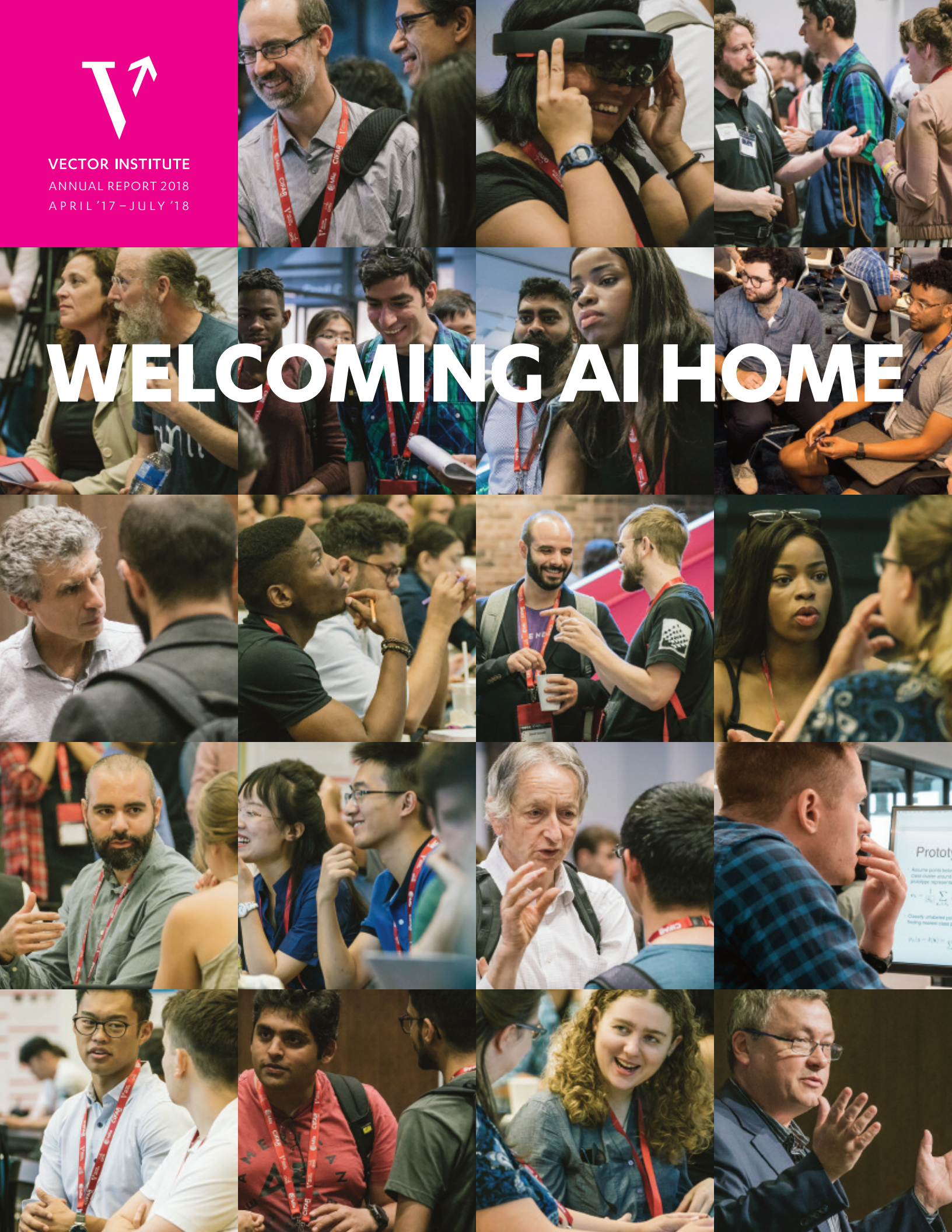
VECTOR INSTITUTE

ANNUAL REPORT 2018

APRIL '17 – JULY '18

WELCOMING AI HOME



CONTENTS

OUR VISION

The Vector Institute will drive excellence and leadership in Canada's knowledge, creation, and use of artificial intelligence (AI) to foster economic growth and improve the lives of Canadians.

OUR MISSION

Vector will lead Ontario's efforts to build and sustain AI-based innovation, growth and productivity in Canada by focusing on the transformative potential of deep learning and machine learning.

We, together with our AI partners in other parts of Canada, will work with Canadian industry and public institutions to ensure that they have the people, skills, and resources to be best in class at the use of AI.

We will support Canada's innovation clusters in AI and focus on helping startups grow to become Canadian-based global leaders.

We will attract the best global talent focused on research excellence; our researchers and academic partners will be part of a vibrant community of innovative problem-solvers, working across disciplines on both curiosity-driven and applied research.

Message from the Board Chair

It is with delight that I think back to the beginnings of Vector and review what has been accomplished. Two years ago, I was attending the Rotman Conference on Machine Learning and the Market for Intelligence, having decided I should learn about this innovative thing called AI. Tomi Poutanen approached me to ask whether he and Jordan Jacobs could come visit me—little did I realize what I was getting myself into.

Their pitch was simple: 'AI is the future. Think of the effect like electricity. It will revolutionize society and economies. Toronto has historic research strengths in this area, along with Montreal and Edmonton. Geoff Hinton has returned to Toronto. The startup system in Toronto is burgeoning. We have a magic moment. But we have no time to waste. Already many of our best people have headed south to pursue their careers. We need to build a centre to recruit the best from around the world, where our own best can stay and grow.'

As with many good ideas, there are many who can claim to have thought it up. In this case, the idea had germinated with a number of scientists and they were keen to make it happen. We first needed a name: Vector. But more importantly we needed money. Now I realized why they wanted a banker!

We will build the supply of domestic talent and be a beacon that attracts talent from around the world. We will make Canadian companies more competitive by helping them harness the transformative potential of AI.

And we got it, first from the Ontario government. Then Ottawa followed with a Pan-Canadian AI Strategy built around three institutes—in Montreal, Toronto, and Edmonton—with affiliated faculty members from universities across Canada. Particularly the University of Toronto was a great partner from day 1. This model allows us to work collectively to build Canadian strength in AI in the face of the ever-increasing competition in the world.

But it was the response of the private sector that was most exciting. This was to be a different institute. Not just one where we would be seen as a world-class centre of academic research, but an organization focused on helping Canadian institutions—whether public institutions or private companies—to be the best-in-class in their fields at using AI. Even more importantly, we would work with the large AI startup community in Ontario to help them scale up to become sustainable world-class competitors. Canadian CEOs responded to our challenge by pledging an amount that effectively matched the funding of each of the two governments. They proved again that we have business leaders in Canada who truly understand that their companies only do well if Canada does well and that working together is the best way for Canada to do well.

This report will tell the story of what Vector has managed to do in a very short period of time. In a word, it has been amazing! We were starting from scratch. Building an institute from nothing. Alan Veerman, our COO, aided by a team hired one at a time, put the many pieces together. Rich Zemel, guided with great advice from Geoff and his colleagues, began the recruiting process, and we discovered we really could attract the world's best. Among those was our CEO, Garth Gibson, a Canadian scholar and academic administrator who built his career at Carnegie Mellon University, a leading university in AI. Garth is doing a great job leading the institute to fulfill its mission.

It has been a true honour to be part of this great journey. If we do this right, and the team is determined that we will, Vector will be seen globally as a go-to place for AI. We will build the supply of domestic talent and be a beacon that attracts talent from around the world. We will make Canadian companies more competitive by helping them harness the transformative potential of AI. We will help advance the public sector in areas such as health, improving outcomes for patients and creating efficiencies, and we will nurture an ecosystem to produce the next generation of great Canadian companies.

ED CLARK
BOARD CHAIR

Message from the President and CEO

Ontario is in the midst of an unprecedented economic boom in its technology sector with AI leading the wave.

In a recent study of North American cities, Toronto received the top score in the "Brain Gain" category, measured as the excess of tech jobs filled over tech degrees granted.[1] Over the past five years, Toronto added over 82,000 workers to its technology talent pool—more than in any other region, including Silicon Valley and the entire San Francisco Bay Area. Since Vector's public launch 18 months ago, we have seen headlines citing well over $800 million in new AI and tech-related investments and expansions announced in Ontario, creating at least 5,000 new jobs across Canada.

Threatening these gains, Canada was recently losing talented machine learning scientists faster than we could produce them. Before the Vector Institute launched in 2017, Canada's world-leading AI talent was routinely recruited by top universities and tech companies abroad. Despite a long history of research excellence in deep and reinforcement learning, Canada did not have the right combination of advanced research institutes, companies, labs, and opportunities to keep them here.

1. Source: CBRE Report — 2018 Scoring Tech Talent. Influencing Innovation, Economic and Real Estate Growth in 50 U.S. and Canadian Markets.

2. McKinsey, "AI Looks North," 2018

By securing and growing a solid base of top AI talent and expanding our partnerships with academia and industry, Vector will continue to advance outstanding machine learning research and give us an advantage in the knowledge economy.

Recognizing the urgency to act and the transformational potential of AI for our economy, the Government of Ontario, Government of Canada—through its Pan-Canadian AI Strategy—and dozens of industry partners all committed the funding that enabled the launch of the Vector Institute.

Vector was founded to reverse the outflow of machine learning talent by retaining and drawing to Ontario top AI researchers and the companies that want to work with them.

In Vector's first year of operation, we have seen success on all these fronts.

Vector has secured partnerships with 41 industry sponsors from across sectors of the Canadian economy. Vector's programs allow them to access top AI talent, stay on top of the latest research developments, and give their executive teams the knowledge and context they need. Lately, we hear almost daily stories of new AI-related products and services. Each week, companies announce new investments in AI. In Canada, 87 per cent of Canadian executives plan to increase their AI investment over the next few years.[2] Our industry sponsors and the companies expanding into Ontario know that staying on top of machine learning advances will give them a competitive edge.

The cornerstone supporting this AI ecosystem is a growing community of machine learning research talent and a broader AI workforce. We have doubled the size of our founding faculty and formed a community of more than 220 talented AI researchers, including post-doctoral researchers and graduate students. We are building on this strong foundation by upskilling industry tech workers and increasing the number of people graduating and working in AI.

Building this community is allowing us to train, attract and retain star researchers. They choose to come here because of Vector's concentration of talent and the flexibility to pursue fundamental research, teach students, work with industry, and commercialize their ideas, not to mention Canada's openness and quality of life.

