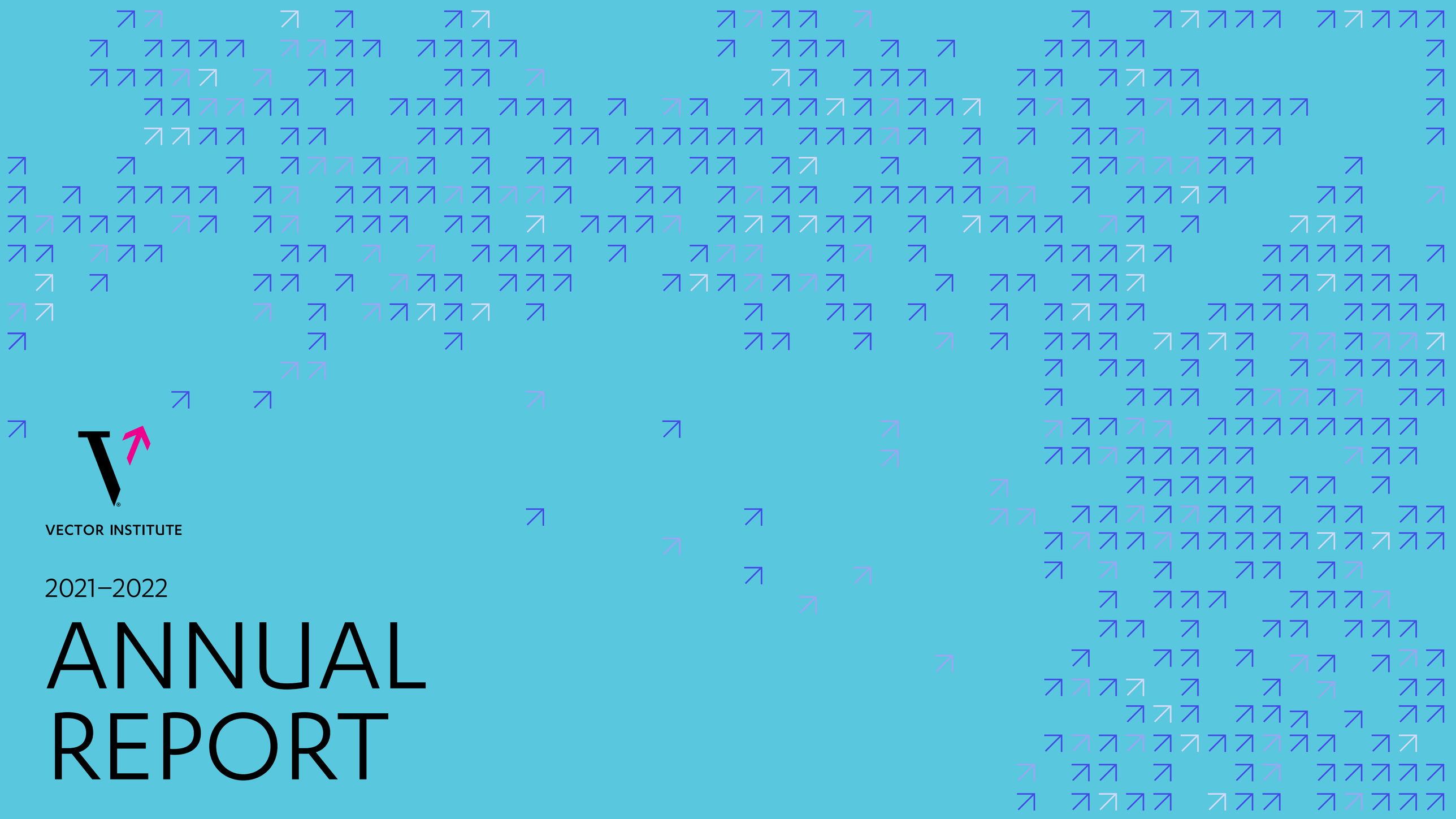

VECTOR INSTITUTE

2021–2022

ANNUAL REPORT

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MESSAGE FROM THE BOARD CHAIR AND THE PRESIDENT & CEO

In the five short years since Vector was founded, artificial intelligence (AI) has cemented its place as a driver of economic competitiveness and growth. Now more than ever, it can play an important role in our economic recovery from the pandemic. Vector is focused on supporting these goals by leveraging our deep research expertise to help organizations apply AI across sectors, securing Ontario's position as a world-leading hub of AI talent and investment attraction. While the profound disruption of the COVID pandemic has not yet abated, we remain proud of the Vector community and its shared efforts to enable Canadian industry, health institutions, and governments to unlock a brighter future for all.

As we enter the next chapter of Canada's Pan-Canadian AI Strategy (PCAIS), which features a broadened emphasis on commercialization, we are seeing Canada's bold strategy flourish through the country's AI ecosystem — built around Vector in Toronto and our counterpart institutes, Amii in Edmonton and Mila in Montreal. We feel the momentum building every day, and we're not alone: The Brookings Institution recently described Vector as "one of the most ambitious efforts in North America to upgrade a strong ecosystem into a world-class position," while Forbes published a piece predicting that Toronto will become the most important AI hub in the world outside of Silicon Valley and China.

Global demand for AI talent continues to outpace supply, making it a costly and competitive space. In Toronto, the tech workforce is expanding more quickly than in any other North American city. We can credit Vector's community as having played a significant part in AI's preeminent role in this growth.

Last year, almost 1,800 Ontario students began their studies in a Vector-recognized AI-related master's program or other study paths in AI — both a record number and a 27 per cent increase over the previous year. Last year also saw more than 1,000 new graduates from AI master's programs in Ontario; a milestone achieved ahead of the province's 2023 target. These skilled AI graduates will hold an envied role in the workforce of the future. Further, our research community has now grown to more than 700, whose influence continues to grow; they published more than 380 research papers in high-impact global conferences and in top-ranked journals this year alone.

To amplify this positive momentum in academic leadership, we strengthened our focus on connecting emerging talent with leading research, merging two of our support teams this year under the leadership of Vice President, Research Operations and Academic Partnerships Melissa Judd.

Meanwhile, our sponsor community has expanded to include 29 enterprise industry sponsors and 16 scaleup sponsors. Our robust network of health sector partners also continues to grow, and now features more than 35 agreements to enable secure access to health datasets for AI-powered research that can improve diagnostics, patient care, and health system performance.

In addition to our hands-on collaborations with large enterprise and scaleup companies, we also prioritized efforts to help small and medium-sized enterprises (SMEs) capitalize on the potential of AI through our new FastLane program. Launched with more than 60 SMEs in December 2021, the program helps SMEs deploy AI within their business and access AI talent so they can grow and compete on the global stage.

Ensuring responsible use of data is a core priority at Vector. With the appointment of Roxana Sultan as our new Chief Data Officer, in addition to her role as Vice President, Health, Vector is helping to lead a culture shift towards modernizing data governance and management. This is imperative as AI is increasingly integrated into the health sector. The pandemic has shown that the power of machine learning, used for research with health data, can improve both the quality and efficiency of health services as Vector is demonstrating through its *Smart Health* Initiative.

Meanwhile, Vector remains committed to increasing opportunity for those interested in AI, helping to build research and career paths for underrepresented groups and communities in Canada who face challenges when entering the field of AI, and STEM and tech more broadly. By offering programs like our Introduction to Machine Learning courses for Black and Indigenous students and a Mothers and Machine Learning course, Vector is striving towards greater inclusion.

As we enter the third year of Vector's *Three-Year Strategy*, we are looking towards new and ambitious goals that will shape our next chapter. Fuelled by success — both our own and that of the broader Canadian AI ecosystem — and the ongoing support of our government and industry partners, we will continue our efforts to ensure that all Canadians benefit from the tremendous potential of AI.

Thank you to the entirety of our Vector community. We look forward to marking the next chapter in Vector's story at our new home in the soon-to-be-completed Schwartz Reisman Innovation Centre.

ED CLARK
Chair of the Board of Directors

GARTH GIBSON
President & CEO

VECTOR'S VISION & MISSION

The Vector Institute is funded by the Government of Canada, the Government of Ontario, as well as industry sponsors from across the Canadian economy.

Funded by the Government of Canada
Financé par le gouvernement du Canada

Canada

Ontario

CIFAR

OUR VISION

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

OUR MISSION

We 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.

SPOTLIGHT ON FIVE YEARS OF AI LEADERSHIP FOR CANADIANS

SINCE THE VECTOR INSTITUTE WAS FOUNDED IN 2017:

2,080+

Students have graduated from Vector-recognized AI programs and study paths

$6.2 M

Scholarship funds committed to students in AI programs

3,700+

Postings for AI-focused jobs and internships offered on Vector's Digital Talent Hub

$103 M

In research funding committed to Vector-affiliated researchers

94

Research awards earned by Vector Faculty Members

470+

people from 35 industry and health sector organizations involved in 13 completed collaborative projects

