAM (fs)	$26,462	$25,224	4.9	nd		Aerospace
73	74	Pason Systems Inc.	$25,219	$22,848	10.4	$245,643	10.3	Software & Computer Services
74	88	Absolute Software Corporation*	$22,758	$16,422	38.6	$118,447	19.2	Software & Computer Services
75	86	Enbridge Inc.	$22,500	$18,300	23.0	$44,378,000	0.1	Energy/Oil & Gas
76	89	Servier Canada Inc. (fs)	$20,831	$16,313	27.7	$359,752	5.8	Pharmaceuticals/Biotechnology
77	75	Winpak Ltd.*	$20,261	$22,744	-10.9	$1,151,565	1.8	Rubber & Plastics
78	95	CES Energy Solutions Corp.	$20,000	$15,000	33.3	$1,078,000	1.9	Energy/Oil & Gas
79		Field Upgrading Limited	$19,600	$9,820	99.6	$0		Energy/Oil & Gas
80	92	Espial Group Inc.	$19,306	$15,511	24.5	$33,433	57.7	Software & Computer Services
81	93	Mediagrif Interactive Technologies Inc.	$19,085	$15,395	24.0	$77,738	24.6	Software & Computer Services
82	85	Computer Modelling Group Ltd.	$17,842	$18,366	-2.9	$75,097	23.8	Software & Computer Services
83	67	Titan Medical Inc.*	$16,753	$29,911	-44.0	$0		Medical Devices & Instrumentation
84	96	Intertape Polymer Group Inc.*	$15,065	$14,295	5.4	$1,166,306	1.3	Rubber & Plastics
85	84	Resolute Forest Products Inc. (fs)	$14,400	$18,400	-21.7	$3,193,000	0.5	Forest & Paper Products
86		Essa Pharma Inc.*	$14,179	$17,302	-18.0	$0		Pharmaceuticals/Biotechnology
87	78	AEterna Zentaris Inc.*	$13,900	$21,853	-36.4	$1,199		Pharmaceuticals/Biotechnology
88		BSM Technologies Inc.	$12,745	$8,641	47.5	$66,717	19.1	Comm/Telecom Equipment
89		Velan Inc.* ++	$12,477	$10,557	18.2	$438,879	2.8	Other Manufacturing
90		Vecima Networks Inc.	$12,091	$10,866	11.3	$71,460	16.9	Comm/Telecom Equipment
91		Intellipharmaceutics International Inc.*	$12,039	$10,820	11.3	$7,147	168.4	Pharmaceuticals/Biotechnology
92		Theratechnologies Inc.	$11,856	$7,594	56.1	$42,864	27.7	Pharmaceuticals/Biotechnology
93	69	Rio Tinto Iron & Titanium Inc. (fs)	$11,764	$27,960	-57.9	$1,120,000	1.1	Mining & Metals
94	100	Hydrogenics Corporation*	$11,443	$10,926	4.7	$62,400	18.3	Energy/Oil & Gas
95		Mogo Finance Technology Inc.	$11,373	$10,114	12.4	$48,681	23.4	Other Services
96		TECSYS Inc.	$11,347	$10,749	5.6	$68,447	16.6	Software & Computer Services
97	77	Héroux-Devtek Inc.	$11,281	$22,000	-48.7	$386,564	2.9	Aerospace
98		Baylin Technologies Inc.	$11,248	$10,229	10.0	$91,642	12.3	Comm/Telecom Equipment
99		AgJunction Inc.*	$10,662	$10,249	4.0	$60,750	17.6	Comm/Telecom Equipment
100	98	ShawCor Ltd.	$10,536	$13,239	-20.4	$1,566,652	0.7	Other Manufacturing

Notes:
1. Data were obtained through annual reports, financial statements, securities commission filings, or through a survey.
2. We have attempted, wherever possible, to provide gross R&D spending before deduction of investment tax credits or government grants.
3. We have attempted, wherever possible, to provide revenue net of interest and investment income.
4. FY2016 R&D spending figures may have been adjusted as more accurate information became available.
5. Canadian-owned company results include worldwide revenue and R&D spending; foreign subsidiaries (fs) for their Canadian operations only.

*Converted to CDN$ at annual average 2017 = 1.2986; 2016 = 1.3248 (Bank of Canada)
**Based on companies with $2 million or more of revenue
++Fiscal 2018 figures were used for year-ended January or February
fs = Foreign subsidiary (includes revenue and R&D spending for Canadian operations only)
nd = Not disclosed
(a) Sanofi Pasteur Limited and sanofi-aventis Canada Inc. (including Sanofi Genzyme Canada).

Research Infosource Inc. is Canada's source of R&D intelligence. Data used for this table were extracted from our proprietary Canadian Corporate R&D Database. Companies wishing to be included in future editions of the Top 100 List, or who wish to adjust their figures should contact us directly.