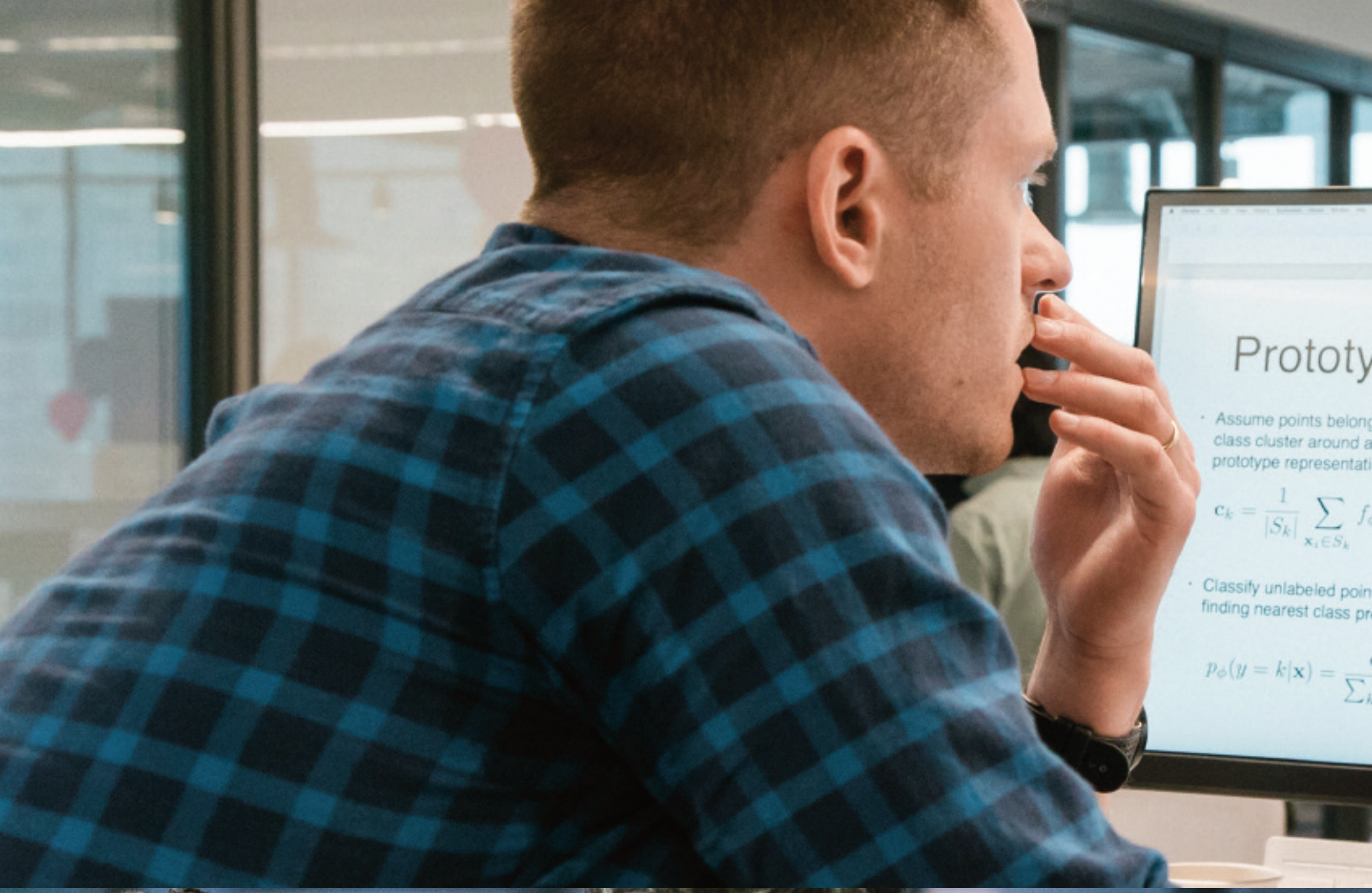
We have worked hard to get here, but to take advantage of the substantial opportunities for growth, the hardest work remains ahead of us.

By securing and growing a solid base of top AI talent and expanding our partnerships with academia and industry, Vector will continue to advance outstanding machine learning research, and give Toronto, Ontario and Canada an advantage in the global knowledge economy.

DR. GARTH GIBSON
PRESIDENT & CEO

TALENT

Training, attracting and retaining a collaborative community of world-class AI talent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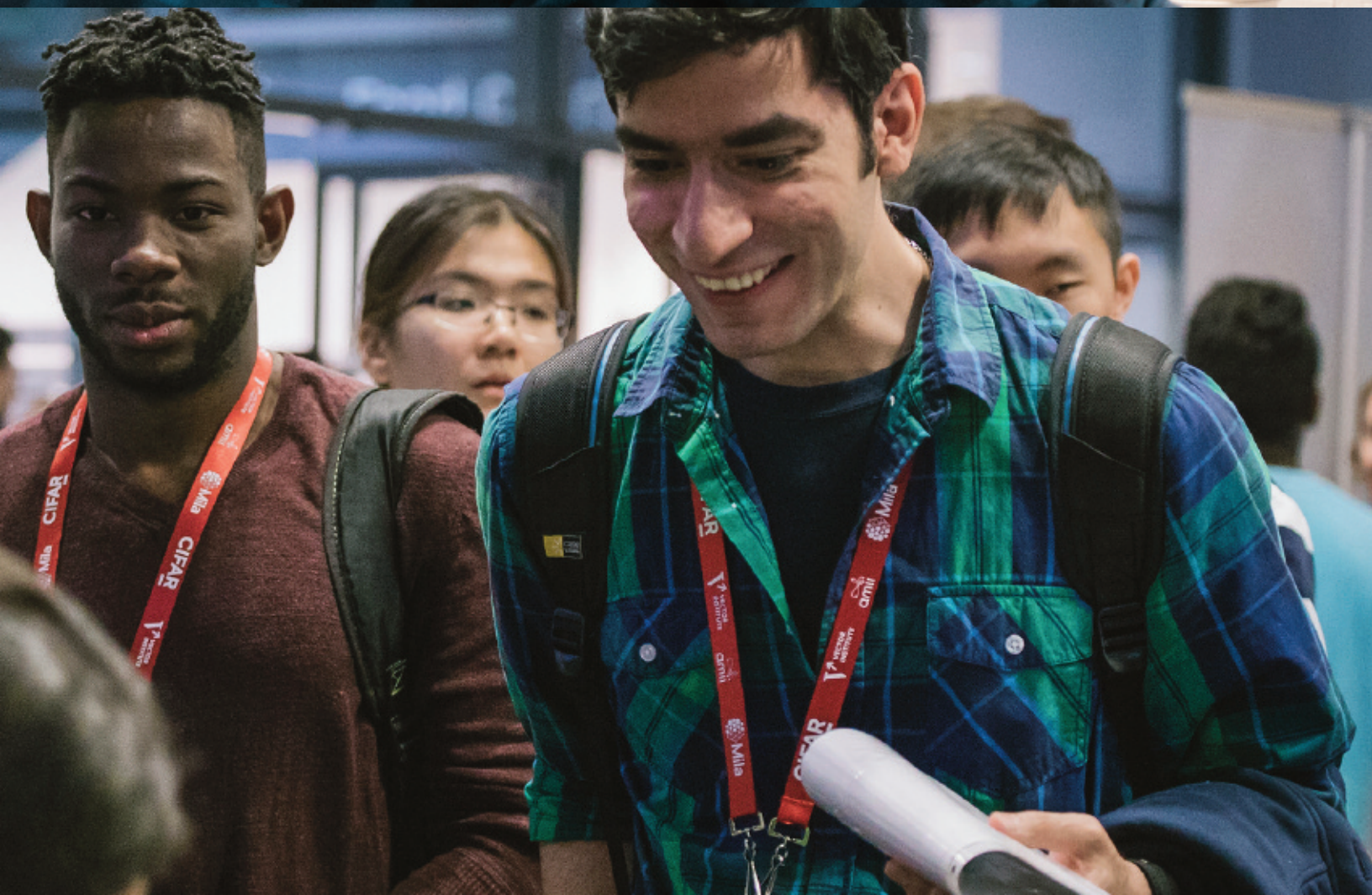
CIFAR
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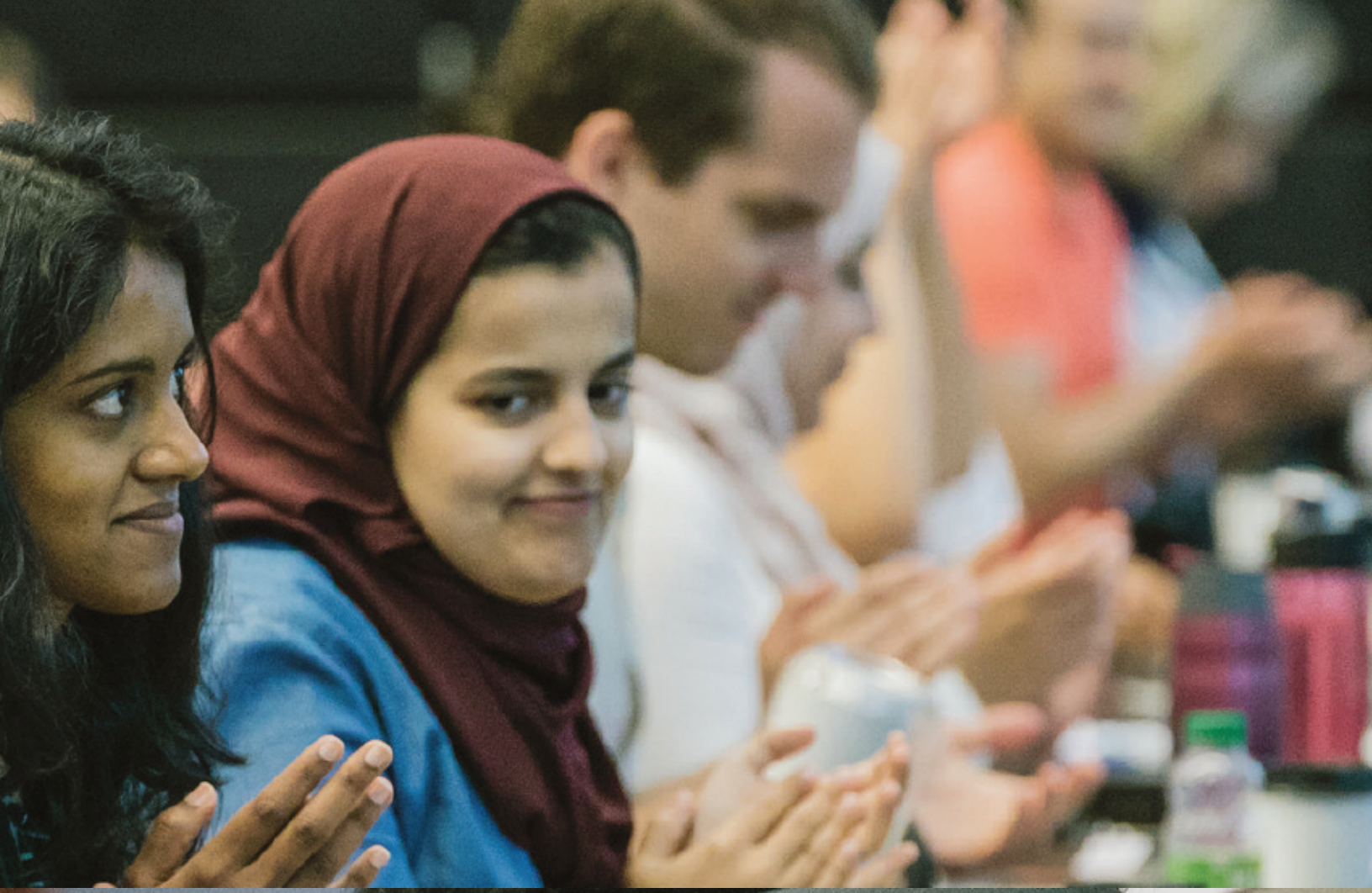
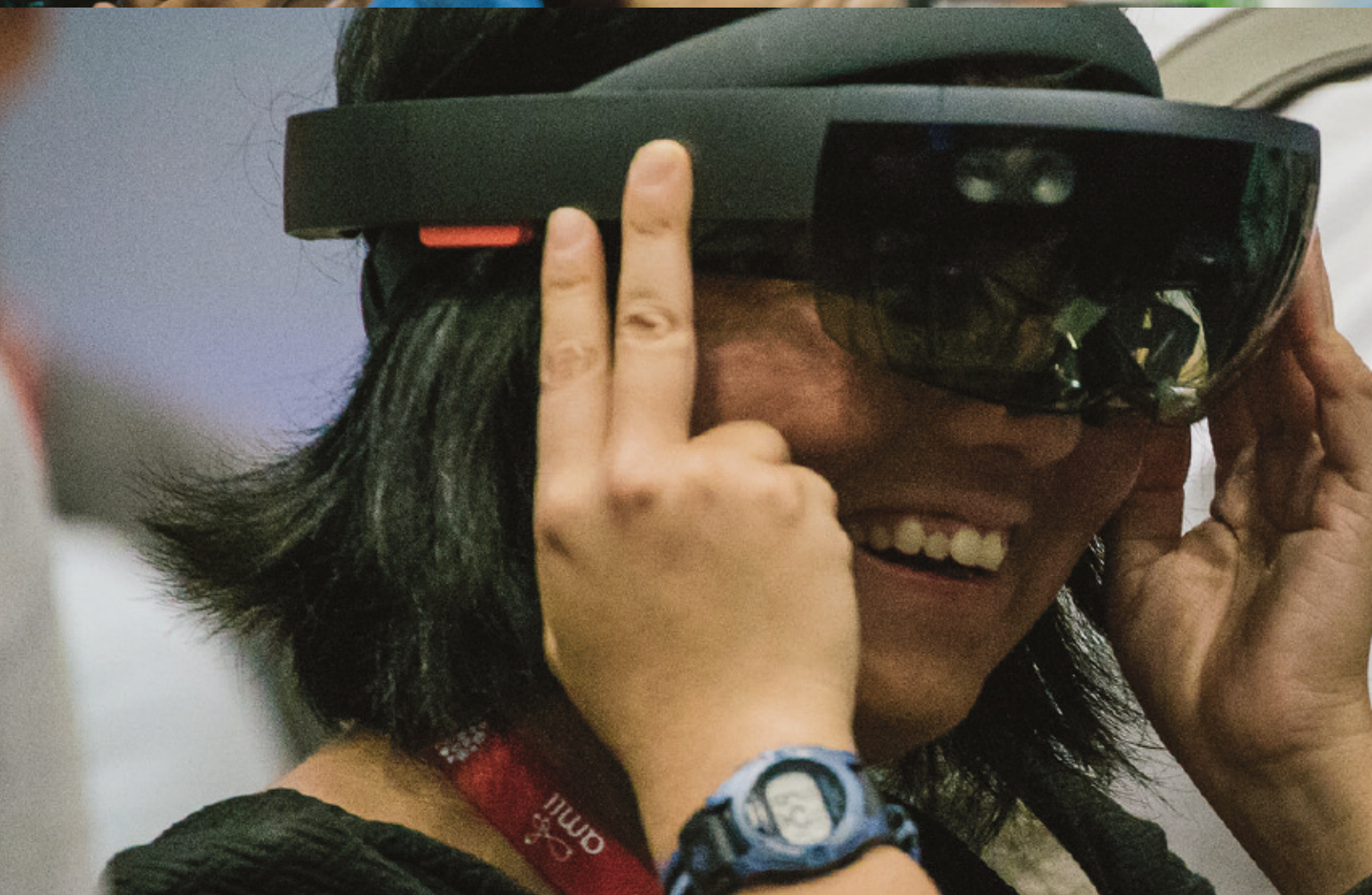
INNOVATION