~20

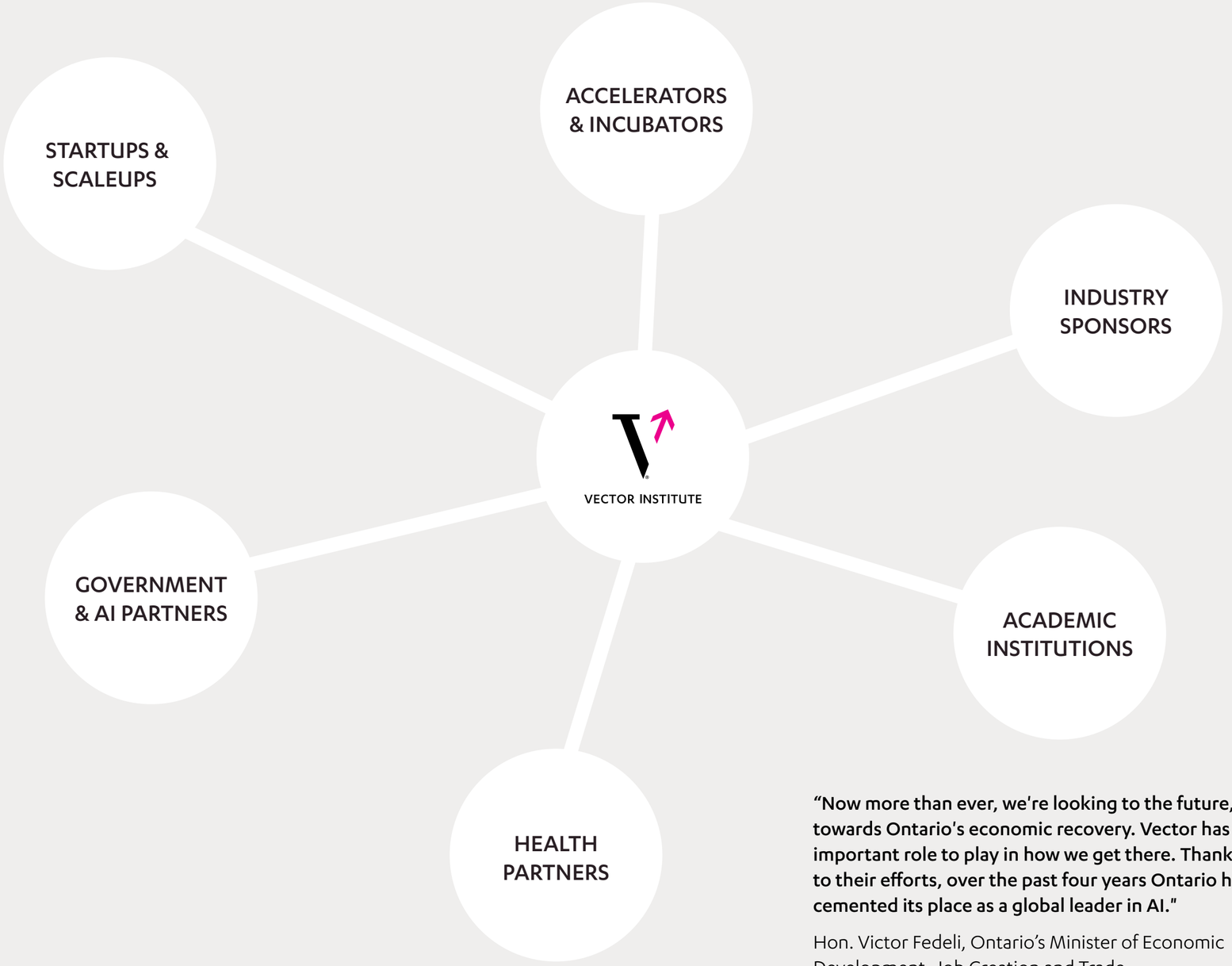
Thought-leadership articles published on important topics in AI

35+

partnerships and agreements with leading health sector organizations

ONTARIO'S VIBRANT AI ECOSYSTEM

The Vector Institute remains at the heart of a thriving AI ecosystem, featuring leading enterprises, academic institutions, health partners, governments, peer institutes, and more. Together with this network, we are advancing the economic and societal benefits of AI for all Canadians.



"Now more than ever, we're looking to the future, towards Ontario's economic recovery. Vector has an important role to play in how we get there. Thanks to their efforts, over the past four years Ontario has cemented its place as a global leader in AI."

Hon. Victor Fedeli, Ontario's Minister of Economic Development, Job Creation and Trade

ONTARIO AI SNAPSHOT 2021–22

The Vector Institute's annual Ontario AI Snapshot, produced in collaboration with Deloitte Canada, reveals significant growth in AI-related employment during 2021–22, driven in large part by a significant increase in venture capital (VC) investments flowing into Ontario's vibrant AI ecosystem.

*In the 2021–22 iteration of this report, Deloitte refined the methodology to improve accuracy of this calculation as well as validated it against other external data sources.

STATE OF ONTARIO'S AI ECOSYSTEM

Arrows indicate year-over-year (YoY) directional change since 2020–21

The complete Ontario AI Snapshot for 2021–22 will be available soon on the Vector Institute website at [vectorinstitute.ai.](vectorinstitute.ai)

↑ YoY
22,458
AI jobs created

↑ YoY
59,673
AI jobs retained

↑ YoY
1,775
New AI Master's & study path enrolments

↑ YoY
1,007
New AI Master's graduates from Vector-recognized programs

↑ YoY
66
New AI-related patents filed across Canada

↑ YoY
$2.86 BILLION
In AI-related VC investment*

↑ YoY
273
Companies invested in the Ontario AI ecosystem

↑ YoY
50
Companies moved into the Ontario AI ecosystem

↑ YoY
34%
Increase in AI R&D spending or budgets*

↓ YoY
22
New AI companies established in Ontario

↓ YoY
51%
Of CEOs surveyed say AI is strategically important to their companies

↔ YoY
53%
Of CEOs surveyed report their companies have commercialized AI products/services or use AI to sell core products/services

INDUSTRY INNOVATION

Vector equips Canadian business to accelerate AI and drive business value

Vector is helping organizations in all sectors and at all levels of AI adoption acquire the skills, frameworks, and talent necessary to compete and innovate using AI.

"At the Vector Institute, you're really helping us to better understand and harness [AI] technologies so that we can build the jobs and the services of tomorrow. Because now more than ever, this is key to improving Ontarians' lives, increasing access to public services and fostering long-term economic growth."

Hon. Peter Bethlenfalvy, Ontario's Minister of Finance

VECTOR'S INDUSTRY SPONSORS

After five years of leadership with Canadian businesses, our community of industry sponsors continues to grow across all sectors, connecting enterprises of all sizes who aim to strengthen, adopt, and apply AI in Canada.

24	Founding sponsors reaffirmed their multi-year commitments
5*	New sponsors joined
29	Total industry-leading enterprises
$40+ MILLION	Industry funding injected directly into Canada's AI ecosystem.

*4 in 2021–22 + 1 in 2020–21

UNLOCKING INNOVATIONS WITH NEW INDUSTRY SPONSORS

“We are starting our journey in AI, and with AI-based digital health care as a key part of the future of Canadian health care, Boehringer Ingelheim (Canada) Ltd.’s new partnership with the Vector Institute provides a strong foundation to grow from.”

Dr. Gabriel Kim, Vice President, Medical and Regulatory Affairs, Boehringer Ingelheim (Canada) Ltd.

“Fostering the development of new technologies within our borders helps Canadian industry, and in turn benefits Canadians. We are proud to help accelerate innovation in this field so that we can harness AI for applications at Bell.”

John Watson, Group President, Customer Experience, Bell

“Partnering with Vector will help us further enhance the customer experience both digitally and in-store, enabling us to better respond to their preferences and anticipate their needs.”

Cari Covent, Vice President of Enterprise Data Strategy & Insights Enablement, Canadian Tire Corporation

“Our work with the Vector Institute will enable us to more fully explore and act on opportunities to use machine learning and AI more broadly to innovate and lead for the future that will ultimately benefit OMERS and our more than 500,000 members.”

Monique Allen, Executive Vice President, Data & Technology, OMERS

INDUSTRY SPONSORS

As of March 31, 2022

"Working with Vector enables our industry sponsors to give their employees unique access to expert researchers, a valuable sandbox environment that allows them to try new AI techniques with their peers, and first-hand access to an AI talent pool that is in high-demand around the globe."

Cameron Schuler, Vector's Chief Commercialization Officer & VP, Industry Innovation.

PLATINUM

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

GOLD

Air Canada	Bell	Boehringer Ingelheim	Canadian Tire	CIBC
CN	Deloitte Canada	EY Canada	Georgian	KPMG Canada
KPMG Canada	Magna	OMERS	PwC Canada	Roche Canada
Sun Life	TELUS	Thales		

SILVER

EllisDon	Linamar

BRONZE

Ada	BenchSci	Canvass AI	Clearpath	Darwin AI
Deep Genomics	FreshBooks	Goldspot Discoveries	Integrate.ai	Layer6
League	Mindbridge	Stradigi AI	Surgical Safety Technologies	TealBook
Wysdom AI				

SPOTLIGHT ON FASTLANE PROGRAM

FAST LANE

AMBITIOUS FAST-GROWING COMPANIES GAIN VALUABLE EXPERTISE BUILDING AND SCALING APPLIED AI SOLUTIONS FOR COMPLEX BUSINESS PROBLEMS

60+

FAST-GROWING SMES

10

EVENTS AND WORKSHOPS DEDICATED TO PROFESSIONAL DEVELOPMENT, TALENT ADVISORY, AND AI COMMERCIALIZATION INSIGHTS

1,300

HOURS OF ENGAGEMENT WITH STARTUPS AND SCALEUPS ACROSS SECTORS

Launched in December 2021, Vector's new FastLane program helps SMEs to adopt AI or scale their existing applied AI capacity — faster and at lower cost — so they can compete on the global stage. Through workshops, events, and programming designed for the unique needs of these ambitious companies, FastLane helps supercharge business transformation and strengthens Ontario's AI pipeline.

Initial SME participants include Sofvie, a Sudbury-based workplace safety software company, 16 Bit, which is harnessing machine learning to improve health diagnostics, and PitStop, which uses AI for predictive maintenance of vehicles and other mobility solutions. Other participants span sectors from agriculture to insurance and are located across the province.

"Vector's FastLane program is a great opportunity for companies to realize the potential of AI towards their own future success and help drive Ontario's economic growth for decades to come."

Hon. Victor Fedeli, Ontario's Minister of Economic Development, Job Creation and Trade

"One of our key interests in Vector's FastLane program is the opportunity to build connections within Vector's research community. Opening dialogues between some of the world's leading AI researchers and receiving guidance on new AI advancements is highly valuable to Canadian companies looking to maintain a competitive edge through AI."

Michael Cohen, CEO, QII.AI, a drone inspection software company

PROGRAMMING AT THE FOREFRONT OF AI

Vector's growing suite of professional development programming enables Canadian enterprises to create business value using AI that equips them to compete globally and retain top talent. Combining technically rigorous content with practical applications and instruction from Vector's leading research faculty, participants gain valuable experience solving real-world problems relevant to their businesses.