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CANADA'S TOP 100 Corporate R&D Spenders

R&D SPENDING FLAT

Total research and development (R&D) spending by *Canada's Top 100 Corporate R&D Spenders* inched up by only 0.7% in Fiscal 2017. Top 100 R&D spending was $12.47 billion in Fiscal 2017 compared with $12.39 billion in Fiscal 2016. R&D spending increased at 70 companies and declined at 30. However, without Bombardier Inc. in the mix underlying R&D spending by 99 leading companies improved significantly, rising by 4.3%. Top-line combined R&D spending was held back by a sharp -18.5% decline in R&D spending at Bombardier Inc. – once again the Top 100 leader.

Combined revenues of 89 of the Top 100 that disclosed this data, rose by a robust 8.7% to $384.75 billion. This led to R&D intensity (R&D spending as % of revenue) dropping sharply in Fiscal 2017 by -8.1%. However with Bombardier Inc. again excluded, R&D intensity among the 88 firms declined somewhat less, by -4.8%.

Bombardier has now headed the Top 100 list for 6 consecutive years, reporting $1.6 billion in R&D spending in Fiscal 2017, although -18.5% less than in Fiscal 2016. Magna International Inc. maintained 2nd place with a 2.3% increase in R&D spending to $677.9 million. IBM Canada Ltd. leapt into 3rd position from 8th place last year with a 9.8% increase in R&D spending to $525.0 million. BCE Inc. moved into 4th place from from 5th with $514.3 million in Fiscal 2017 and Pratt & Whitney Canada Corp. placed 5th, up from 6th place with R&D spending of $513.0 million in Fiscal 2017.

THE $100 MILLION CLUB

Thirty-one Top 100 firms – up from 26 in Fiscal 2016 – gained a place in Research Infosource's *$100 Million Club* of companies that spent $100 million or more on R&D. Joining the Club this year were Shopify Inc. ($176.6 million), Sierra Wireless, Inc. ($109.4 million), Ontario Power Generation Inc. ($106.0 million), Bayer Inc. ($104.9 million) and ProMetic Life Sciences Inc. ($101.9 million). In total, $100 Million Club members spent $9.94 billion on R&D, a gain of 3.6% in Fiscal 2017. Club members also accounted for 80% of total Top 100 R&D spending in Fiscal 2017, compared with 77% in Fiscal 2016.

R&D SPENDERS TIERS

Grouping the Top 100 companies into 3 R&D spending tiers (Tier 1 = $100 million or more of R&D spending, Tier 2 = $30 million-$99.9 million, Tier 3 = less than $30 million), we highlight 9 firms that were top R&D spending leaders in Fiscal 2017 in their category. Bombardier Inc. ($1.6 billion), Magna International Inc. ($677.9 million) and IBM Canada Ltd. ($525.0 million) were tops in Tier 1. Pfizer Canada Inc. ($97.9 million), Linamar Corporation ($86.6 million) and Arbutus Biopharma Corporation ($81.4 million) led Tier 2. IMAX Corporation ($27.1 million), L3 WESCAM ($26.5 million) and Pason Systems Inc. ($25.2 million) paced Tier 3.

R&D SPENDING GROWTH

In Fiscal 2017, the leading firms for growth in R&D spending in Tier 1 were Shopify Inc. (79.3%), Suncor Energy Inc. (75.0%) and Open Text Corporation (42.3%). The Tier 2 leaders were Novelion Therapeutics Inc. (224.9%), Lockheed Martin Canada (176.8%) and Aurinia Pharmaceuticals Inc. (128.8%). Tier 3 R&D growth leaders were Field Upgrading Limited (99.6%), Theratechnologies Inc. (56.1%) and BSM Technologies Inc. (47.5%).

R&D INTENSITY

While Top 100 R&D intensity (R&D spending as a percent of revenue) fell by -8.1% among the 89 firms for whom complete data were available, a number of companies bucked the trend by posting very strong gains in R&D intensity in Fiscal 2017. In Tier 1, the leading firms were ProMetic Life Sciences Inc. (260.6%), BlackBerry Limited (25.6%) and Shopify Inc. (20.2%). Tier 2 leaders were Arbutus Biopharma Corporation (585.8%), Zymeworks Inc. (80.7%) and Novelion Therapeutics Inc. (35.4%). Heading Tier 3 were Intellipharmaceutics International Inc. (168.4%), Espial Group Inc. (57.7%) and Theratechnologies Inc. (27.7%).