Transferring machine learning research and knowledge to drive AI innovation

"In just over a year, the Vector Institute, along with Amii and Mila, have demonstrated the enormous potential for Canadian AI. By attracting and retaining the world's top AI talent, they are giving Canadian start-ups the access they need to compete, while at the same time, increasing investments in Canada. Through the Pan-Canadian AI Strategy, we will create more jobs for the Canadian AI community, fueling world-class research and economic growth."

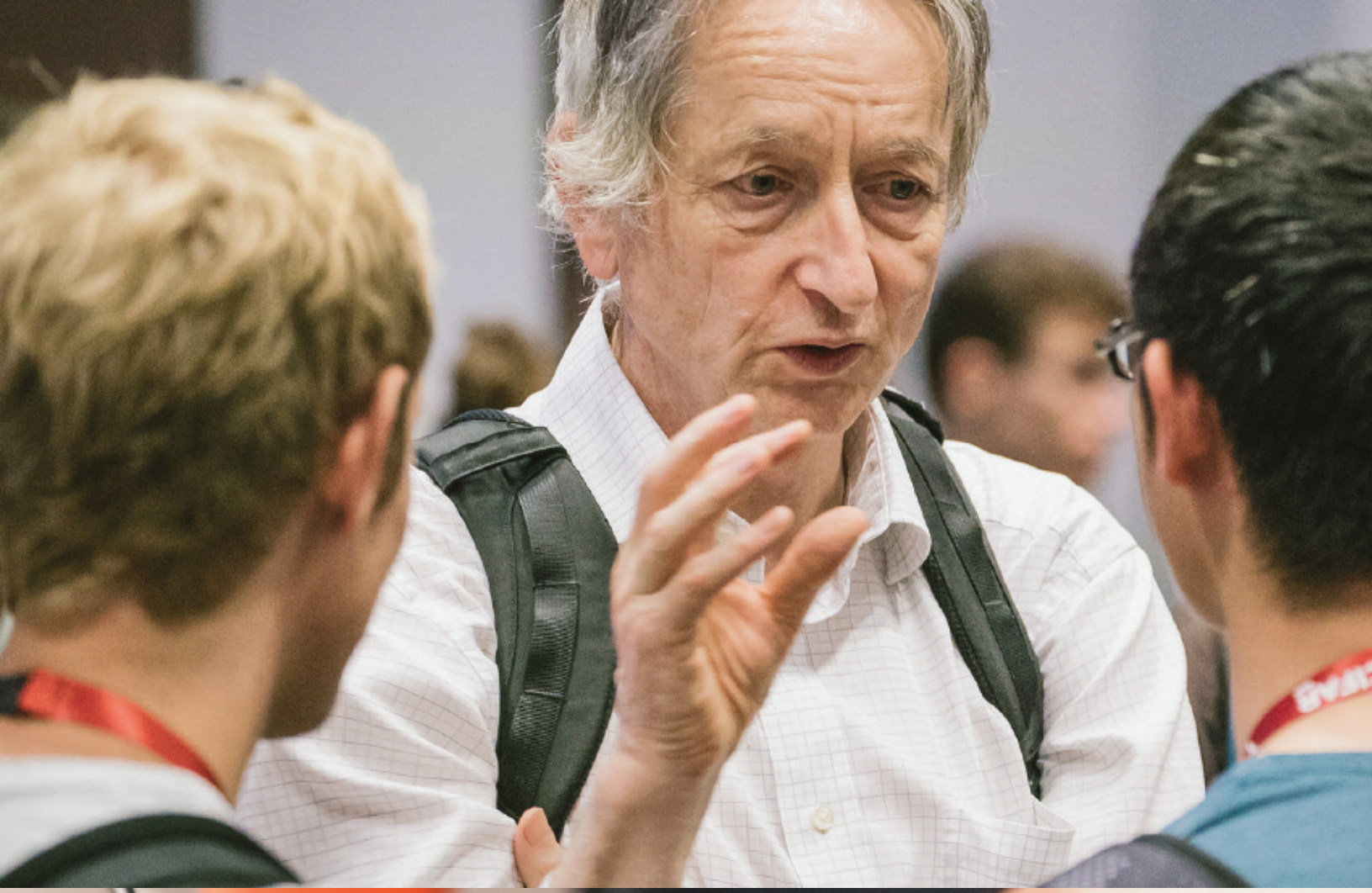
The Honourable Navdeep Bains
Minister of Innovation
Science and Economic Development

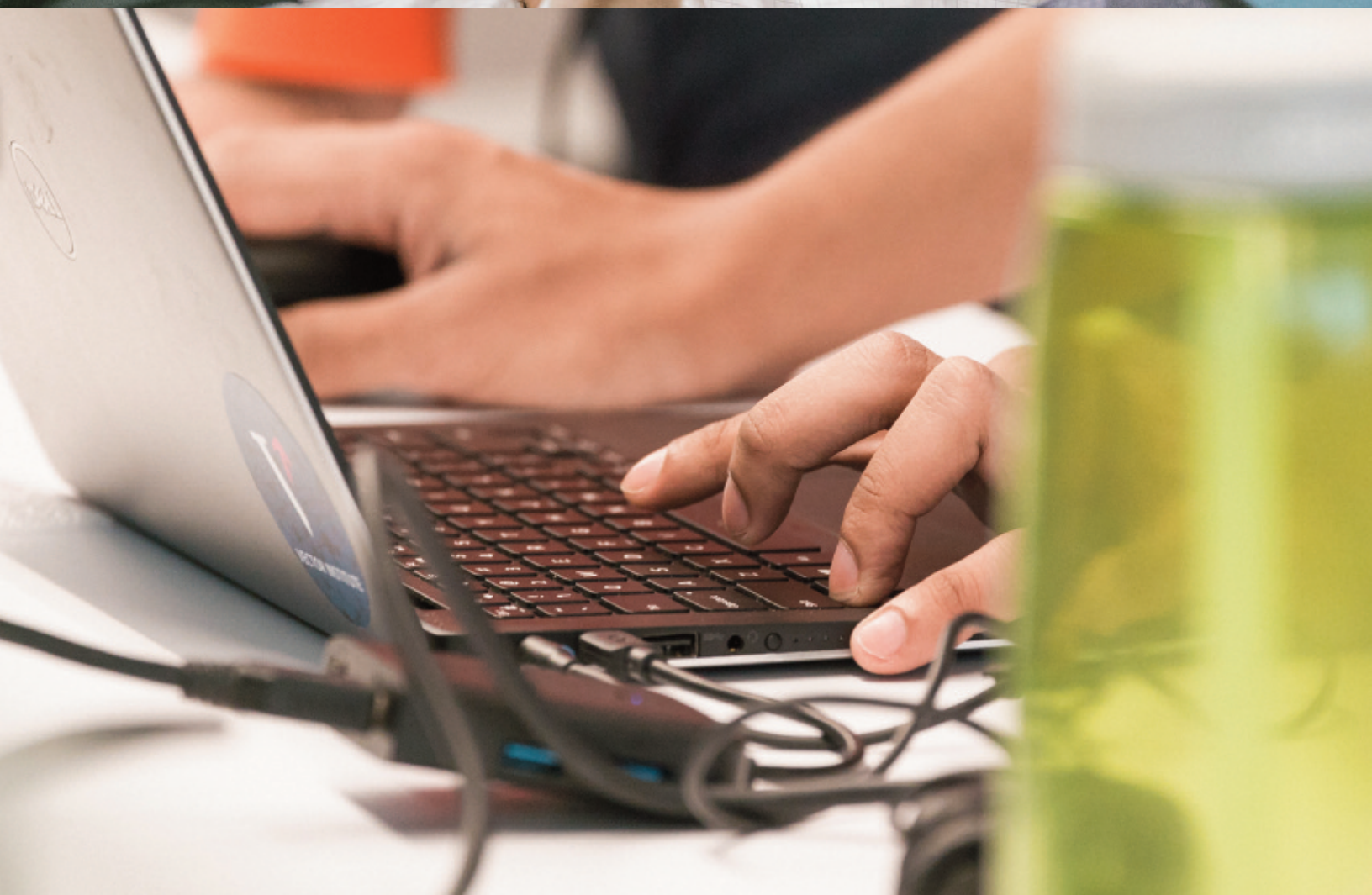




LEADERSHIP

Growing Ontario's AI ecosystem to advance research, draw new investments, create jobs, enable competitive startups, and strengthen the knowledge economy