6,300+

Participants upskilled or trained in Vector's programming for industry sponsors and the public in 2021–22

MOTHERS & MACHINE LEARNING

- Six-week, academically rigorous course; 39 participants completed the inaugural program
- Flexible format, with financial support for caregivers to enable full participation
- Course developed by Vector Faculty Member Juan Felipe Carrasquilla Álvarez and jointly funded by Vector and Google TensorFlow
- Unlocks a vital source of talent, enabling mothers on maternity leave and stay-at-home caregivers to chart a new career in the growing field of AI

> **"The Mothers and Machine Learning course was amazing, introducing me to the huge world of artificial intelligence. I am eager to pursue a career in this field."**
>
> Course participant

FASTLANE PROGRAM

- Launched with 64 fast-growing SMEs
- Specialized workshops and programming enable SMEs to adopt AI or scale existing applied AI capacity faster to accelerate their growth and competitiveness
- Strengthens Ontario's AI talent pipeline and supports its position as the world's fastest-growing AI tech hub

BOOTCAMPS

- Industry sponsor participants build proof-of-concepts for their company-specific use cases using state-of-the-art techniques
- 170 participants engaged in immersive three-day sessions on such topics as Privacy Enhancing Techniques (PETs) and Forecasting with Deep Learning, from which the code was shared via open source

> **"Vector's [Forecasting with Deep Learning] bootcamp, along with the prep and post work, helped to compress about six months of work into about 4-6 weeks and helped our team to rapidly progress through the initial project phase."**
>
> Industry sponsor participant

SECTOR-SPECIFIC INTRODUCTION TO AI PROGRAMS

- Three sessions uniquely shaped to address AI-related topics in specific sectors (manufacturing, services, and logistics) attracted over 500 participants.
- Vector's programming elevates knowledge and capabilities among senior, non-technical professionals, including C-suite, Finance, Marketing, and HR, with a special focus on SMEs.
- Participants gained insights from Vector industry and research leaders; developed use cases; received guidance on deploying AI as a solution; and explored the implications of AI for business, policy and ethics.

PROGRAMMING AT THE FOREFRONT OF AI

ENDLESS SUMMER SCHOOL

6 SESSIONS
229 PARTICIPANTS

- Upskills industry sponsor workforces to help them retain top talent
- Equips practitioners with advanced technical skills, techniques and the latest industry-relevant developments
- Topics included: AI Model Governance; Large Language Models; and AI for Health

BUSINESS INSIGHTS SERIES

4 SERIES
300 PARTICIPANTS

- Non-technical professionals gain new perspectives and frameworks for understanding AI opportunities, implementation, and scale
- Topics included: Financing for AI Projects; Engineering and DevOps for AI; and Lessons Learned in Equity, Diversity and Inclusion in AI

BIAS IN AI PROGRAM FOR SMES

- SME professionals develop technical skills to shape responsible applications of AI where bias may exclude or disadvantage population segments
- Innovative 5-week program funded by the National Research Council of Canada Industrial Research Assistance Program

> **“It was fascinating to learn about model fairness and model explainability, which tend to be overlooked in other machine learning type courses. We are able to dissect various problem spaces step-by-step, leverage techniques to identify and address biases, and tackle a Kaggle-like project on model fairness.”**
>
> Bias in AI program participant

COMMERCIALIZATION SESSIONS

11 SESSIONS
613 PARTICIPANTS

- Connects entrepreneurial researchers to experienced industry specialists, founders, investors, and advisors
- Builds networks and enhances their understanding of key concepts of entrepreneurship, from intellectual property to investment to go-to-market strategies and more

FACE-TO-FACE PROGRAM

32 SESSIONS

- Industry sponsors benefit from insights and guidance from Vector researchers and AI Engineering experts in one-to-one meetings designed to address highly specific AI challenges
- Topics included: forecasting using deep learning, best practices for synthetic data creation and use, and multilingual natural language processing (NLP)

COLLABORATION IN ACTION: RECENT COMPLETED PROJECTS

COLLABORATIVE PROJECTS EQUIP CANADIAN INDUSTRY TO APPLY AI

Vector's collaborative projects provide unique opportunities for technical professionals to work alongside Vector researchers and industry peers, learning how to apply AI models and techniques to create value within their companies. Project themes are selected based on needs identified by industry and the potential for widespread impact.

8	Projects completed
12,000+	Hours of knowledge transfer to industry sponsor employees
380+	Participants from 29 sponsors
7	New collaborations launched covering such topics as Trustworthy AI, Conversational AI, and Robotics.

COMPUTER VISION

Since early 2021, senior technical and strategic professionals from eight industry sponsors have been collaborating with Vector researchers on a multi-phase project designed to help these companies understand and apply recent advances in computer vision. Upon the project's conclusion, participants gathered for a two-day symposium hosted by Vector in October 2021 to share outcomes and applications from the project. For example, in their project work relating to anomaly detection and autonomous mobility systems, Linamar explored how AI can increase manufacturing efficiency by automating quality assurance, while Thales explored how computer vision can support the long-term development of autonomous trains.

TELUS MODEL-BASED REINFORCEMENT LEARNING (MBRL) OPEN SOURCE PROJECT

Since 2019, TELUS and a team of Vector researchers, industry experts, and engineering leaders have been collaborating on the use of MBRL to finetune heating, ventilation, and air conditioning (HVAC) systems to improve energy-efficient temperature control in 24/7 data centres. Following the promising results of the initial pilot test, which showed a decrease of almost 12 per cent in reduced annual electricity consumption in a data centre, TELUS and Vector have elected to provide the new algorithm to the wider business, energy conservation, and research communities via open source, reflecting the commitment of both organizations to leverage AI to create better outcomes for Canadians and the environment.

> **"This is a brilliant example of how our expertise in research and engineering can create value and make it easier to deploy leading AI research outcomes. Now we want to amplify the project's value by open sourcing it for others to adopt."**
>
> Deval Pandya, Vector's Director, AI Engineering

LONG COVID

Industry sponsors Roche Canada, Deloitte Canada, and TELUS collaborated with Vector's industry team and researchers to apply natural language processing (NLP) techniques to more than 460,000 social media posts by people who had self-reported long COVID. Preliminary results showed that patterns related to symptom frequencies, co-occurrence, and distribution over time could be successfully detected and visualized using the framework and could be applied by researchers and clinicians to understand health trends and impacts.

> **"This study is a tangible example of how AI can help improve lives. It also demonstrates how AI specialists, corporate, and health sectors can work together and share their expertise to help address some of the most worrisome outcomes of COVID-19."**
>
> Cameron Schuler, Vector's Chief Commercialization Officer & Vice President, Industry Innovation

DATASET SHIFT

In August 2021, Vector released the Dataset Shift and Potential Remedies Technical Report. The report was the final output from the multi-year collaborative Dataset Shift Project in which professionals from seven industry sponsors worked with Vector researchers. Vector Project Manager Sedef Akinli Kocak, along with project participants, led a tutorial based on insights from this report at the European Conference on Machine Learning & Principles and Practice of Knowledge Discovery in Databases (ECML PKDD 2021) in September 2021.

> **"You get an immediate concrete benefit when people work on a project together with guidance, and guided by Vector, they're steered in the right direction. There's hands-on exposure to techniques and technologies."**
>
> Andrew Brown, Senior Director of Data Science and AI Research with CIBC, one of the project's participants

SPOTLIGHT ON AI INNOVATORS

WORKING DIRECTLY WITH BRONZE SPONSORS AND THROUGH PROGRAMS THAT INCLUDE FASTLANE, BOOTCAMPS, PROGRAMS FOR SMES, AND COMMERCIALIZATION SESSIONS, VECTOR IS ENABLING AI INNOVATORS TO BOTH START AND SCALE.

One of these exciting AI innovators is Vector Postgraduate Affiliate Estelle Inack, co-founder of yiyaniQ, the first company to be spun-out from Vector. yiyaniQ uses quantum intelligent methods, which are a combination of quantum-inspired and AI techniques to get faster and more accurate derivative pricing calculations and to find the most optimal combination of assets, thus helping to address some of finance's most difficult problems.

The technology was first showcased in a 2021 research paper on Variational Neural Annealing co-authored by Inack, Vector graduate students Mohamed Hibat-Allah and Roeland Wiersema, Vector Faculty Affiliate Roger G. Melko, and Vector Faculty Member Juan Felipe Carrasquilla Álvarez. After patenting the technology, she chose to commercialize it herself rather than license it to a third party.

"I felt that I had a better grasp of the model's capabilities," Inack says. The company's name reflects the personal connection to its co-founder. It comes from Basa'a, a local language used in her native Cameroon. "Yi means intelligence, and yaani means tomorrow," she says. "The Q is for quantum, of course."

RESEARCH & EDUCATION

Vector is advancing the frontiers of AI knowledge

What was once only a few founding faculty has evolved over the last five years into a flourishing community comprising over 700 researchers who are pushing the boundaries of AI, machine learning, and deep learning in critical areas to benefit Ontarians, Canadians, and people around the world.

Vector continues to drive this growth through new and expanding efforts to attract and develop an outstanding community. Highlights of these efforts include:

- Fostering collaboration between industry and academia to connect leading research and AI application.
- Creating more ways for researchers to work with industry sponsors and health sector partners on real-world problems and novel data sets.
- Expanding access to events focused on research and applications and increasing access to internships.

For individuals who come through Vector's doors, a world of opportunity awaits. Whether they arrive as interns, graduate students, Postdoctoral Fellows, or Faculty, they have the opportunity to choose their own pathway: from applied and research internships, to graduate studies or a Postdoctoral Fellowship, to becoming a Faculty Member -- all while having the option to start a business or work with some of Canada's largest corporations on AI-driven innovation that will enable Canada's economy to thrive in the future.

MEET VECTOR'S WORLD-CLASS AI RESEARCH COMMUNITY

Vector is advancing its goal of becoming a Top 10 global centre for AI research by attracting the world's most accomplished, ambitious, and innovative researchers who are unlocking new achievements across a wide range of AI and machine learning topics.

714	**Members of the Vector research community, comprising:**
35	Faculty Members including 32 Canada CIFAR AI Chairs
103	Faculty Affiliates
51	Postdoctoral Fellows
410	Graduate Researchers
115	Undergraduates

NEW

OPEN CALL PORTAL EXTENDS GLOBAL REACH

Vector's Research Internship Program plays a crucial role in growing a dynamic AI ecosystem for industry, health, innovation, and advanced research. Through a new Open Call portal, Vector is better able to reach top AI talent from across Canada and around the world. Meanwhile, prospective research interns benefit from easier access to a fast-growing AI ecosystem and opportunities to work alongside Vector's world-class faculty on new machine learning and deep learning discoveries.

"I was invited to give a long talk about our compression work at a Vector's Thursday talk seminar. It was a great opportunity for me to learn how to present my work, let others know about our results, and interact with other researchers who had interesting feedback. I was also shown how to maximize the impact of one's research and collaborate more effectively. "

Yann Dubois, Vector Research Intern, Winter/Spring 2021

VECTOR INSTITUTE FACULTY MEMBERS

Faculty Members are Canada CIFAR AI Chairs, except those marked with an asterisk.