REGIONAL PERFORMANCE

Forty-three Top 100 companies headquartered in Ontario spent a combined total of $5.38 billion on R&D in Fiscal 2017, a gain of 7.8% and representing 43% of the Top 100 total, up from 40% in Fiscal 2016. Twenty-eight companies in Quebec spent a total of $4.95 billion on R&D, a drop of -7.6% which represented 40% of the Top 100 total, down from 43% the prior year. Twenty-nine R&D companies in western Canada allocated $2.14 billion to R&D, increasing their spending by 4.8%, which represented 17% of the Top 100 total, up from 16% in Fiscal 2016.

INDUSTRY PERFORMANCE

In Fiscal 2017, the industry sectors representing the largest share of the Top 100 R&D total included: Software & Computer Services, where 18 companies spent a combined $2.59 billion on R&D (a gain of 8.2%) and accounted for 21% of the Top 100 total. Six Aerospace companies, spent a combined $2.39 billion (a decline of -11.4%) representing19% of the total, 25 Pharmaceuticals/Biotechnology companies with a total $2.04 billion in R&D spending in Fiscal 2017, up 3.9% and accounted for 16% of the Top 100 total. Three Telecommunications Services companies represented 10% of the total 100 R&D spending with combined spending of $1.21 billion, a growth of 2.5% over Fiscal 2016.

BUCKING THE TREND

Several industry sectors performed counter to expectations with regard to their revenue and R&D spending, while others moved in predictable directions. Normally it would be expected that companies with growing revenue will increase their R&D spending, while those with revenue falls will cut back on R&D. In fact, while combined revenue fell by -5.7%, 22 Pharmaceuticals/Biotechnology firms in the Top 100, increased their combined R&D spending by 4.3% in Fiscal 2017. On the other hand, 8 Energy/Oil & Gas companies had a combined revenue increase of 25.2%, but overall R&D spending dropped by -6.0% in Fiscal 2017. Twenty Information and Communications Technology (ICT) Services firms grew their R&D spending (5.8%), slightly ahead of their revenue gain (4.5%).

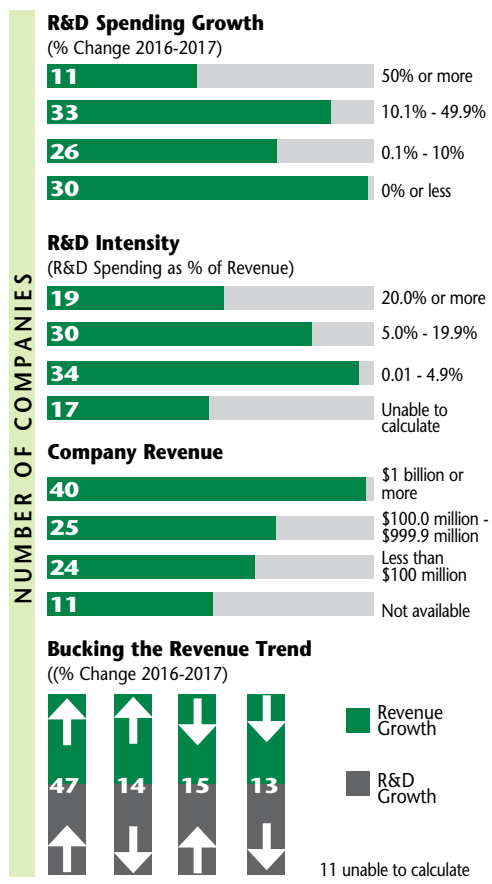
Top 100 – Leading Industries

Industry	% of Total
Software & Computer Services (18)	21
Aerospace (6)	19
Pharmaceuticals/Biotechnology (25)	16
Telecommunications Services (3)	10
Energy/Oil & Gas (9)	8
Communications/Telecom Equipment (11)	8
Automotive (3)	6

THIS YEAR AND NEXT

Top-line R&D spending growth for Canada's Top 100 R&D Spenders in Fiscal 2017 was stalled at 0.7%. However, R&D spending of 99 leading firms (without Bombardier) was a more encouraging 4.3% – a respectable result, though not one that will set the research world on fire. Research Infosource's *$100 Million Club* gained 5 members this year, bringing it to 31 large performers. Furthermore, 70 of the Top 100 increased their R&D spending versus 30 where R&D spending declined. These results come against a backdrop of solid performance of the Canadian economy in 2017. Despite trade uncertainties, Fiscal 2018 has begun on another positive economic note and as such we expect that Top 100 R&D performance will expand moderately next year, but probably not at a pace that will significantly improve Canada's innovation performance.