IMPACT BY THE NUMBERS

200

Vector held one-on-one and small group meetings with more than 200 representatives from a range of health sector organizations to identify areas for collaboration

500

The AI Job and Data Fair attracted 30 companies based in Canada and overflowed with 500 highly-qualified attendees visiting their booths

220

Vector has become a community of 220 active researchers, including faculty and graduate students working on a wide range of projects, from more than 30 countries

17

All 17 Machine Learning Advances and Applications seminars featured leading AI scientists and were filled to capacity with hundreds of researchers and students

12

Vector is actively collaborating with 12 universities to increase the number of graduates of AI-related master's programs recognized as equipping students with the skills and competencies sought by industry

15

Vector held 15 events for industry, including Endless Summer School, Face-to-Face Meetings, Pitch Days, and AI for Execs, to facilitate connections and AI knowledge transfer

1,200

Competition to attend the Deep Learning & Reinforcement Learning Summer School was fierce, as Vector received more than 1200 applications from 60 countries

41

Vector's array of industry sponsors increased to 41 companies, from startups to multi-national enterprises across several sectors in the Canadian economy

250

The Deep Learning & Reinforcement Learning Summer School, hosted in partnership with CIFAR, brought together 250 graduate students and industry professionals from across Canada and 19 other countries

100

Vector researchers published more than 100 papers at high-impact conferences and in top-ranked journals

Building the Vector Institute

VECTOR'S FIRST ANNIVERSARY

In March 2018, Vector hosted more than 100 industry, academic, and government partners to mark the institute's one-year anniversary. The event featured speeches by Dr. Elissa Strome, CIFAR's Executive Director, Pan-Canadian AI Strategy; Dr. Garth Gibson, Vector's President & CEO; and government representatives. Congratulations to all of Vector's researchers, staff and sponsors who made the first year a resounding success!

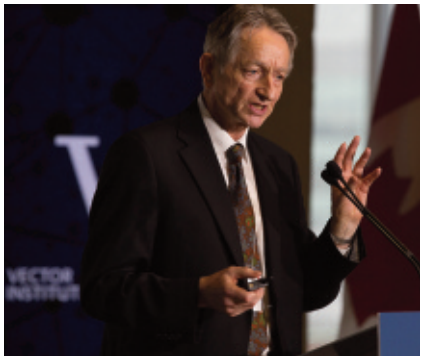
The Vector Institute was launched in March 2017 with support from both government and private sector partners, which gave the institute momentum from day one. Existing initially as a legal entity only on paper with eight founding researchers, Vector carried that momentum forward, transforming into a fully functioning research institute. Since Vector's doors opened in January 2018, the institute has continued to grow in strength and numbers, with 21 faculty members, a total of more than 220 researchers, including post-docs and graduate students, and 24 professional staff.

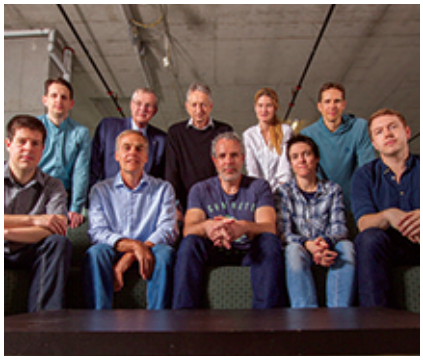
Vector has rapidly become a place that offers a growing community of exceptional researchers the freedom and flexibility to push the frontiers of machine learning research. This was achieved by hiring a world-class AI faculty, recruiting a talented professional team, building a home in the MaRS complex, and procuring the first phase of powerful and varied computing resources Vector's machine learning scientists need for cutting-edge research.

STATE-OF-THE-ART FACILITIES

Starting from bare concrete and ductwork in March 2017, Vector built a nearly 24,000 square foot facility on the seventh floor of the MaRS West Tower, in the beating heart of Canada's innovation economy. Faculty members and staff moved into Vector's open and vibrant space in January 2018, equipped with advanced computing resources and purpose-built for collaboration, including offices, meeting rooms, seminar rooms, and nearly 170 desks, which are already overflowing with faculty and graduate students.

The Vector Institute was launched in March 2017 with support from both government and private sector partners, which gave the institute momentum from day one.





The team behind the creation of the Vector Institute

Back row: Jordan Jacobs, Ed Clark, Geoffrey Hinton, Sanja Fidler, Tomi Poutanen
Front row: Roger Grosse, Richard Zemel, Brendan Frey, Raquel Urtasun, David Duvenaud

Photo: Johnny Guatto/University of Toronto

FUNDING

Securing $135 million in funding for Vector's first five years of operation allowed us to hit the ground running. These sources of funding include:

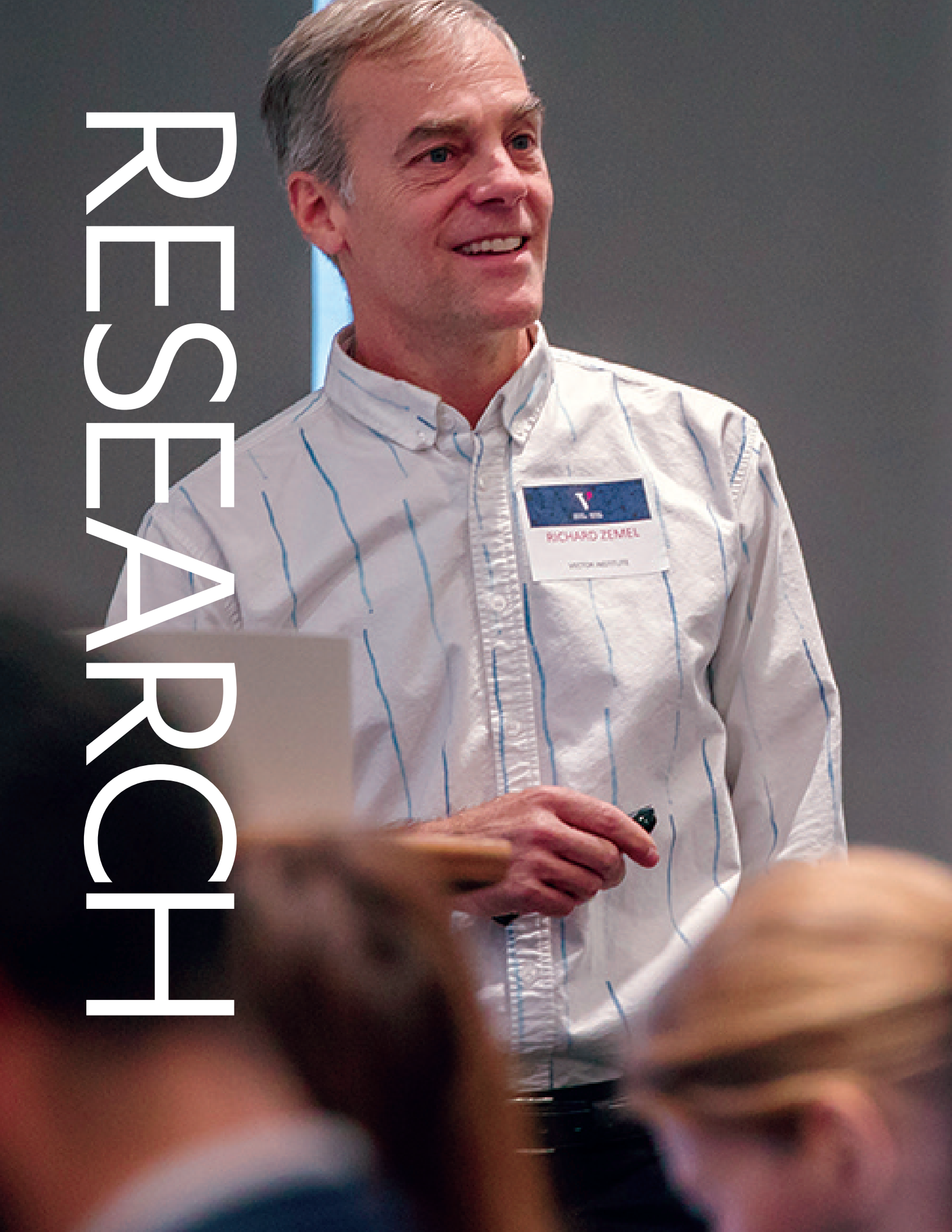
- Provincial funding from Ontario's Ministry of Economic Development, Job Creation and Trade to establish the institute, deliver core programming, and support the development of the AI ecosystem
- Federal funding from Innovation, Science and Economic Development Canada through the Pan-Canadian AI Strategy, administered by the Canadian Institute for Advanced Research (CIFAR)
- Industry sponsorships signed with 41 enterprise, startup and scale-up companies from a range of sectors across the Canadian economy

COMPUTING RESOURCES

After research talent, the greatest bottleneck for AI research is the availability of raw computing power. By consulting with Vector researchers and scouring the global market for high-powered graphics processing units (GPUs), networking switches, and other equipment, Vector has procured a versatile range of hardware and established the technology infrastructure necessary for exceptional machine learning research, all at competitive costs.

In addition, Amazon Web Services, Google Cloud Platform, and Microsoft Azure have donated a combined total of nearly $500,000 USD in cloud computing resources to Vector, which went live in 2018. These cloud resources allow Vector researchers to complete their work during periods of high demand by supplementing in-house CPU and GPU capability with cloud resources in advance of major research deadlines, when experimenting with different configurations and resources, and when performing large experiments too demanding for Vector's local servers.

RESEARCH



Top AI scientists from Canada and around the world have chosen Vector as their destination to conduct cutting-edge machine learning research, train the next generation of talent, and empower our industry and health sector partners to become leaders in the adoption of AI.

Research

RESEARCH HIGHLIGHTS

Since launching, Vector researchers have published more than 100 papers, many featured in top conferences such as Neural Information Processing Systems (NIPS), Computer Vision and Pattern Recognition (CVPR), the International Conference on Learning Representations (ICLR), the International Conference on Machine Learning (ICML), and in top journals such as Nature. Several Vector researchers are Canada Research Chairs, CIFAR Fellows and industry fellows, and serve on the organizing committees of major international AI conferences.

When Vector launched in March 2017, global competition to hire machine learning and deep learning graduates was reaching an all-time high. Canadian-trained graduate students were leaving for international opportunities. Demand has only grown since then.

Vector has thrived in this climate by offering world-class researchers the freedom and flexibility to push frontiers within an advanced AI ecosystem, in a welcoming country they are excited to call home. Vector has quickly become a destination for top AI talent seeking opportunities to collaborate with peers and conduct research, teach students, work with industry or launch a new startup company. Vector's faculty members bring together experience from international AI hotspots, including labs at the University of Toronto, MIT, Stanford University, Carnegie Mellon University, Microsoft Research, Google Brain, Uber ATG, NVIDIA, and others.

With highly diverse backgrounds from international and Canadian institutions and research labs, Vector's faculty and the post-docs and graduate students they supervise form a vibrant community of innovative problem-solvers, working across disciplines on both curiosity-driven and applied research. They bring expertise in areas from deep learning and machine learning to natural language processing, machine vision, quantum computing, health care and even music.