Alán Aspuru-Guzik, University of Toronto
Jimmy Ba, University of Toronto
Shai Ben-David, University of Waterloo
Michael Brudno, University of Toronto
Juan Felipe Carrasquilla Álvarez, Vector Institute
Jeff Clune*, University of British Columbia
David Duvenaud, University of Toronto
Murat A. Erdogdu, University of Toronto
Amir-massoud Farahmand, Vector Institute
Sanja Fidler, University of Toronto
David Fleet, University of Toronto Scarborough
Brendan Frey*, University of Toronto
Animesh Garg, University of Toronto
Marzyeh Ghassemi, University of Toronto
Anna Goldenberg, Hospital for Sick Children
Roger Grosse, University of Toronto
Rahul G. Krishnan, University of Toronto
Chris Maddison, University of Toronto
Alireza Makhzani, Vector Institute
Sheila McIlraith, University of Toronto
Quaid Morris, University of Toronto
Sageev Oore, Dalhousie University
Nicolas Papernot, University of Toronto
Gennady Pekhimenko, University of Toronto
Toniann Pitassi, University of Toronto
Pascal Poupart, University of Waterloo
Daniel Roy, University of Toronto
Frank Rudzicz, Li Ka Shing Knowledge Institute, Unity Health St. Michael's Hospital and University Health Network
Angela Schoellig, University of Toronto
Leonid Sigal, University of British Columbia
Graham Taylor, University of Guelph
Raquel Urtasun*, University of Toronto
Bo Wang, University of Toronto
Yoaliang Yu, University of Waterloo
Richard Zemel, University of Toronto

INTRODUCING VECTOR'S NEWEST FACULTY MEMBER, JEFF CLUNE

Vector welcomed Jeff Clune, Associate Professor of computer science at the University of British Columbia to our Faculty Member community this year. In addition to his work as Research Manager at OpenAI, Clune was previously a Senior Research Manager and founding member of Uber AI Labs, which was formed after Uber acquired a startup he helped lead. Clune focuses on deep learning, including deep reinforcement learning. He was also the Loy and Edith Harris Associate Professor in Computer Science at the University of Wyoming and a Research Scientist at Cornell University. After earning an undergraduate degree at University of Michigan, he earned a PhD in Computer Science and M.A. in Philosophy, both from Michigan State University.

VECTOR FACULTY AFFILIATES

The Vector Faculty Affiliates Program brings together leading researchers from across Ontario for two-year appointments, expanding the community's expertise in AI, computer science, engineering, and other disciplines related to machine learning, as well as strategic domains of application.

Ajay Agrawal, University of Toronto
Benjamin Alarie, University of Toronto
Ashton Anderson, University of Toronto
Hassan Ashtiani, McMaster University
Timothy Barfoot, University of Toronto
Suzanna Becker, McMaster University
Vaughn Betz, University of Toronto
Ben Blencowe, University of Toronto
Yuri Boykov, University of Waterloo
Michael Brown, York University
Marcus Brubaker, York University
Neil Bruce, University of Guelph
Kieran Campbell, Lunenfeld-Tanenbaum Research Institute
Timothy Chan, University of Toronto
Fanny Chevelier, University of Toronto
John Connolly, McMaster University
V. Radu Craiu, University of Toronto
Mark Daley, Western University
Konstantinos Derpanis, Ryerson University
Sven Dickinson, University of Toronto
Thomas Doyle, McMaster University
James Elder, York University
Melike Erol-Kantarci, University of Ottawa
Benjamin Fine, University of Toronto
Ali Ghodsi, University of Waterloo
Avi Goldfarb, University of Toronto
Katarina Grolinger, Western University
Jessica Gronsbell, University of Toronto
Maura Grossman, University of Waterloo
Yuhong Guo, Carleton University
Gillian Hadfield, University of Toronto
Benjamin Haibe-Kains, University of Toronto
Sean Lewis Hill, University of Toronto
Jesse Hoey, University of Waterloo
Michael Hoffman, University of Toronto
Ting Hu, Queen's University
Ihab Ilyas, University of Waterloo
Alec Jacobson, University of Toronto
Tracey Jenkin, Queen's University
Hui Jiang, York University
Alistair Johnson, Hospital for Sick Children
Gautam Kamath, University of Waterloo
Nachiket Kapre, University of Waterloo
Jonathan Kelly, University of Toronto
Elias B. Khalil, University of Toronto
Farzad Khalvati, University of Toronto
Kyros Kutulakos, University of Toronto
Kate Larson, University of Waterloo
Vianey Leos Barajas, University of Toronto
David Lie, University of Toronto
Jimmy Lin, University of Waterloo
Daniel James Lizotte, Western University
Tegan Maharaj, University of Toronto
Muhammad Mamdani, University of Toronto
Anne Martel, Sunnybrook Research Institute
Chris McIntosh, University of Toronto
Paul David McNicholas, McMaster University
Roger Melko, University of Waterloo
Alex Mihailidis, University of Toronto
Jason Millar, University of Ottawa
Yalda Mohsenzadeh, Western University
Andreas Moshovos, University of Toronto
Parvin Mousavi, Queen's University
Anthony Niblett, University of Toronto
Mihai Nica, University of Guelph
Aleksandar Nikolov, University of Toronto
Anna Panchenko, Queen's University
Vardan Papyan, University of Toronto
Gerald Penn, University of Toronto
Abhishek Pratap, Centre for Addiction and Mental Health
David Richard Rokeby, University of Toronto
Laura Rosella, University of Toronto
Jeffrey S. Rosenthal, University of Toronto
Sushant Sachdeva, University of Toronto
Reza Samavi, Toronto Metropolitan University
Scott Sanner, University of Toronto
Nisarg Shah, University of Toronto
Bhavin Shastri, Queen's University
Florian Shkurti, University of Toronto
Amber Simpson, Queen's University
Jared Simpson, Ontario Institute for Cancer Research
Karan Singh, University of Toronto
Stephen L. Smith, University of Waterloo
Ranil Sonnadara, McMaster University
Lincoln Stein, Ontario Institute for Cancer Research
Suzanne Stevenson, University of Toronto
Yu Sun, University of Toronto
Babak Taati, University Health Network
Isaac Tamblyn, University of Ottawa
Hamid Reza Tizhoosh, University of Waterloo
Ruth Urner, York University
Olga Veksler, University of Waterloo
Nandita Vijaykumar, University of Toronto
Linbo Wang, University of Toronto
Boyu Wang, Western University
Joseph Jay Williams, University of Toronto
Yang Xu, University of Toronto
Yimin Yang, Lakehead University
Grace Yi, Western University
Albert Yoon, University of Toronto
Fattane Zarrinkalam, University of Guelph
Hongyang Zhang, University of Waterloo
Xiaodan Zhu, Queen's University
Joel Zylberberg, York University

VECTOR AFFILIATED INSTITUTIONS

Vector's vibrant community, including its Faculty Members, Faculty Affiliates, Postgraduate Affiliates, graduate researchers, Postdoctoral Fellows, Vector Scholarship in AI recipients and students in Recognized AI Master's Programs represent and collaborate with a wide range of institutions across Canada, including:

BROCK UNIVERSITY

CARLETON UNIVERSITY

CENTRE FOR ADDICTION AND MENTAL HEALTH

DALHOUSIE UNIVERSITY

ICES

LAKEHEAD UNIVERSITY

LUNENFELD-TANENBAUM RESEARCH INSTITUTE, SINAI HEALTH SYSTEM

MCMASTER UNIVERSITY

ONTARIO INSTITUTE FOR CANCER RESEARCH

ONTARIO TECH UNIVERSITY

OTTAWA HOSPITAL RESEARCH INSTITUTE

PERIMETER INSTITUTE FOR THEORETICAL PHYSICS

QUEEN'S UNIVERSITY

SINAI HEALTH SYSTEM

SUNNYBROOK RESEARCH INSTITUTE

THE HOSPITAL FOR SICK CHILDREN

TORONTO METROPOLITAN UNIVERSITY

TRILLIUM HEALTH PARTNERS

UNITY HEALTH TORONTO

UNIVERSITY HEALTH NETWORK

UNIVERSITY OF BRITISH COLUMBIA

UNIVERSITY OF GUELPH

UNIVERSITY OF OTTAWA

UNIVERSITY OF TORONTO

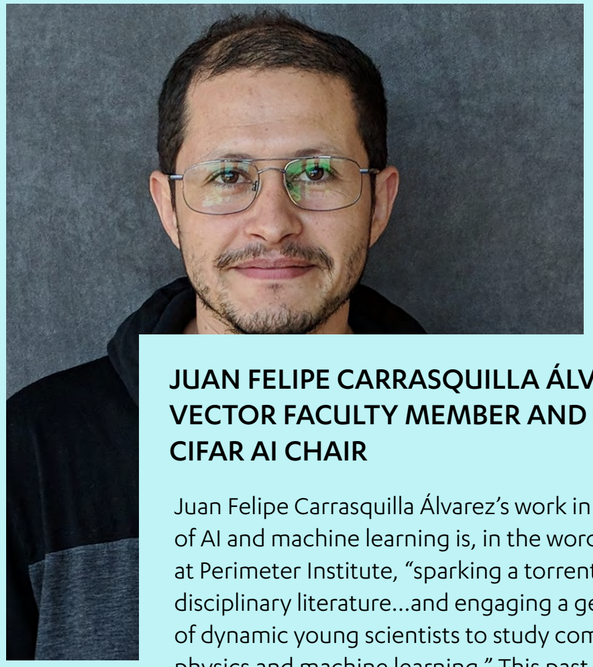
UNIVERSITY OF WATERLOO

UNIVERSITY OF WINDSOR

WESTERN UNIVERSITY

YORK UNIVERSITY

SPOTLIGHT ON RESEARCHERS



JUAN FELIPE CARRASQUILLA ÁLVAREZ, VECTOR FACULTY MEMBER AND CANADA CIFAR AI CHAIR

Juan Felipe Carrasquilla Álvarez's work in the field of AI and machine learning is, in the words of a peer at Perimeter Institute, "sparking a torrent of cross-disciplinary literature…and engaging a generation of dynamic young scientists to study computational physics and machine learning." This past year, he designed and spearheaded Vector's new Mothers & Machine Learning program. Additionally, he served as the advisor on Vector spinout, yiyaniQ. Other highlights from this past year include co-authoring a paper that presents a pioneering approach to manipulating qubits using machine learning. Carrasquilla Álvarez believes the new approach could apply to a number of different quantum-related problems, including the use of microscopic refrigerators to cool electronic devices and fibre-optic networks. "I was contacted about using this strategy to do something which is completely different from what I had considered," he says. "You can never tell where your work is going to end up."