Top 100 Corporate R&D Spenders Key Demographics FY2017



Top Corporate R&D Spenders by Tier FY2017

R&D Spending

Spending Overall		Tier 1	$000
1	1	Bombardier Inc.	$1,603,771
2	2	Magna International Inc.	$677,869
3	3	IBM Canada Ltd. (fs)	$525,000

Spending Overall		Tier 2	$000
1	32	Pfizer Canada Inc. (fs)	$97,865
2	33	Linamar Corporation	$86,605
3	34	Arbutus Biopharma Corporation	$81,391

Spending Overall		Tier 3	$000
1	71	IMAX Corporation	$27,082
2	72	L3 WESCAM (fs)	$26,462
3	73	Pason Systems Inc.	$25,219

R&D Spending Growth (% Change 2016-2017)

Growth Overall		Tier 1	%
1	20	Shopify Inc.	79.3
2	11	Suncor Energy Inc.	75.0
3	9	Open Text Corporation	42.3

Growth Overall		Tier 2	%
1	41	Novelion Therapeutics Inc.	224.9
2	52	Lockheed Martin Canada (fs)	176.8
3	54	Aurinia Pharmaceuticals Inc.	128.8

Growth Overall		Tier 3	%
1	79	Field Upgrading Limited	99.6
2	92	Theratechnologies Inc.	56.1
3	88	BSM Technologies Inc.	47.5

R&D Intensity* (R&D Spending as % of Revenue)

Intensity Overall		Tier 1	%
1	30	ProMetic Life Sciences Inc.	260.6
2	13	BlackBerry Limited	25.6
3	20	Shopify Inc.	20.2

Intensity Overall		Tier 2	%
1	34	Arbutus Biopharma Corporation	585.8
2	48	Zymeworks Inc.	80.7
3	41	Novelion Therapeutics Inc.	35.4

Intensity Overall		Tier 3	%
1	91	Intellipharmaceutics International Inc.	168.4
2	80	Espial Group Inc.	57.7
3	92	Theratechnologies Inc.	27.7

Notes:
1. R&D Spending Tiers: Tier 1 = $100 million or more of R&D spending,Tier 2 = $30 million-$99.9 million,Tier 3 = less than $30 million.
*Based on companies with $2 million or more of revenue fs = Foreign subsidiary (included revenue and R&D spending for Canadian operations only)

PARTNER PERSPECTIVE

Innovation puts Syncrude in the oil sands spotlight


Syncrude's research and development team of scientists and engineers have earned more than 200 patents since 1966.

In 2014, the Alberta Science and Technology Leadership (ASTech) Foundation recognized Syncrude's Research & Development (R&D) Team with a Special Award for their collective 50-year contribution to the advancement of the science behind Canada's oil sands. Syncrude's commitment to innovation began in 1964 and continues to this day.

Syncrude operates large oil sand mines, utilities plants, a bitumen extraction plant and upgrading facility in Northern Alberta that processes bitumen and produces value-added light, sweet crude oil for domestic consumption and export.

Innovation is a core company value that has allowed Syncrude to evolve into an industry leader when it comes to developing the oil sands and addressing environmental needs including reclaiming mine sites.

"The industry was in its infancy in 1964 and solutions to unlocking the mysteries of the oil sands would need to be invented, tested and implemented because they simply didn't exist," says Mal Carroll, General Manager, Research and Development. "We remain committed to advancing the industry through research and development while reducing our environmental footprint and returning the land we've mined back to nature."

Syncrude is one of only a few oil sands operators with a dedicated Research and Development facility, and is among the top 50 R&D spenders in Canada. The company spends about $65 million annually on research and development, more than half of which is invested in environmental initiatives.

It has invested more than $1.5 billion over the past 50 years on its own research and in collaboration with North American universities and research organizations to advance the oil sands industry and its leading edge technologies. This work has led to incremental but significant change in processes and technology, and has also produced major industry advancements. Some of Syncrude's innovations include:

• Hydrotransport technology, an energy efficient method of mixing oil sand with water close to the mine face so it can be sent via pipeline to the processing plant.

• Lower Energy Extraction, which uses less energy and resources than traditional hot water bitumen extraction methods.

• Bitumen froth pipelining technology, which enabled the development of oil sands mines that are remote from an upgrading facility.

• Inclined Plate Settlers for Froth Treatment to remove water and solids from diluted bitumen froth.

• Tailings management technologies that enable the use of treated tailings materials in land reclamation.

• Establishing the Syncrude Analytical Methods. These are the accepted standard for industry, government and universities to measure and analyze the components and properties of oil sand, as well as the related substances formed during processing.

From corrosion and erosion abatement, and extending the life of tires used for heavy haulers, to hydrotransport and innovative land reclamation approaches, Syncrude continues to make steady and impactful progress for responsible development of the oil sands.

These investments into R&D have generated an estimated $33 billion of value for Syncrude and include more than 200 patents awarded since 1966. The innovations to responsibly mine, extract and upgrade bitumen would not exist to the extent they do today without the work of the Syncrude's Research and Development team. Syncrude's commitment to innovation and investment in research and development will ensure these advancements continue for the life of its operation and the industry as a whole.

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#1 in research intensity per graduate student

McMaster University

BRIGHTER WORLD

Source: Research Infosource Inc. 2018