Since launching, Vector has attracted fourteen new faculty members—more than doubling the founding team. All of Vector's faculty members have options to pursue careers elsewhere, but have decided to either stay, immigrate or return home to Canada. Today, Vector's community of faculty and graduate students represents more than 30 countries.

Vector has also established collaborative working relationships with the institute's sibling organizations under CIFAR's $125 million pan-Canadian AI strategy: Alberta Machine Intelligence Institute (Amii), based in Edmonton, and Montreal's Mila. This collaboration helps to ensure that the Canadian AI ecosystem continues to rival the best in the world.

Vector's faculty and the post-docs and graduate students they supervise form a vibrant community of innovative problem-solvers, working across disciplines on both curiosity-driven and applied research.

RESEARCHERS

Vector's Chief Scientific Advisor is Geoffrey Hinton, who is renowned for his pioneering research in deep learning that catalyzed the explosion of machine learning research and applications pursued around the world today. Research Director Richard Zemel is a Senior Fellow at CIFAR, a Natural Sciences and Engineering Research Council of Canada (NSERC) Industrial Research Chair in Machine Learning, and one of the world's leading researchers on fairness. He also serves on the Advisory Board of the Conference on Neural Information Processing Systems (NIPS), the premier international machine learning conference. Along with Geoffrey Hinton and Richard Zemel, Vector's founding researchers include University of Toronto Professors David Duvenaud, Sanja Fidler, Brendan Frey, Roger Grosse, Daniel Roy, and Raquel Urtasun.

BRINGING ONTARIO-BASED AI TALENT TOGETHER

Prior to the founding of the Vector Institute, Ontario universities were already home to a number of top AI researchers doing invaluable work. Recruiting them to join Vector's faculty has given them new resources and a community of peers to collaborate with, while allowing them to retain their affiliation with their home universities. This model builds Vector's research and innovation capacity, benefits Ontario universities, and bolsters Ontario's AI ecosystem.

DAVID DUVENAUD

Area of research: core machine learning

David's research covers hyperparameter optimization, variational inference, deep learning and automatic chemical design.

SANJA FIDLER

Areas of research: deep learning, vision, natural language processing

Sanja's main research interests are in semantic visual scene understanding. She is also interested in the interplay between language and vision.

DAVID FLEET

Area of research: vision

David's research interests span computer vision, image processing, visual perception and visual neuroscience. He is interested in how animals see and learn, and how we can develop machines with similar or better visual capabilities.

BRENDAN FREY

Area of research: health and computational biology

Brendan develops techniques that use large-scale datasets to derive predictive models of how genes and many other genomic features act in combination to produce genetic messages that control cellular activities. He has recently focused on applying deep learning to model "cell variables" and understand human diseases.

ANNA GOLDENBERG

Area of research: health and computational biology

Anna's main research focus is to develop machine learning methods that can help decipher human disease heterogeneity, which involves combining data from multiple sources. Examples of her recent research include predicting the necessity of thyroid biopsy and resection, and the age of cancer onset in children with cancer predisposition syndrome.

ROGER GROSSE

Area of research: deep learning

Roger's research investigates algorithms for deep learning and Bayesian learning: faster training, better generalization, better uncertainty measures, and easier tuning.

QUAID MORRIS

Area of research: health and computational biology

Quaid uses machine learning to do biomedical research, focusing on cancer evolution, post-transcriptional regulation, and gene function prediction. His lab is also interested in electronic health records, auto-immune disease, and biological image analysis.

PASCAL POUPART

Areas of research: broader AI

Pascal's research focuses on machine learning and decision-theoretic planning with applications to natural language processing, sports analytics, telecommunication networks, and assistive technologies.

DANIEL ROY

Area of research: theory

Daniel's research blends computer science, statistics and probability theory. He studies "probabilistic programming" and develops computational perspectives on fundamental ideas in probability theory and statistics.

All Vector faculty members have options to pursue careers elsewhere, but have decided to either stay, immigrate to or return home to Canada. Today, Vector's community of faculty and graduate students represents more than 30 countries.

FRANK RUDZICZ
Areas of research: health and computational biology, natural language processing
Frank's research applies natural language processing and machine learning to various tasks in health care, for example, to detect dementia from speech patterns.

GRAHAM TAYLOR
Areas of research: core machine learning, deep learning
Graham's research aims to discover new algorithms and architectures for deep learning, such as the automatic construction of hierarchical algorithms from high-dimensional, unstructured data. He is especially interested in applying his work on time series to better understand human and animal behaviour, environmental data, music, speech, and financial time series.

RAQUEL URTASUN
Areas of research: deep learning, vision
Raquel is a world-leading expert in machine perception for self-driving cars. Her research interests include machine learning, computer vision, robotics and remote sensing.

RICHARD ZEMEL
Areas of research: core machine learning, deep learning, vision, ethics
Richard's research contributions include foundational work on systems that learn useful representations of data without any supervision; methods for learning to rank and recommend items; and machine learning systems for automatic captioning and answering questions about images.

A BEACON FOR WORLD-CLASS AI TALENT
Since Vector launched, in helping to reverse the "brain drain" of Ontario's AI talent, the faculty has recruited a number of brilliant researchers. Some are recent graduates of PhD programs who joined Vector despite numerous offers from renowned educational institutions and corporate research labs elsewhere. Others are well-established researchers who stayed in or came to Ontario because they saw the advantages of joining an AI research powerhouse that embraces opportunities for industry and health care innovation.

ALÁN ASPURU-GUZIK
Area of research: sciences
Alán's research lies at the intersection of computer science, chemistry and physics. His mission to accelerate the discovery of new molecules and materials has led him and his research team from Harvard to Vector and the University of Toronto.

JIMMY BA
Areas of research: core machine learning, deep learning, reinforcement learning and robotics
Jimmy's research focuses on the development of learning algorithms for deep neural networks. His accomplishments include developing the Adam Optimizer, an algorithm widely used to train deep learning models.

JUAN FELIPE CARRASQUILLA
Area of research: sciences
Juan investigates the intersection of condensed matter physics, quantum computing, and machine learning. Applications of these ideas include the identification of phases of matter in numerical simulations and experiments, as well as the validation of near-term quantum devices and quantum simulations of condensed matter systems.

MURAT ERDOGDU
Area of research: theory
Murat's primary research interest is to design optimization algorithms for machine learning models. He has shown that using efficient algorithms significantly reduces model-training time, allowing researchers to test models more efficiently.

AMIR-MASSOUD FARAHMAND
Area of research: reinforcement learning and robotics
Amir-massoud's research interests are in reinforcement learning and machine learning with a focus on developing theoretically-sound algorithms for challenging industrial problems.

MARZYEH GHASSEMI
Areas of research: health and computational biology, ethics
Marzyeh's research interests include clinical risk prediction with semi-supervised learning, optimal treatment discovery using expert demonstrations, and non-invasive patient phenotyping for behavioral conditions.

ALIREZA MAKHZANI
Area of research: core machine learning
Alireza's most recent research focuses on generative models and their applications in semi-supervised learning, neural networks that can learn sparse representations of data, and deep reinforcement learning algorithms.

SAGEEV OORE
Areas of research: deep learning, creativity and music
Sageev's research interests include probabilistic generative models and machine learning and deep learning architectures, with an emphasis on creative applications, including teaching machine learning models to generate music.

Geoffrey Hinton
Chief Scientific Advisor

Richard Zemel
Research Director

Alán Aspuru-Guzik

Jimmy Ba

Juan Felipe Carrasquilla

David Duvenaud

Murat Erdogdu

Amir-massoud
Farahmand

Sanja Fidler

David Fleet

Brendan Frey

Marzyeh Ghassemi

Anna Goldenberg

Roger Grosse

Alireza Makhzani

Quaid Morris

Sageev Oore

Pascal Poupart

Daniel Roy

Frank Rudzicz

Graham Taylor

Raquel Urtasun

Vector Research at a Glance*

VECTOR RESEARCH TALKS

Sharing ideas is a great way to build a solid research community. Every Tuesday afternoon, Elliot Creager gathers researchers together to review the latest papers posted to arXiv.org. Other regular meetings include weekly seminar-style Themed Talks led by Amir-Massoud Farahmand and Alireza Makhzani, and the Machine Learning Group organized by Renjie Lao, which meets every Friday.

220+
Active Researchers

21
Faculty Members

63
Faculty Affiliates

32
Postgraduate Affiliates

106
Students (i.e. post-docs, PhDs, Master's)

FACULTY APPOINTMENTS AT AFFILIATED INSTITUTIONS

University of Toronto
Carleton University
Dalhousie University
University of Guelph
McMaster University
Ryerson University
SickKids Research Institute
University Health Network (UHN)
University of Waterloo
Western University
York University

THE AI FIELD'S TOP CONFERENCES HAVE ACCEPTED VECTOR RESEARCH PUBLICATIONS IN HIGH NUMBERS

- 13 papers accepted at NIPS 2017
- 16 papers accepted at NIPS 2018
- 11 papers accepted at ICLR 2018
- 10 papers accepted at ICML 2018
- 8 posters accepted at CVPR 2018

*As of July 2018

THE VECTOR INSTITUTE MACHINE LEARNING ADVANCES AND APPLICATIONS SEMINAR

The Fields Institute for Research in Mathematical Sciences hosts Vector's biweekly Machine Learning Advances and Applications Seminar. Each meeting brings together hundreds of researchers and students to share ideas, discuss applications of machine learning techniques to industry, and build a robust machine learning community in Toronto. From August 2017 through May 2018, Vector hosted 17 seminars featuring many of the field's top researchers, including Geoffrey Hinton, his former student Ilya Sutskever, Jon Shlens of Google Brain, Chris Williams of University of Edinburgh, and Jennifer Listgarten of Microsoft Research. In response to the overwhelming popularity of the seminar, Vector is working with the Fields Institute to broaden access through online channels.

HONOURS AND AWARDS

Canada Research Chair Awards (2017-2018)
- Roger Grosse (Probabilistic Inference and Deep Learning)
- David Duvenaud (Generative Models)
- Anna Goldenberg (Computational Medicine)
- Graham Taylor (Machine Learning)

Canada's Top 40 Under 40 (2018)
Graham Taylor

MIT Technology Review: 35 Innovators Under 35 (2018)
Marzyeh Ghassemi

Canada 150 Research Chair (2018)
Alán Aspuru-Guzik

NSERC Industrial Research Chair (IRC) in Machine Learning (2018)
Richard Zemel

Connaught Innovation Award (2018)
Frank Rudzicz

Connaught New Researcher Award (2018)
Sanja Fidler

NVIDIA Compute the Cure Grant (2017)
David Duvenaud and Quaid Morris

Amazon Academic Research Award (2017)
Sanja Fidler

Best Paper Award for Workshop on Transparent and Interpretable Machine Learning in Safety Critical Environments at NIPS (2017)
Graham Taylor

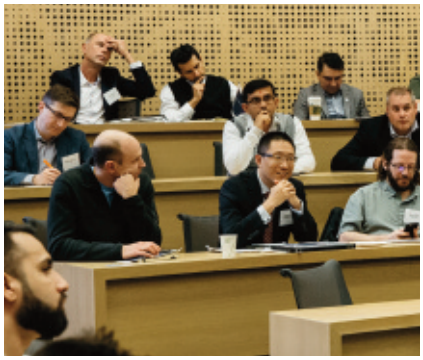
Association for the Advancement of Artificial Intelligence (AAAI) Best Technical Demonstration Honorable Mention Award (2017)
Sageev Oore

Best Paper Honorable Mention Award at CVPR (2017)
Sanja Fidler and Raquel Urtasun

INDUSTRY INNOVATION

Vector's collaboration with leading industry sponsors has created a virtuous cycle of attracting AI talent, investment, and innovation to catalyze growth in Canada's AI ecosystem and knowledge economy.