ANGELA SCHOELLIG, VECTOR FACULTY MEMBER AND CANADA CIFAR AI CHAIR

How can we push the limits of machine learning? And what boundaries do we need to set to robots' autonomous decision-making to prevent them from becoming a threat? These are just some of the questions Vector Faculty Member and Canada CIFAR AI Chair Angela Schoellig is trying to answer. Schoellig's goal is to enhance the performance, safety, and autonomy of robots by enabling them to learn from past experiments and from each other. Leading research that is both theory-based and practical, she and her team have won several competitions with their self-driving cars, including the North-American SAE AutoDrive Challenge four consecutive times (2018-2021). Schoellig is an Associate Professor at the University of Toronto Institute for Aerospace Studies and a principal investigator of the NSERC Canadian Robotics Network and of the University's Robotics Institute. She holds a Canada Research Chair (Tier 2) in Machine Learning for Robotics and Control, and was awarded a Alexander von Humboldt Professorship in 2021.

SHARING LANDMARK RESEARCH THAT FOSTERS AI INNOVATION

The Vector Institute's renowned research community continues to advance breakthroughs in the science and application of AI. In dozens of timely, globally relevant, and impactful projects and work themes, these researchers are unlocking new ways to apply AI to drive better economic, health, and societal outcomes.

RESEARCH IN ACTION: HIGHLIGHTS

USING AI, ROBOTS, AND QUANTUM COMPUTING TO FIGHT CLIMATE CHANGE

In an MIT Technology Review profile, Vector Faculty Member Alán Aspuru-Guzik discussed using AI, robots, and quantum computing to create the new materials needed to fight climate change. Aspuru-Guzik's goal is to rapidly accelerate materials discovery, which is frustratingly slow, to help humans to rapidly develop an arsenal of resources for fighting climate change, like batteries and carbon-capture filters.

DEVELOPING A NEW MACHINE LEARNING MODEL

A team comprising Vector and Apple researchers developed a new machine learning model that can create 3D environments without any reference images. Vector Institute interim Research Director Graham Taylor sees this new breakthrough as having potential positive implications for modelling software for the construction industry, as well as gaming software, and real estate and design applications.

HARNESSING AI TO IMPROVE FOOD PRICE FORECASTING

In another project led by Taylor, researchers from Vector and the University of Guelph's Centre for Advancing Responsible and Ethical Artificial Intelligence (CARE-AI) deployed innovative machine learning models to improve the accuracy of Canada's annual Food Pricing Report produced by Dalhousie University and University of Guelph. The team, which included Vector Institute's Applied Machine Learning Scientist Ethan Jackson and Applied Machine Learning Intern and University of Guelph Master's student Sara El-Shawa, developed a breakthrough with an improved model that learns by forecasting numerous economic time series, based on a multi-task learning model developed at Quebec's AI institute, Mila. The team hopes the same tools can be applied to other forecasting models across sectors.

RESEARCH SYMPOSIUM 2021–22

This annual two-day event brings the Vector research community together to share its latest leading-edge work and build productive collaboration in a dynamic program of keynote presentations, poster presentations, and networking opportunities.

"Vector's research symposium is notable because it features a lot of student and postdoc work. With long timelines and the freedom to be curious, this kind of academic research can take larger risks that have the potential to pay off in big ways."

Graham Taylor, interim Research Director, Vector Institute

RESEARCH AWARDS AND ACHIEVEMENTS

Each year, members of Vector's research community are recognized for outstanding contributions to AI and machine learning fields. Highlights of 2021–22 include:

GLOBAL REACH OF VECTOR RESEARCHERS AND THEIR WORK

Vector researchers published papers, gave presentations, or led workshops at many of the top AI conferences this year, including NeurIPS, CVPR, ICLR, ICML, and ACM FAccT.

380+	Research papers presented at high-impact global conferences and in top-ranked journals
200+	Research talks
60+	Vector-hosted research events

FACULTY MEMBERS

Jimmy Ba
Google Research Machine Learning and Data Mining Award (2021)

Juan Felipe Carrasquilla Álvarez
TensorFlow Award for Mothers and Machine Learning Program (2021)

David Duvenaud
ICFP Distinguished Paper Award (2021)
ICML Outstanding Paper Honorable Mention (2021)
Sloan Research Fellowship (2022)

Amir-massoud Farahmand
Outstanding Area Chair, ICLR (2021)

Alireza Makhzani
Best Paper Award, NeurIPS Workshop on Deep Generative Models and Downstream Applications (2021)

Nicolas Papernot
Sloan Research Fellowship (2022)

Gennady Pekhimenko
International Symposium on Computer Architecture Hall of Fame (2021)

Frank Rudzicz
Best Student Paper Award, CMCL at NAACL (2021)

Leonid Sigal
Outstanding Reviewer Award, CVPR (2021)

Raquel Urtasun
Mark Everingham Prize, ICML (2021)

FACULTY AFFILIATES

Jason Anderson
Best Paper Award, IEEE Euromicro Digital System Design Conference (2021)

Timothy Barfoot
Best Student Paper Award (supervisor), IEEE International Conference on Robotics and Automation (2021)

Vaughn Betz
Best Paper Award, ACM Transactions on Reconfigurable Technology and Systems (2021)

Ben Blencowe
Canada Research Chair in RNA Biology and Genomics (2021)

Timothy Chan
Finalist, Pierskalla Best Paper Award, INFORMS Health Applications Section (2021)

Melike Erol-Kantarci
International Conference on Computer, Information and Telecommunication Systems, Distinguished Service Award (2021)

Yuhong Guo
Outstanding Reviewer Award, NeurIPS (2021)

Alec Jacobson
Best Paper Award, Sketching for Human Expressively Workshop, ICCV (2021)
Sloan Research Fellowship (2022)

Hui Jiang
Published the book Machine Learning Fundamentals (Cambridge University Press, 2021)

Gautam Kamath
Best Reviewer Award, ACM Conference on Computer and Communications Security (CCS) (2021)

Jonathan Kelly
Best Paper, 1st Runner Up Award, IEEE International Conference on Multisensor Fusion and Integration (2021)

Vianey Leos Barajas
Collaborative Research Team (CRT) Grant from Canadian Statistical Sciences Institute (CANSSI) (2021)

Tegan Maharaj
Artists + Machine Intelligence (AMI) Research Award, Google Research (2021)

Paul David McNicholas
John L. Synge Award, Royal Society of Canada (2021)

Roger G. Melko
CAP/DCMMP Brockhouse Medal, Canadian Association of Physicists (2021)

Bhavin Shastri
Early Career Achievement Award, SPIE (2022)

Florian Shkurti
Amazon Research Award, Robotics (2021), Outstanding Reviewer, CVPR (2021)

Stephen L. Smith
Best Poster Award (as PhD research advisor), ACM International Conference on Human-Agent Interaction (2021)

Xiaodan Zhu
Best Paper Award, The 34th Canadian Conference on Artificial Intelligence (2021)

TALENT & WORKFORCE DEVELOPMENT

Vector is helping to attract, develop, and connect the AI-skilled workforce that will transform Ontario's economy

Vector is working with both universities and employers to respond to the rapid rise in demand for AI talent by building pathways for high potential students to access degree programs that are fostering the AI skills most in demand by employers.

Along the way, these next-generation talent stars develop vital technical and work skills through Vector's programming and work-integrated learning experiences.

And through Vector's Digital Talent Hub, recruitment events, and career supports, they connect with top employers, driving the positive hiring outcomes that are transforming Ontario's economy.

"Thanks to Vector's skillful execution of its vision, in just a few years Ontario's pool of workforce-ready AI talent has blossomed."

Hon. Jill Dunlop, Ontario Minister of Colleges and Universities

1,775

AI master's students began their studies in recognized AI-related programs and study paths, up 27% from last year

1,007

graduates from recognized AI-master's programs at Ontario universities, exceeding the province's target to graduate 1,000 AI master's students per year by 2023 ahead of schedule

VECTOR RECOGNIZED UNIVERSITY PROGRAMS ARE BUILDING ONTARIO'S AI WORKFORCE OF THE FUTURE

26 Recognized AI master's programs at 11 Ontario universities

7 New degree programs

19 Programs with updated curricula in AI-specific minors, concentrations and courses

As part of its work to help develop a steady pipeline of AI-skilled talent, Vector awards recognition to AI master's programs and AI-focused study paths at Ontario universities that are graduating students with the skills and competencies highly sought by industry. Vector recognition delivers benefits to:

- Leading employers – who know that graduates have developed capabilities in crucial aspects related to AI application
- Students – who can access Vector's workforce-skill development and career programming
- Universities – which benefit from the input of Vector Faculty Members and industry representatives when developing new curriculum and integrating AI across disciplines, to meet the demands of a changing market.

RECOGNIZED AI MASTER'S PROGRAMS AND STUDY PATHS

University of Guelph

- Master of Science/Master of Applied Science (collaborative specialization in AI)
- Master of Data Science*

Lakehead University

- Master of Science (Computer Science – AI)

Ontario Tech University

- Master of IT Security (Artificial Intelligence Security)
- Master of Business Analytics and Artificial Intelligence*

University of Ottawa

- Master of Computer Science (Applied AI)
- Master of Applied Science (MASc) in Electrical and Computer Engineering and Master of Engineering (M.Eng) in Electrical and Computer Engineering — Applied Artificial Intelligence Concentration

Queen's University

- Master of Science (Computer Science, AI)
- Master of Applied Science (Electrical and Computer Engineering, Field of Study in AI)

Queen's University (Smith School of Business)

- Master of Management in Artificial Intelligence
- Master of Management Analytics; Global Master of Management Analytics
- Master of Financial Innovation and Technology (MFIT)*

Toronto Metropolitan University

- Master of Engineering (Electrical, Computer and Biomedical Engineering, AI)
- Master of Science in Data Science and Analytics

University of Toronto (Rotman School of Management)

- Master of Management Analytics

University of Toronto (Dalla Lana School of Public Health)

- Master of Health Informatics
- Master of Science in Health Policy, Management and Evaluation, Emphasis in Health Systems AI

University of Waterloo

- Master of Data Science and Artificial Intelligence
- Master of Mathematics in Data Science

Western University

- Master of Data Analytics (Artificial Intelligence)
- Master of Computer Science and Electrical and Computer Engineering (collaborative specialization in AI)
- Collaborative Specialization in Machine Learning for Health and Biomedical Sciences*

University of Windsor

- Master of Science in Computer Science - Artificial Intelligence [with/without Co-Operative Education]

York University

- Master of Science (Computer Science, AI)

York University Schulich School of Business

- Master of Business Analytics
- Master of Management in Artificial Intelligence

* Recognized in 2021–22

VECTOR SCHOLARSHIPS IN AI ATTRACT TOP TALENT TO ONTARIO UNIVERSITIES

109

Vector Scholarships in AI awarded

34

Programs

13

Universities

351

Scholarships awarded since the program launched in 2018

Supported with funding from the Province of Ontario, the Vector Institute Scholarship in Artificial Intelligence (VSAI) helps Ontario universities to attract the best and brightest students to study in AI-related master's programs.

Scholarship recipients connect directly with leading AI researchers, clinicians, and teams from top employers, giving them an advantage against peers in this highly competitive market. They also gain access to Vector's Digital Talent Hub and AI-specific career support programs and events.

"A large part of why I decided to return to Toronto from California was due to how strong Vector is as an institute in AI and the fact that there are so many great professors here that I can learn from. Being in this ecosystem has been a really great help for both my professional and academic journey."

Alex Cui, Vector Scholarship in AI Recipient 2021–22

"The scholarship funding from the Vector Institute has played an instrumental role in expanding graduate teaching, learning, and research opportunities in AI at Queen's University."

Dr. Fahim Quadir, Vice-Provost and Dean, School of Graduate Studies & Professor of Global Developmental Studies, Queen's University

PRACTICAL, HANDS-ON PROGRAMMING TO FOSTER WORKFORCE SKILLS AND EXPERIENCE

Throughout the year, students benefit from Vector-led programming, events, and work-integrated learning opportunities that help them develop the technical and career skills that prepare them to join Ontario's workforce.

1,740+ Students participated in career development programming

85+ One-on-one career support sessions and two webinars (offered in collaboration with Phase AI) provided Vector students with resume and portfolio feedback and mock technical interviews

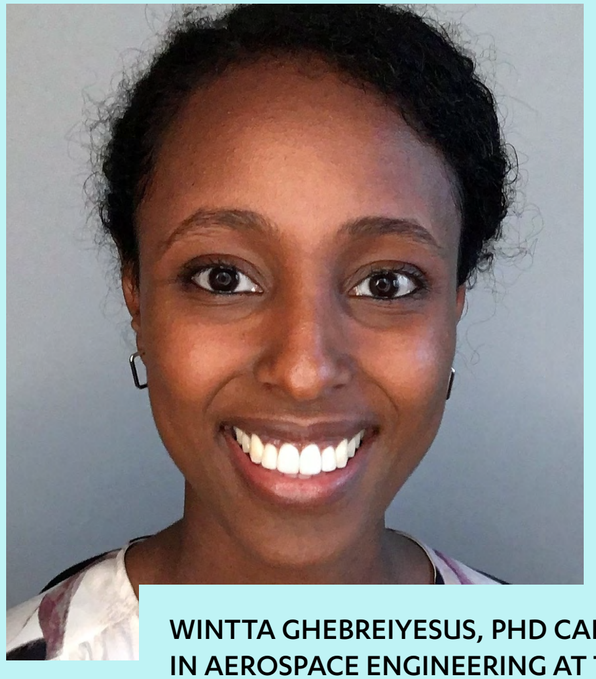
43 Applied interns in Vector's expanded internship program (up from 5 last year), working on Vector projects across its industry innovation, health, research, and AI engineering teams

SPOTLIGHT ON EXPANDING PATHWAYS

The Vector Institute is committed to developing programming for Black and Indigenous students, postdoctoral fellows, and recent graduates to build research opportunities and expand career pathways in AI for historically underrepresented groups.

In 2021–22, Vector launched a new Introduction to Machine Learning course. Open to Black and Indigenous post-secondary students from across Canada, the course introduces participants to common machine learning algorithms as well as a broad overview of model-building and optimization techniques. More than 100 students applied to the six-week course, with 19 post-secondary institutions represented in the initial cohort.

Meanwhile, new internships provide hands-on learning and work experience in machine learning and AI, expanding and accelerating opportunities to Black and Indigenous talent in Canada. Vector is working in collaboration with the Black Professionals in Tech Network (BPTN) on this programming.

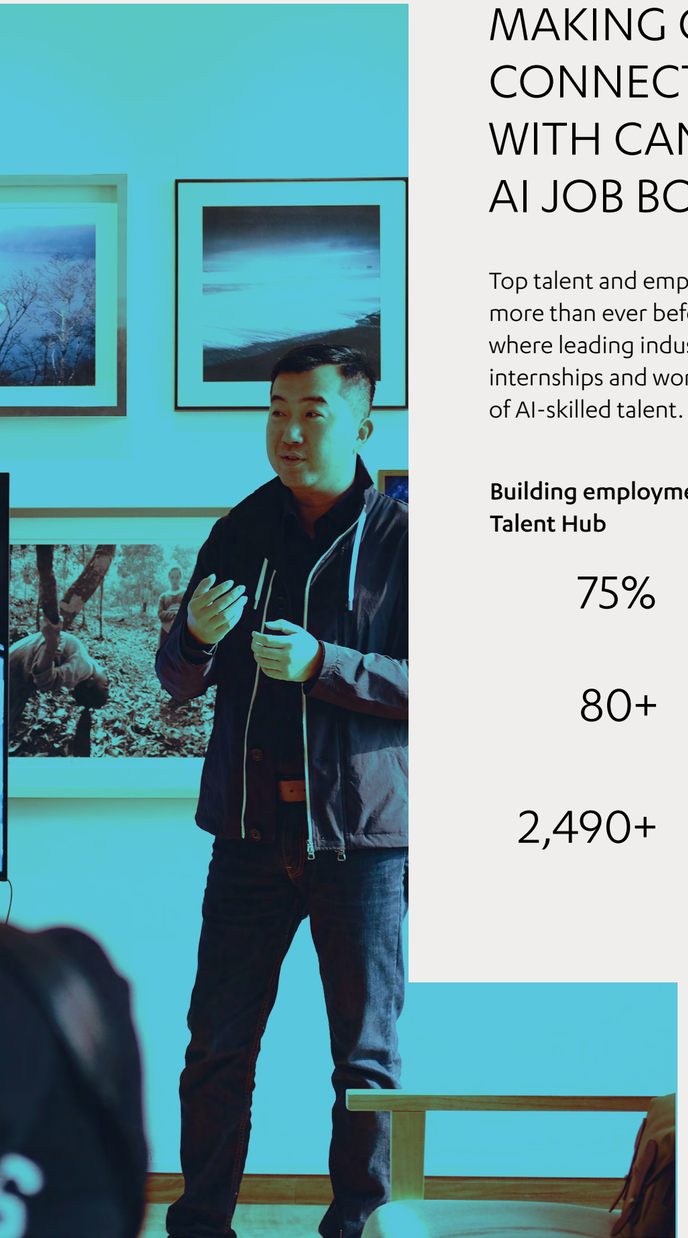


WINTTA GHEBREIYESUS, PHD CANDIDATE IN AEROSPACE ENGINEERING AT TORONTO METROPOLITAN UNIVERSITY

Wintta Ghebreiyesus was among the first cohort of students in Vector's newest Introduction to Machine Learning course, where she explored machine learning concepts and commonly-used algorithms. A PhD candidate in aerospace engineering at Toronto Metropolitan University with a research focus on avionics and control systems, Ghebreiyesus' award-winning capstone presentation explored the use of unsupervised K-means learning techniques. Following the course, she will join Vector as an applied intern in 2022, where she will work on leveraging AI in customer experience, retention, and loyalty programs for Vector's industry community.

JAMES BOVELL, BSC CANDIDATE IN MATHEMATICS AND STATISTICS AT MCMASTER UNIVERSITY

James Bovell is currently in his third year at McMaster University pursuing his BSc in Mathematics and Statistics, where he was introduced to Vector's new Introduction to Machine Learning course. During the course, Bovell learned more about Python and how it can be used to visualize data using various applications. The course, and Vector as a whole, has influenced Bovell's interest in pursuing a career in Data Science, and has led to a 2022 internship at Vector as a Data Analyst and Visualization Intern.



MAKING CAREER CONNECTIONS FASTER WITH CANADA'S LARGEST AI JOB BOARD

Top talent and employers in Ontario are connecting more than ever before on Vector's Digital Talent Hub, where leading industry sponsors advertise AI-related internships and work opportunities to a growing pool of AI-skilled talent.

Building employment momentum on Vector's Digital Talent Hub

75%	Year-over-year increase in jobs posted, with 2,240 jobs posted this year
80+	Top employers used the Digital Talent Hub to find top AI-skilled talent, up 42% from last year
2,490+	Active job seeker profiles, up 57% since last year

VECTOR CONNECTS TOP TALENT AND EMPLOYERS AT THE AI SUMMIT AND CAREER FAIR

At Vector's annual AI Summit and Career Fair, AI graduate students and alumni gather to hear from industry leaders, practitioners, and researchers in AI. Students explore career opportunities at organizations leading AI research and adoption, learn what it takes to get hired, and network with other AI students and alumni from across the province. This year's event featured keynote presentations from The Honourable Jill Dunlop, Ontario Minister of Colleges and Universities, and Vector Faculty Member Sanja Fidler, who shared advancements in 3D content generation using AI.

400	Graduate students
50+	Employers

12 MONTHS POST-GRADUATION

93%	**of graduates from Vector-recognized AI programs are employed or pursuing further education in the field**
92%	**of those employed have remained in Ontario.**

SPOTLIGHT ON MINING INNOVATOR GOLDSPOT TAPS VECTOR FOR NEW HIRES

Mining exploration leader Goldspot Discoveries is tapping a rich vein of AI-skilled talent through its Vector sponsorship. The mining innovator, which uses AI and machine learning to generate data-driven insights that improve mineral targeting, has discovered that Vector's Digital Talent Hub, career fairs, and other workforce-connection opportunities are ideal venues to attract top talent to the company. In 2021–22 alone, Goldspot made five successful hires through Vector channels, representing six per cent of its staff complement.

Goldspot data scientist Shervin Manzuri Shalmani – himself hired through a Vector career fair in 2020 – says the company has "developed an appetite for hiring through Vector," which has created a network effect. "When you hire through Vector, you hire high-calibre people who know other very high-quality people."

HEALTH

Vector is unlocking AI-enabled health innovation for Ontario

Vector helps drive improvements in health research, systems, and care by engaging with partners both in the health and academic sectors to enable effective, safe, and secure research access to Ontario's diverse health data.