Industry Innovation



The launch of the Vector Institute and its growing community of AI experts are enabling Canadian firms to become world-leading users of AI. Vector and its surrounding ecosystem—which includes other research institutes, startup networks and programs, and industry—have also attracted global companies looking for AI talent to Toronto, investments to grow Ontario's AI ecosystem, and new jobs. The result is a virtuous circle of talent and innovation that has already made the Toronto-Waterloo corridor one of the best places in the world for companies seeking AI talent.

To drive innovation and economic development, Vector engages industry sponsors in AI research and innovation and illuminates the great potential AI has for revolutionizing various industries. Since launching, Vector has held 15 industry-focused events—all well-attended by sponsors. At the same time, the number of Vector sponsors has grown dramatically to include 41 corporations and startups operating in a variety of sectors. Agreements reached with Vector's 41 industry sponsors collectively represent approximately one-third of the institute's funding in its first five years, reflecting the private sector's vested interest in developing the AI ecosystem and investing in the production of top talent.

ENDLESS SUMMER SCHOOL (ESS)

The Endless Summer School is Vector's flagship program for industry sponsors, designed to share knowledge with them by highlighting cutting-edge research developments in the field, so they can refine AI solutions to enhance their competitiveness. The ESS also works to build a community of academic and industry AI researchers. Each full-day event addresses a single AI-related topic with technically detailed presentations by leading Vector researchers, industry researchers, and graduate students. The knowledge-sharing that ESS facilitates helps sponsors ensure their use of machine learning is state-of-the-art. To date, Vector has held six events, and will hold eight to 10 each year at maturity. So far, topics have included:

- New Algorithms
- Vision Techniques
- Learning Latent Structures
- Privacy and Fairness
- Machine Learning and Health
- Robotics

AI FOR EXECS

In order to strategize the effective use of machine learning techniques, industry sponsors asked for a program that would provide their executives with a comprehensive—but less-technical—understanding of the opportunities AI creates and its best uses. Responding to high demand from industry sponsors, Vector held its first executive level engagement, "Analytics, AI and People," in January 2018, in partnership with the Smith School of Business at Queen's University. The second event focused on the uses of AI in business.

These events offer Vector sponsors a business-focused and non-technical setting for their senior management to learn how different industries are implementing AI across Canada and beyond, and how best to communicate with their technical teams about their goals in implementing AI. Each AI for Execs session has also featured case

To drive innovation and economic development, Vector engages industry sponsors in AI research and innovation and illuminates the great potential AI has for revolutionizing various industries.

studies of how specific companies are deploying AI, to aid sponsors as they consider their AI strategies. Going forward, Vector will offer AI for Execs events quarterly, refining their format with feedback from sponsors.

FACE-TO-FACE (F2F) MEETINGS

The success of Endless Summer School led Vector to develop Face-to-Face Meetings between the institute's researchers and corporate sponsors. For these meetings, the industry innovation team works with sponsors to help define specific opportunities and challenges they face in their businesses that machine learning can address. With opportunities and challenges defined, sponsors are paired with a Vector researcher who has the relevant experience and expertise to guide and help them optimize their use of AI. This targeted form of knowledge sharing accelerates the AI programs that Vector's sponsors run.

The positive feedback from the first session in March 2018 prompted three more rounds of F2F Meetings and engaged 23 sponsors. The industry innovation team plans to hold F2F Meetings on an ongoing basis and evolve them to address specific challenges and ideas that may lead to future applied research projects.

PITCH DAYS

Vector's sponsors include a dynamic mix of large well-established companies from various sectors and promising startups and scale-ups making use of advanced machine learning techniques. The former tend to seek new and ingenious uses of machine learning to solve problems and enhance their performance. The latter tend to use machine learning as a tool to capture new customers and markets.

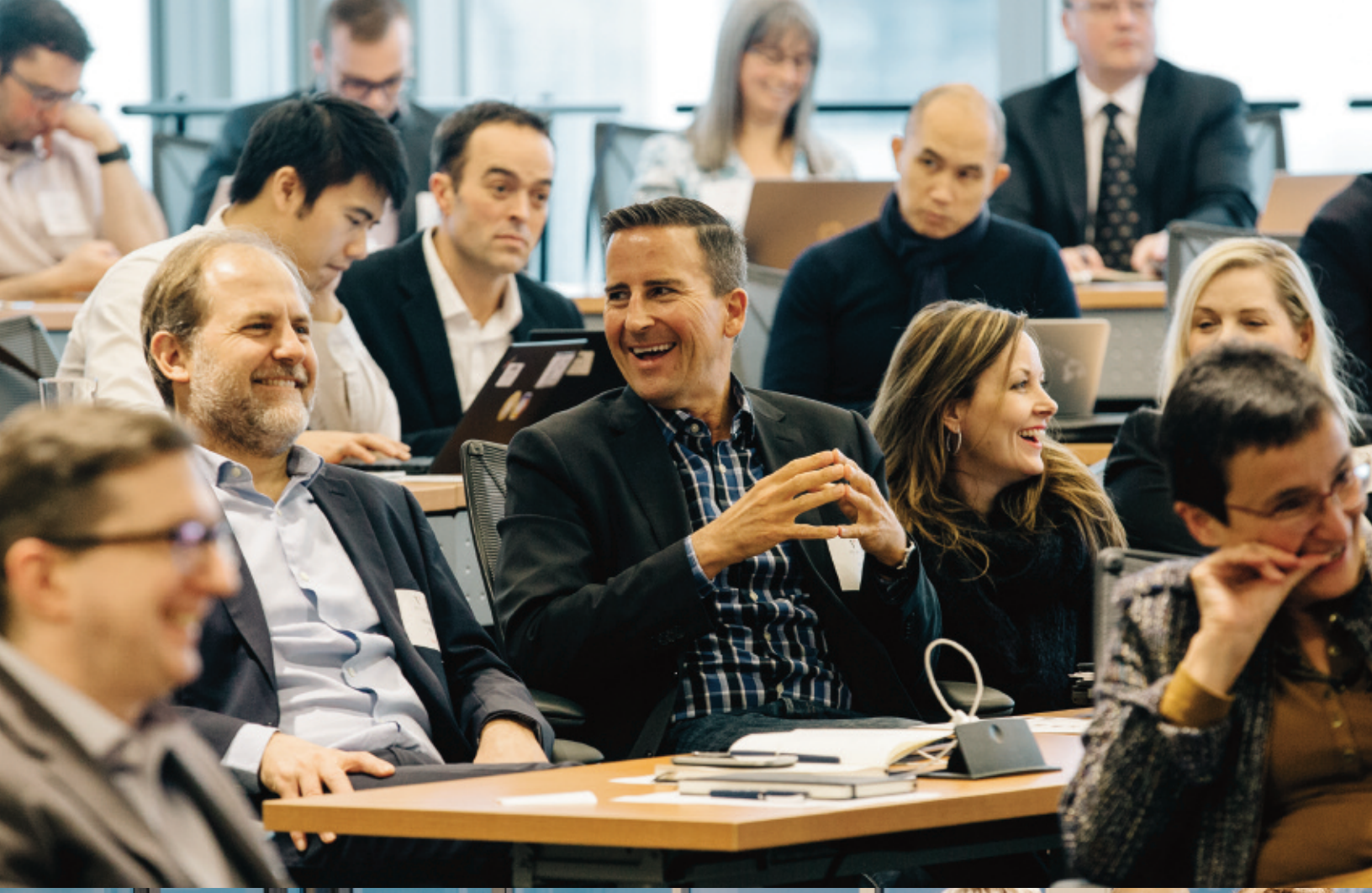
Each event gives Bronze sponsors, along with interesting startup and scale-up firms that Vector encounters, an opportunity to pitch their capabilities to some of Canada's largest companies giving them a platform to showcase their skills, products, and services and connect and grow in Canada.

Pitch Days are another catalyst for Ontario's AI ecosystem, boosting startups to accelerate their growth and increase their connections while helping large companies become more globally competitive through the deployment of AI in novel and profitable ways. Vector identifies candidate startups in connection with partners such as MaRS Ventures and the University of Toronto's Creative Destructive Lab.

FIRST SPONSORS' PROJECT– BANKS PROJECT

Vector has unique opportunities as an independent third party to bring competitors together to cooperatively solve significant problems that affect Canadians.

One opportunity is in the area of financial services and specifically financial crimes, which have a direct and significant impact on costs for consumers. In an effort to reduce consumer costs, Vector's Banks Project involves Canada's largest financial institutions collaborating to develop new methodologies and algorithms that would make Canadians more secure.



Vector's Industry Sponsors

PLATINUM
FOUNDING

Accenture
BMO
Google
Loblaw Companies Limited
NVIDIA
RBC
Scotiabank
Shopify Inc.
TD Bank Group
Thomson Reuters
Uber

GOLD
FOUNDING

Air Canada
CIBC
CN
Deloitte
EY
Georgian Partners
Intact Financial Corporation
KPMG
Magna International
Manulife
PwC Canada
Sun Life Financial
TELUS
Thales