Anchoring these efforts is Vector's *Smart Health* initiative, which leverages Vector's AI and machine learning research expertise to help a growing network of health partners apply AI to reduce costs, improve patient-centred care, and refine clinical outcomes. With this initiative, Vector is scaling its efforts to:

- Provide access to essential health AI expertise, dedicated scientific computing, and technical support to accelerate health projects and deliver improvements faster;
- Develop frameworks to improve access to data for AI with a focus on security, privacy, and confidentiality;
- Help Ontario hospitals adopt machine learning applications and partner on health data initiatives;
- Upskill clinicians and health sector professionals with tailored programming; and,
- Enable recruitment of AI specialists through targeted hiring support, curated events, and a dedicated AI job board, and in select cases co-hiring top AI talent that Ontario health institutions could not hire on their own.

NEW DATA SHARING AGREEMENTS ENABLE MORE HIGH-IMPACT RESEARCH

19 new academic partnerships

10 data sharing agreements fully executed with Ontario hospitals and research collaborators

Fulfilling AI's promise in improving patient care and reducing health service delivery costs begins with access to high-quality data. In 2021–22 Vector continued its ongoing work to establish and expand agreements with hospitals, clinical research institutes, and related health sector partners to enable safe and secure access to health data, creating an unparalleled resource that is fuelling new insights to improve diagnostics, patient care, and health system performance.

With a growing number of datasets of clinical and administrative health data available from Vector's new and existing partners across Ontario's health system, Vector-affiliated researchers are leading crucial AI-enabled research across a range of subject areas, from the impact of "long COVID" to cancer treatment to the use of predictive AI in clinical settings and many more.

GEMINI & VECTOR: UNLOCKING ONE OF CANADA'S LARGEST HEALTH DATASETS

33 hospitals, representing

60%+ of Ontario's hospital beds

GEMINI has grown from an initial project on general medical ward admissions anchored at Unity Health Toronto in collaboration with several University of Toronto-affiliated hospitals to over 30 hospitals across Ontario and admissions to all medical wards and the ICU. Collecting and standardizing a range of data points and data formats across health institutions, GEMINI now represents the largest set of clinically granular hospital inpatient data in the country and one of few such examples globally.

As an active partner in the project, Vector contributes technical and research expertise to enable AI and machine learning to unlock insights from GEMINI data for better health outcomes and hospital efficiency. GEMINI's stable and secure data infrastructure and virtual data access model allow Vector researchers to develop world-leading machine learning models for an array of health research, including studies related to Ontario's COVID-19 pandemic response. GEMINI's continued growth is creating new opportunities for Vector researchers to engage in even more projects to benefit patients, clinicians, and health systems across Canada.

AI DEPLOYMENTS ARE DRIVING BETTER HEALTH OUTCOMES

Thanks to Vector's support and expertise, Ontario hospitals, public health units, and broader health sector organizations are applying AI to facilitate better health outcomes and system performance. Highlights of 2021–22 include:

PATHFINDER PROJECTS

Vector enables select, highly-targeted AI-implementation projects designed to guide future AI-assisted research and technology adoption.

In spite of delays and complications associated with the COVID-19 pandemic, two additional Pathfinder projects were completed in 2021–22:

Automated tick identification to enable timely care: Vector researchers partnered with Public Health Ontario (PHO) to develop an app that uses computer vision to quickly identify blacklegged ticks (potential Lyme disease carriers), cutting the risk of identification lag and supporting more timely interventions. After a successful pilot within a PHO lab, discussions are underway to determine how to roll out the app for public use.

> **"We are delighted to be part of the Pathfinder initiative and believe that as a result we will empower individuals with additional tools to assess their risk of Lyme disease if bitten by a tick, and further enable early antibiotics to prevent disease where needed."**
>
> Dr. Vanessa Allen, Infectious Disease Consultant and Microbiologist, University Health Network/Sinai Health

Improving Cardiac Patient Care with an ML-enabled app: Members of Vector's research community have collaborated with University Health Network (UHN) to develop a machine-learning-based app that remotely monitors vital signs and symptoms of congestive heart failure patients in real-time, helping them manage their care at home, and reducing unnecessary hospital admissions. Tested by more than 300 patients, the project has completed its first phase and is now being assessed for the potential to scale to other hospitals and institutions.

> **"Vector's continued support helps us refine our health platforms and create a path towards commercialization and scaling so that more patients can benefit."**
>
> Dr. Heather Ross, Division Head of Cardiology, Sinai Health System and UHN's Peter Munk Cardiac Centre (PMCC), and Director, Ted Rogers Centre for Heart Research at PMCC.

CYCLOPS

Co-developed by Vector's Health AI Implementation and AI Engineering teams, CyclOps is a ground-breaking suite of evaluation and monitoring tools that health organizations can use to assess the scalability, resilience, and robustness of machine-learning-driven risk prediction models. CyclOps enables organizations to develop and evaluate sophisticated ML models in clinical settings across time, locations, and cohorts.

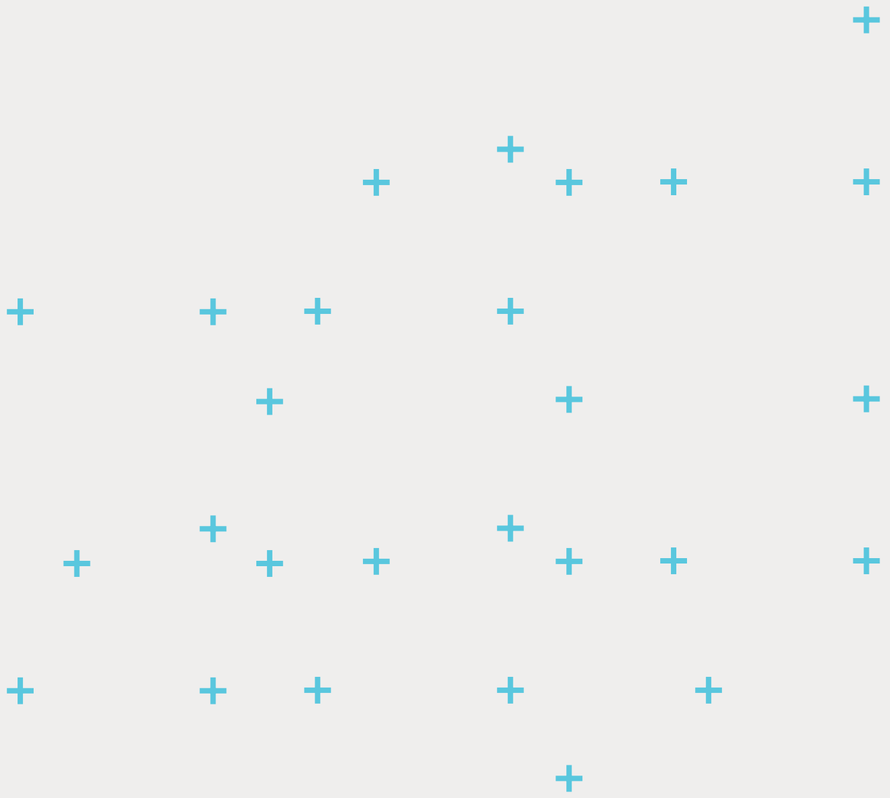
Developed with open-source components to promote collaboration and ensure ease of access for the health community, CyclOps has generated significant interest from Vector partners and the broader hospital community and is now being further developed using GEMINI data and hospital partner health data.

HELPING INDUSTRY APPLY AI FOR HEALTH

Vector representatives co-led the implementation of industry sponsor Roche Canada's My Health Data Path data literacy initiative and EndALS Kaggle challenge.

PARTNERSHIPS FOSTER AN AI-FOR-HEALTH SKILLED COMMUNITY

Vector continues to expand its network of health institutions, clinical research institutes, and health-related industry partners that access Vector upskilling programs, collaborative projects, and research.



Many of these partners responded enthusiastically to the Privacy Enhancing Technologies (PET) bootcamp (see pg. 37) in which participants collaborated on building a PET model to apply to their work with sensitive patient and clinical data. The experience has generated interest in additional hands-on projects designed to build foundational trust in - and direct experience working with - safe and secure frameworks for health data research and analyses.

Meanwhile, Vector continues to expand upskilling and education programs for health professionals on the use of AI to support their work. These programs help translate research, foster a highly skilled health workforce, and build capacity to apply AI and machine learning to deliver better patient outcomes and system improvements across Canada's health sector.

AI for Public Health (AI4PH) – Launched in March 2022 and led by Vector Faculty Affiliate and Dalla Lana School of Public Health associate professor Laura Rosella, the AI4PH initiative will equip a new generation of public health practitioners with practical skills in AI for public health. The first certificate and training program of its kind in Canada, AI4PH features skill development programs co-developed by Vector Faculty and a cross-Canada team of interdisciplinary experts in public health, computer science, epidemiology, ethics, and engineering. Through workshops, graduate studies and internship placements with government and other public health partners, AI4PH will enable future public health AI specialists to harness real-time data processing, analysis, and visualization from broad and specific data sources to gain a better understanding of what is happening in the population.

NEW CHIEF DATA OFFICER ROLE REINFORCES VECTOR'S LEADERSHIP IN DATA GOVERNANCE

Building on five years of leadership in fostering a safe, trustworthy approach to data, Vector created a new Chief Data Officer role in 2021–22. Roxana Sultan adds the title Chief Data Officer to her work as Vice President, Health, and is leading Vector's data strategy to advance modern data governance frameworks, policies, and processes to guide the safe use of data.

While the role is rooted in Vector's leading work in making health data more accessible for safe and secure research and application in Canada, it aims to apply those principles to all data. This is a particular imperative as AI is increasingly integrated across sectors, from health to finance to government and more.

"By fostering practical and enforceable frameworks to guide where and how data are stored and protected, and who has access and why, we can equip the health sector and others to develop and scale innovative technologies and to contribute data-driven insights to improve outcomes for Canadians," says Sultan.

SPOTLIGHT ON ACCELERATING AI ADOPTION IN HEALTH CARE

54 health clinician participants

16 health care leaders

37 Institutions

27 Hours

Through Vector's collaboration with The Michener Institute of Education at UHN, health care clinicians and leaders are gaining new skills and knowledge to help them apply AI to improve health systems and outcomes. Through two uniquely tailored certificate learning programs, the institutes are transforming the skills and mindsets of front-line health care professionals and leaders to build a workforce with the knowledge and capabilities to apply AI-enabled health practices in organizations and systems. Clinicians and health care leaders are able to discover how different types of machine learning algorithms work, recognize the value of clinical expertise for guiding data decisions and identifying potential biases, and discuss the ethical implications of trade-off decisions and their impact on patient care. In addition to the certificate programs, the initiative engages the health care community through research projects, symposia, and roundtables.