SILVER
FOUNDING

EllisDon Corporation
Linamar Corporation

BRONZE
FOUNDING

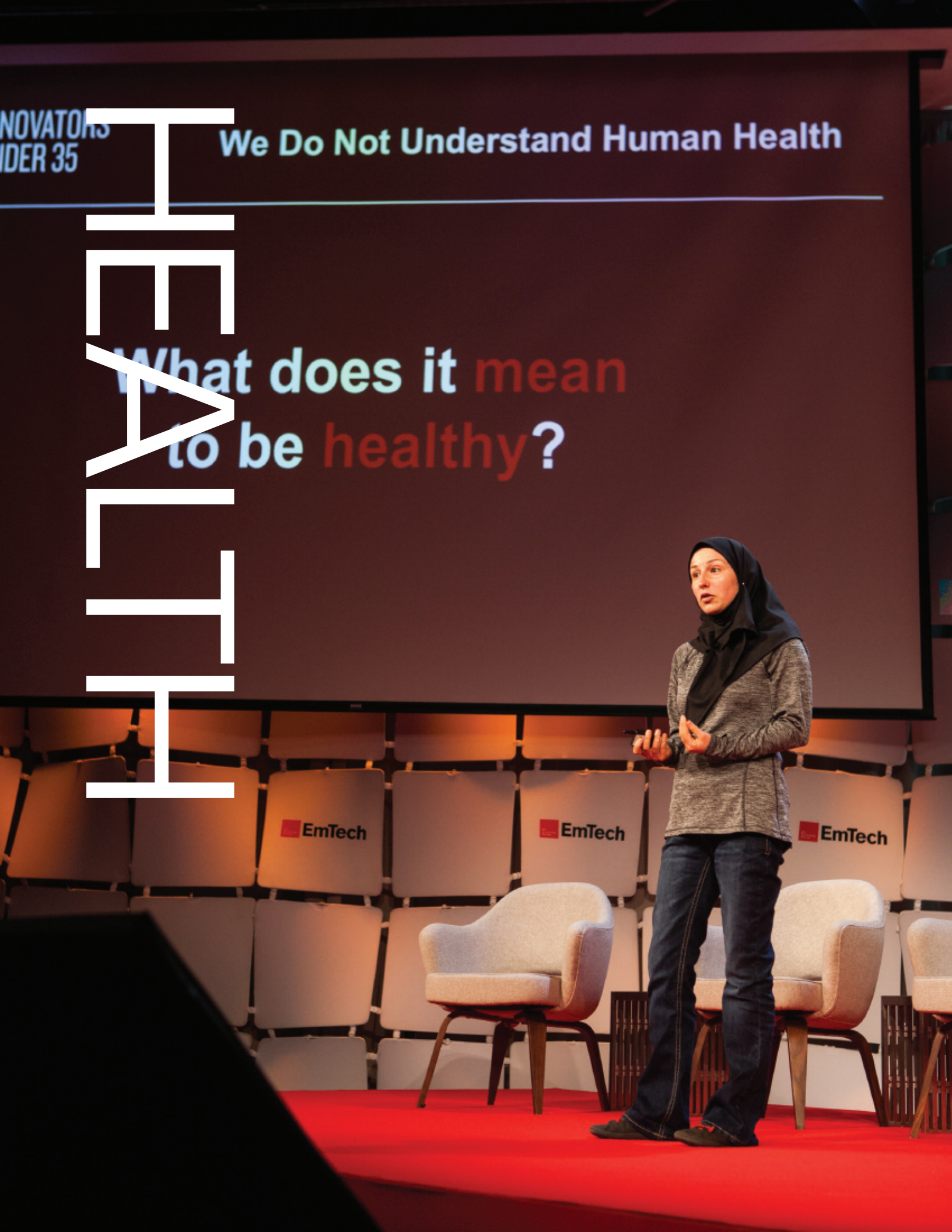
Chan Zuckerberg Initiative (formerly Meta)
Clearpath
Deep Genomics
Dessa
FreshBooks
Helpful.com
integrate.ai
Layer 6 AI
ROSS Intelligence
Thalmic Labs
Wattpad

BRONZE 2018

stradigi AI
Wysdom AI
tealbook

Dessa and ROSS Intelligence are the last Bronze sponsors to partner with the Vector Institute under the original sponsorship terms. Under the new Industry Innovation Strategy planned for 2018-19, innovative startup and scale-up firms will be asked to contribute expertise and time to the Vector Institute community rather than funds.

HEALTH


NOVATORS
IDER 35
We Do Not Understand Human Health
What does it mean
to be healthy?
EmTech
EmTech
EmTech

In partnership with health sector leaders, machine learning researchers at Vector are beginning to transform Ontario's population-wide health data into knowledge that promotes health and helps make health care delivery more efficient and cost-effective.

Health

PRIORITY WORK STREAMS

Vector is working on three strategic priority work streams for health:

- World-Class Research: attracting and retaining highly talented AI scientists to apply machine learning to address challenges in the health sector
- Widespread Application: supporting exemplary health AI application projects and building the workforce that will enable widespread adoption and application of AI in the health sector
- Research-Ready Accessible Data: responsibly transforming the invaluable health care datasets held by Ontario into knowledge that can save and improve lives, and reduce the costs of health care

With the establishment of the Vector Institute, Ontario's health sector has gained another major advantage—a critical mass of outstanding AI research talent. Vector is working to bring machine learning researchers together with health system leaders, clinicians, and researchers, to transform Ontario's health data into knowledge that helps people stay healthy and creates new, cost-saving efficiencies in the health system.

Ontario has a health data advantage. As a single-payer public health system, the province has longitudinal population-wide data holdings for all publicly funded health services. These invaluable data cover an ethnically diverse population and, in many cases, go back 20 years or more. For decades, these data have been a critical resource used by qualified researchers to inform patient and population health care.

To explore joint interests and potential collaboration, Vector has held one-on-one and small group meetings with representatives from dozens of leading health sector organizations, including Ontario government ministries, provincial agencies, hospitals, research institutes and several centres affiliated with the University of Toronto.

Among the most exciting developments in health at Vector over the past few months is the creation of the Risk Dashboard program for machine learning research, a partnership with the Peter Munk Cardiac Centre to co-recruit AI talent, and formal affiliation with The Hospital for Sick Children.

RISK DASHBOARD: A PROOF-OF-CONCEPT COLLABORATION

Vector is collaborating with the Institute for Clinical Evaluative Sciences (ICES), a prescribed entity and legislated data holder, to identify populations at risk of becoming high-cost health system users. Under the new Risk Dashboard program for machine learning research, Vector researchers and ICES scientists are working together using the Ontario Data Safe Haven, in a project supported by Compute Ontario. This allows data held by ICES to be managed and analyzed in an advanced computing environment at High-Performance Computing for Healthcare (HPC4Health)—a collaboration of the University Health Network (UHN) and the Hospital for Sick Children.

Demonstrating the value of the Risk Dashboard and the Ontario Data Safe Haven will help accelerate the application of machine learning techniques in the health care system. The results will help improve the health of the population and find new efficiencies in the system.

Vector is working to bring machine learning researchers together with health system leaders, clinicians, and researchers, to transform Ontario's health data into knowledge that helps people stay healthy and creates new, cost-saving efficiencies in the health system.

THE BEST BRAINS EXCHANGE

In February, Vector participated in a full day "Best Brains Exchange" meeting organized by the Ontario Ministry of Health and Long-term Care and funded by the Canadian Institutes for Health Research. At the meeting, representatives from government, industry and academia discussed how AI and machine learning can improve the health of the entire population and make health care systems more efficient. Speakers included senior government officials and Vector's Garth Gibson and Alison Paprica, who facilitated the meeting. The result was a list of priorities for advancing health care with machine learning techniques that will inform Vector's selection of AI health projects in the coming year.

UHN'S PETER MUNK CARDIAC CENTRE AI TEAM

The Vector Institute has partnered with UHN and the Peter Munk Cardiac Centre (PMCC) to develop cutting-edge cardiac care with machine learning. The goal is to bring PMCC physicians and technical experts together with Vector scientists to deploy machine learning techniques that advance health research, individualize patient care, and make hospital operations more efficient.

To this end, PMCC, UHN and Vector are working together to recruit a Lead AI Scientist—a position that will be cross-appointed to UHN and PMCC, the University of Toronto and the Vector Institute.

THE HOSPITAL FOR SICK CHILDREN (SICKKIDS RESEARCH INSTITUTE)

Dr. Anna Goldenberg joined Vector as a researcher and Associate Research Director, Health. She is a Senior Scientist in the SickKids Research Institute's Genetics and Genome Biology Lab, and Assistant Professor in U of T's Department of Computer Science, in the Computational Biology Group. She investigates how machine learning methods can be used to decipher human disease heterogeneity, and collaborates with clinicians to ensure that her lab's work is practical and relevant in a clinical setting.

EDUCATION AND TRAINING

Vector is working with universities across the province to increase the supply of talented graduates to support Ontario's growing AI ecosystem.

Education and Training

Supporting Ontario's thriving AI ecosystem requires the creation of a high-flow pipeline of talent. Vector is leading a provincial capacity-building initiative that includes accelerating the number of graduates from AI-related master's programs.

GUIDANCE FOR AI-RELATED MASTER'S PROGRAMS

After broad consultation with industry, academic, and government representatives, Vector published a resource document that defines the essential skills and competencies that employers seek. This document serves as guidance to universities that want to create or expand Vector-recognized AI-related master's programs and contribute to building Ontario's AI capacity.

PROGRAM REVIEW PANEL

A Program Review Panel equally composed of academic faculty in AI and industry experts has been established to review master's program submissions. Programs that meet a set of essential requirements and prepare highly qualified graduates with area-specific advanced knowledge, skills, and competencies sought by the AI-sector will gain the recognition of the Vector Institute. The program review panel is paying particular attention to AI-related learning outcomes and ensuring that the AI-related programs sufficiently cover and include:

- Core technical knowledge in AI in STEM-related and complementary areas, such as the application of AI technology to business, public health, etc.
- At least three curriculum components with learning outcomes focused on AI-related methodologies and applications
- Learning outcomes related to communication, teamwork, and interdisciplinary practice related to AI
- Learning outcomes related to the ethics and societal implications of AI

By July 2018, twelve universities with demonstrable strength in AI had either submitted or signalled their intent to submit programs for recognition, including one new purpose-built program in AI. Universities are actively engaged in modifying existing and developing new AI-related programs.

PROGRAM DEVELOPMENT FUND

To support universities contributing to the initiative, Vector launched a Program Development Fund in June 2018 to help offset the cost of expanding existing or developing new curriculum components for AI-related master's programs that meet the essential requirements.

SCHOLARSHIPS, INTERNSHIPS, AND NETWORKING

As part of the initiative, Vector will introduce merit-based scholarships to attract top talent to Ontario's AI programs and to recognize the potential contributions of highly-qualified trainees to the AI ecosystem.

In addition to scholarships, Vector is leveraging its partnerships with industry to develop internship and other experiential learning opportunities for trainees. To further cultivate a community among trainees and industry partners, Vector will expand job fairs, pitch days, summer schools, and introduce theme-based AI challenges, multi-company AI-based projects, and workshops to build AI capacity and technical ability, while increasing the Ontario AI graduate pool and workforce. Programs will complement education and upskilling programs offered to industry professionals through Vector's Industry Innovation work stream.

2018 Deep Learning and Reinforcement Learning Summer School

Vector's Job & Data Fair featured a special panel discussion with Yoshua Bengio, Geoffrey Hinton, and Richard Sutton who imparted their advice for the audience full of up-and-coming AI scientists and practitioners.

In Vector's flagship event of the year, the institute partnered with CIFAR and the two other AI Institutes under the Pan-Canadian AI Strategy—Amii and Mila—to host the 2018 Deep Learning & Reinforcement Learning Summer School. The Summer School was convened alongside Vector's AI Job and Data Fair for attendees and sponsors—the first of its kind—and took place at the Rotman School of Management's Desautels Hall from July 25 to August 3, 2018, leveraging Vector's strategic partnership with the Creative Destruction Lab.

The 2018 Deep Learning and Reinforcement Learning Summer School brought together over 250 of the best and brightest minds in machine learning—including graduate students and industry professionals—selected from a pool of over 1,200 applications from 60 countries. Hosting the 10th edition of the 2018 Deep Learning and Reinforcement Learning Summer School placed the Vector Institute at the centre of one of the globe's leading programs for graduate students and researchers involved in AI research and its applications. Not only does the 2018 Deep Learning and Reinforcement Learning Summer School play a significant role in attracting and retaining talent in the Canadian AI ecosystem and facilitate sharing exceptional AI research, it also gave the Vector Institute an opportunity to build connections and spark research collaborations between Canadian and global participants and showcase the Toronto–Waterloo corridor as one of three rapidly growing AI centres within Canada. The City of Toronto and Toronto Global also supported activities to showcase the diversity and quality of life in the GTA.

The Vector Institute's AI Job and Data Fair included booths from 30 industry sponsors and other companies based in Canada, and attracted a capacity crowd of 500 researchers, students, and various AI specialists. A rewarding event for all, the fair was an ideal setting for organizations with a Canadian AI presence and partners of the Vector Institute to showcase opportunities for top global talent to work with sponsors on real-world problems.

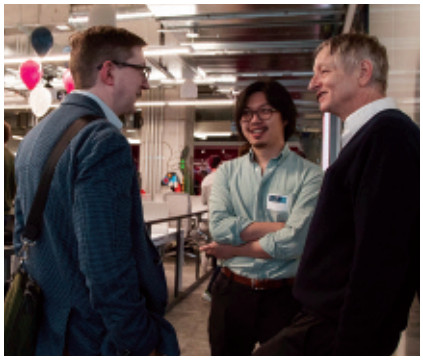
https://www.youtube.com/watch?v=5ZPBbvsycWs

The Summer School brought together over 250 of the best and brightest minds in machine learning


CIFAR




The Year Ahead



In Vector's second year, we will build on our momentum and continue to attract top machine learning researchers, help build an AI workforce in Ontario, and drive AI innovation by engaging with our industry sponsors and partners, all with a strong focus on growing Ontario's AI ecosystem.

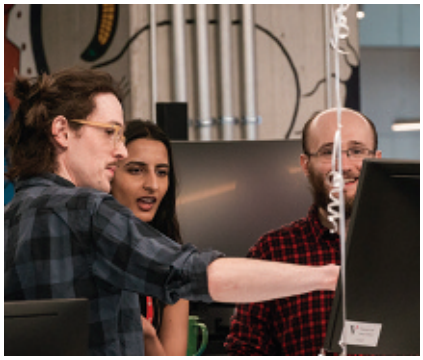
Vector's engagement with industry has been a success to date, but we have only just begun exploring the potential for collaboration. In the coming year, new programs will launch to help industry sponsors advance their use of AI.

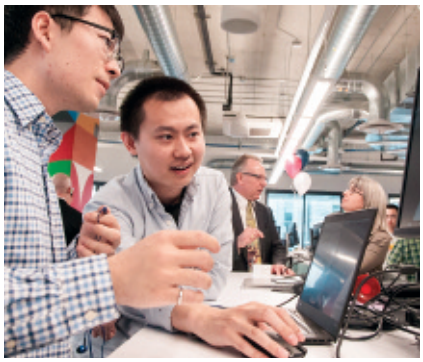
One program will enhance sponsors' ability to recruit graduates trained by members of Vector's world-class faculty and affiliated institutions. Another program will increase the opportunities for technical professionals to upgrade their machine learning skills. Building on the Banks Project, Vector will also seek new opportunities to bring other industry competitors together to solve shared research and development problems.

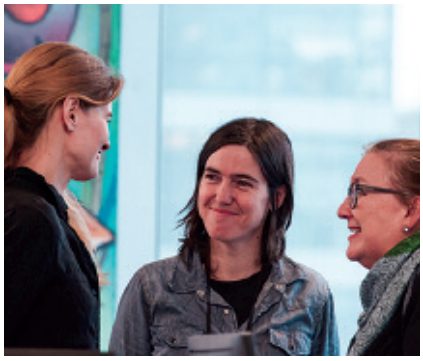
As Vector continues to attract new industry sponsors, work with small and medium-sized enterprises, and create business opportunities for Ontario's AI startups and scale-ups, the institute will also be actively collaborating with Ontario's health sector to deploy machine learning in ways that improve health care while making it more efficient.

Whether directly or indirectly, all of Vector's activities build strength and capacity into Canada's AI ecosystem, contribute to the sustainable growth of Ontario's knowledge economy, create tech jobs, and expand the Toronto–Waterloo corridor's already-impressive tech talent pool.

The singular foundation of Vector's value for Canadians and Canadian businesses is Vector's growing community of world-class researchers and graduate students. The more exceptional AI scientists Vector attracts, the more talented machine learning graduates can be deployed in the Canadian economy. The more industry sponsors can expand the use of AI in Canadian business, and the more our economy will grow to hire them. Simply put, supply creates demand.







In the coming year, Vector aims to hire another dozen world-leading faculty members, including many new to Canadian academia. Vector will also seek recognition for its faculty members as Canadian CIFAR AI Chairs, and expand its affiliation programs to include additional expertise in AI, computer science, engineering, and other related disciplines. And to ensure the next generation of productive machine learning scientists develop their skills and launch their careers in Ontario, Vector will create new scholarships and establish hundreds of Vector-connected AI internships.

Vector is also in the midst of building out its research programming to strengthen the local AI community. The institute will continue to expand the Machine Learning Advances and Applications Seminars to bring together internationally renowned AI researchers from both academia and industry to share recent breakthroughs and new techniques advancing the field.

Vector's complementary strengths of advanced AI research excellence combined with industry and university engagement will place Vector at the forefront of AI, leading and guiding the transformative effects of machine learning to give industry sponsors a competitive edge and to benefit all Canadians.

Financials

STATEMENT OF OPERATIONS

	2018	2017
Revenue		
Province of Ontario	$4,783,159	$0
Government of Canada	$2,000,000	$0
Industry partners	$7,749,985	$0
Investment income	$33,709	$0
Amortization of deferred capital contributions	$357,851	$0
	$14,924,704	**$0**
Expenditures		
Research and education	$2,414,693	$0
Industry skills training	$53,467	$0
Technology adoption	$432,839	$0
Business acceleration	$1,500,000	$0
General and administration	$1,437,250	$0
Amortization of capital assets	$357,851	$0
	$6,196,100	**$0**
One-time expenditures		
Transition costs	$944,911	$0
Total expenditures	**$7,141,011**	**$0**
Excess (deficiency) of revenue over expenses	**$7,783,693**	**$0**

STATEMENT OF FINANCIAL POSITION

	March 31, 2018	March 31, 2017
Assets		
Current assets		
Cash	$38,381,380	$30,000,000
Accounts receivable	$2,770,302	$0
Prepaid expenses	$70,081	$0
HST rebate receivable	$404,875	$0
	$41,626,638	**$30,000,000**
Capital assets	$3,179,000	$0
	$44,805,638	**$30,000,000**
Liabilities and Fund Balances		
Current liabilities		
Accounts payable and accrued liabilities	$1,864,764	$0
Other liabilities		
Deferred contributions	$31,978,181	$30,000,000
Deferred capital contributions	$3,179,000	$0
	$37,021,945	**$30,000,000**
Fund balances		
Unrestricted net assets	$7,783,693	$0
	$44,805,638	**$30,000,000**

To view the Vector Institute's audited financial statements for the 2017-2018 fiscal year, please visit https://vectorinstitute.ai/

Leadership

MEMBERS AND BOARD OF DIRECTORS

The Vector Institute is governed by a highly accomplished volunteer Board of Directors drawn from the private sector, public sector, academic and research communities. Vector's Members of the Corporation and Board of Directors include:

Ed Clark, Chair
Janet Bannister
Scott Bonham
Charmaine Dean
Janet Ecker
Vivek Goel
Chaviva Hosek
Nadir Mohamed
Michael Serbinis
Terrence Sullivan

The Vector Institute also gives thanks to Jordan Jacobs, Mary Jo Haddad, Stephen Lake, Pearl Sullivan and Shivon Zilis for their time, energy and dedication as founding members of Vector's Board of Directors. Their vision, insight and experience were instrumental in establishing and guiding Vector towards its vision and mission in its inaugural year.

PROFESSIONAL TEAM

From commercialization and industry innovation, to research programs, academic partnerships, health strategy, and more, Vector has put together an experienced and highly professional team to carry out its mission.

LEADERSHIP

Garth Gibson
President and CEO

Brenda Brouwer
Head, Academic Partnerships

Gary Burlakoff
Director of Finance

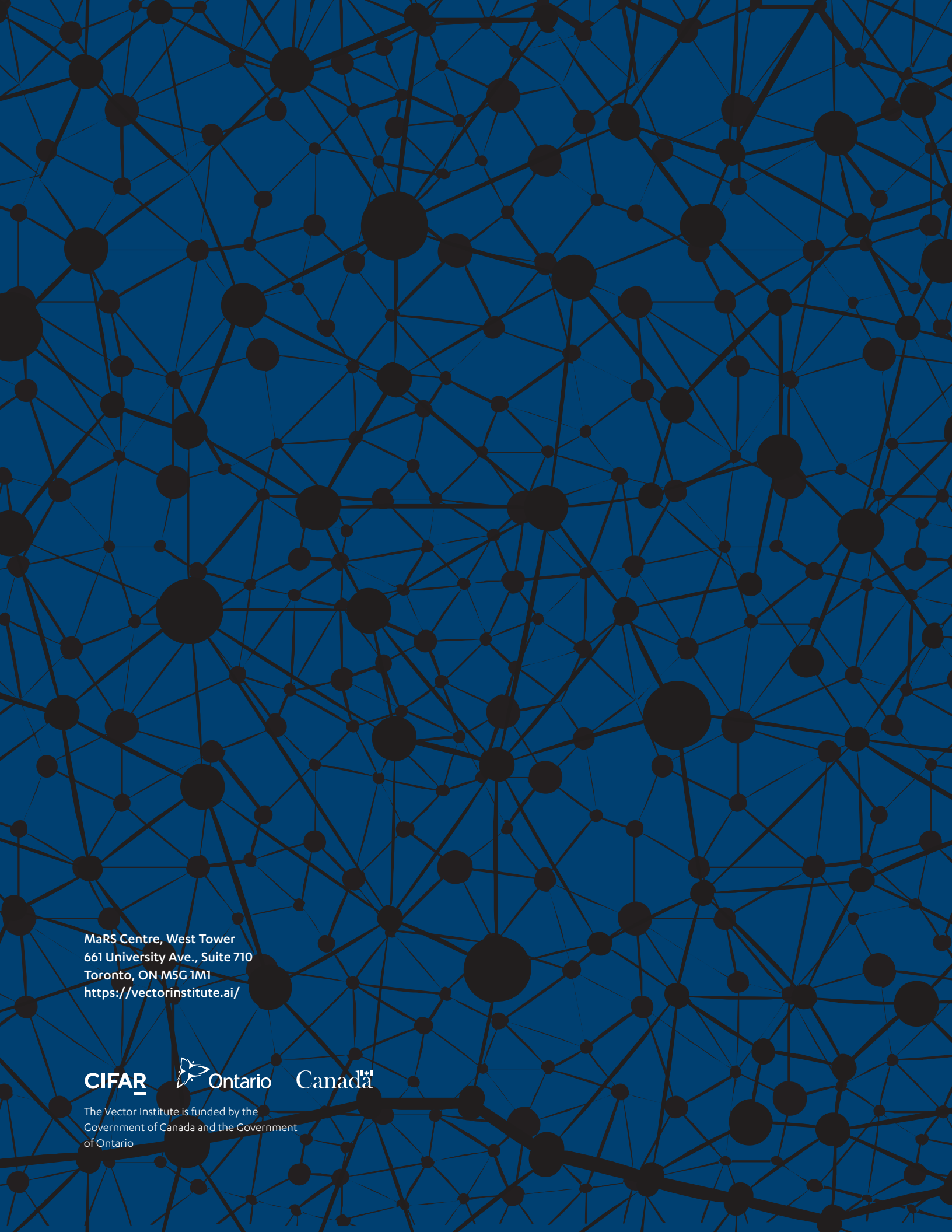
Alison Paprica
VP, Health Strategy and Partnerships

Cameron Schuler
VP, Industry Innovation and Chief Commercialization Officer

Alan Veerman
Chief Operations Officer

David Wexler
VP, Human Resources

Richard Zemel
Research Director



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https://vectorinstitute.ai/

CIFAR Ontario Canada

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VECTOR INSTITUTE

ANNUAL REPORT 2018