Following this year's AI for Clinician Champions Program cycle, some participants are already working to implement AI in their hospitals. As one participant stated: "Having the clinicians empowered with this information will help us leverage the power of AI in a responsible and ethical way to solve the 'last mile' problems we are currently facing."

Accelerating the appropriate adoption of AI in health care by building new knowledge, skills, and capacities in Canadian health care professions is funded by the Government of Canada's Future Skills Centre.

The Michener Institute of Education at UHN, Vector Institute, and IVADO partnered to host a symposium entitled AI Enabled Care: Building Collaboration for Deeper Learning and Better Care. Nearly 250 health care providers, policy makers, industry partners, and technical experts engaged in discussions of AI implementation in clinical settings, featuring health experts and AI champions from across Canada.

AI ENGINEERING

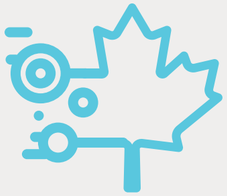
Vector is engineering new frontiers of AI application in industry, health and government

Knowledge transfer

Working directly with AI professionals to build their capacity and expertise

Hands-on guidance

Collaborating on real-world projects to accelerate successful AI deployment



Enhancing Canada's AI infrastructure

Building and maintaining Canada's essential machine learning computational infrastructure to enable innovation

Amplifying research

Enabling world-class researchers to unlock and share AI progress to benefit a global community

Enabling Responsible AI

Advancing technologies and frameworks that help ensure privacy, fairness, and accountability in AI application

Vector's AI Engineering team enables researchers and partners in industry, health, and government to accelerate AI deployments that have the potential to unlock transformative benefits.

Vector's growing team of applied machine learning experts is providing guidance, expertise, and tailored software tools to support Vector's partners in collaborative projects through their robust technological and deep learning expertise and extensive compute capacity.

A continued emphasis on enhancing Vector's AI infrastructure and software engineering expertise to support world-leading research is enabling Vector-affiliated researchers to conduct and advance their experiments, pushing the frontiers of AI innovation.

The team works with these researchers to demonstrate and publish their ground-breaking work through open-source platforms so that more people can benefit from these advances, delivering on Vector's commitment to amplify AI's positive impact for all.

This work is anchored in a comprehensive approach to integrating responsible AI throughout the organization. Focused on developing and promoting state-of-the-art techniques, technologies, and frameworks that are rooted in deep learning, the team advances both engineering and advocacy to improve governance, privacy, fairness, explainability, security, and anti-bias, while also helping to inform public policy for AI.

CREATING IMPACT THROUGH APPLICATION

330% Growth in full-time AI Engineering resources dedicated to enabling partners and innovation

5,000+ Hours of engagement with industry sponsors, health partners, and other participants

1,000+ GPUs available

ACCELERATING KNOWLEDGE TRANSFER AND AI DEPLOYMENT

Through Vector's bootcamps, signature hands-on engagements, and frequent live demonstrations, the AI Engineering team worked directly with researchers, industry sponsors, and health partners to provide expertise and upskilling in the software, technology, and tools that enable successful AI application.

Highlights of 2021–22 include:

- New bootcamps on Privacy Enhancing Technologies (see spotlight, next page) and Time Series Forecasting and express projects such as Long Haul COVID and SAFE Reinforcement learning
- More than 10 demonstrations on topics including robotic process automation, active learning, and anomaly detection
- Deeper AI Engineering engagement on collaborative projects with industry sponsors and health partners to solve practical challenges of AI deployment
- Continued dialogues to advance understanding of responsible AI, including a virtual fireside discussion between senior Vector and industry experts attended by 120 leaders and practitioners across a variety of sectors

SCALING FACE-TO-FACE MEETINGS TO CREATE IMPACT

Adding new full-time resources and highly skilled applied AI interns to the team has enabled more of Vector's industry, health, and government partners to access deep expertise and direct guidance in solving AI deployment engineering challenges.

Industry sponsors also benefited from greater AI Engineering participation in Vector's Face-to-Face meetings, where members of the Industry Innovation, AI Engineering, and Research teams provide direct, case-specific support to address the real-world AI challenges of these organizations.

ADVANCING LEADING AI RESEARCH BY HARNESSING VECTOR'S ENGINEERING RESOURCES

This year, the AI Engineering team worked directly with researchers and their labs, exploring their specific topics and collaborating with them to build and engineer software solutions and tools to address the technological barriers limiting their work.

Following a successful pilot project in 2020–21, more researchers than ever — including Vector Faculty Affiliates, Postdoctoral Fellows, and graduate researchers working with Faculty Affiliates — are now able to access Vector's expanded high performance scientific computing resources, which support further research progress across the community. This access was sustained seamlessly and securely amidst the COVID-19-related shift to remote work.

AMPLIFYING RESEARCH OUTCOMES TO FOSTER REAL-WORLD IMPACT

In addition to helping to engineer the MBRL solution that TELUS applied to their data centre cooling project (see p. 14), Vector's AI Engineering experts worked closely with TELUS on making the models available to a wider audience by publishing the work on an open-source platform.

Similarly, the team also collaborated with researchers to share Vector-led research in Parameter Reduction for unseen deep architecture work through open-source.

FOSTERING NEW WAYS TO DEPLOY AI TO ADDRESS CLIMATE CHANGE

In addition to fostering responsible and trustworthy AI through tools, dialogue, and knowledge transfer, Vector is finding new ways to help industry and government apply AI to address global challenges such as climate change. In 2021–22, the AI Engineering team built innovative implementations that deploy AI to forecast wildfires and to improve the energy efficiency of HVAC systems.

Vector has started tracking its computer-related emissions, collaborating with Forests Ontario to help sequester unavoidable emissions through tree planting initiatives. In 2021-22, Vector supported Forests Ontario's 50 Million Tree Program, which specializes in large-scale afforestation projects across the province, as well as its Reconciliation Community Tree Plant events, a planting program in partnership with First Nations communities and organizations.

SPOTLIGHT ON EQUIPPING AI PROFESSIONALS TO WORK SAFELY WITH SENSITIVE DATA

55 participants

20 organizations across health, industry sectors and government

1,440+ hours of engagement

Technical professionals from both the private and public sectors gained new, immediately applicable skills in Privacy Enhancing Technologies (PETs) through a new Vector bootcamp in 2021–22.

Guided by experts from Vector's AI Engineering, Industry, Research, and Health teams, participants developed a new understanding of PETs, crucial elements in ensuring privacy and confidentiality of sensitive data while harnessing the power of machine and deep learning. These technologies and tools comprise a vital skill set for those who work regularly with financial, health-related, industrial, or government data.

Over the three-day program, participants explored different technologies and models, learning new concepts in differential privacy, homomorphic encryption, and multi-party computation. Often working with use cases that reflect their day-to-day challenges, they built a basic, working PET prototype, and gained new hands-on experience in applying PETs to their work with sensitive data.

"Across dozens of projects, the AI Engineering team collaborates with our industry, research, and health colleagues at Vector to support AI adoption and application," says Deval Pandya, Vector's Director of AI Engineering. "Together with participants and our Vector peers, we identify the problem, research the challenge, and understand the current state. Then we build a referencing model and engineering toolkit together. Often we can share it via open source to enable others to benefit from this work."

THOUGHT LEADERSHIP

Vector is building its influential voice on AI's societal and economic impacts

The Vector Institute continues to build its authoritative voice on AI by contributing to local, national, and global conversations regarding research, responsible AI, workforce development, economic competitiveness, and other important topics at the intersection of AI and society. Vector also actively contributes expertise and insights on policy issues related to AI adoption to support the best interests of Ontarians and Canadians.

2021–22 HIGHLIGHTS

AMPLIFYING IDEAS

- Vector's senior leadership published a range of Op-Eds and articles on health, scientific computing infrastructure, trustworthy AI, and AI-related policy. These appeared in *The Globe and Mail, The Toronto Star* and other leading publications.
- Vector and its CIFAR Canada AI Chair community were mentioned more than 2,700 times in media articles in 2021–22; executives and Faculty Members were interviewed by dozens of media outlets, including BNN Bloomberg, *The Globe and Mail, The Toronto Star, The Hill Times, The Logic, BetaKit, Canadian Small Business Magazine*, GlobaliveMedia's The AI Edge series, and more.

ELEVATING DIALOGUE

Vector continues to foster dialogue and discussion of AI and its potential for societal and economic impact. Highlights of 2021–22 include

- Hosting a discussion about responsible AI between senior leadership from Vector and industry sponsor PwC
- Hosting a discussion of emerging issues in applied AI, featuring author and *New York Times* technology columnist Cade Metz and Vector's interim Research Director Graham Taylor, attended by more than 400 people
- Publishing more than 40 articles examining new ideas, emerging developments, and innovative applications of AI across industry, health, and government, on Vector's own blog site, including the launch of a multi-part series on trustworthy AI

CONTRIBUTING EXPERTISE

Vector also frequently participates in national and international consultations and presentations, contributing expertise and providing recommendations on topics related to AI and its role in economic development and health policy, responsible AI data governance, and many others. Highlights of 2021–22 include:

- Vector's ongoing participation in the Global Partnership on AI (housed at the OECD) on priorities including data governance, commercialization, the future of work, responsible AI, and COVID-19
- Responding to Ontario's Trustworthy AI Framework Consultation and guiding implementation with practical actionable insights
- Responding to Ontario's public consultation on modernizing privacy in Ontario and hosting a public event, Building a Digital Ontario, at which Vector's President and CEO discussed Ontario's new Data & Digital Strategy in a one-on-one conversation with Ontario's Minister of Finance and Minister responsible for digital and data transformation, the Hon. Peter Bethlenfalvy
- Sharing AI expertise with the Ontario Ministry of Health to derive insights from Ministry data and on data governance considerations
- Ongoing participation in Canada's Advisory Council on Artificial Intelligence

Vector representatives also participated in nearly 50 external conferences, panels, and events in 2021–22, including:

- AIxIA 2021, where Vector's Chief Commercialization Officer and VP, Industry Innovation Cameron Schuler was a keynote presenter
- Canadian Internet Governance Forum
- CAIMIN, the Canadian Nuclear Society's conference on AI
- Collision 2021
- IEEE

"The Vector Institute and the Schwartz Reisman Institute continue to raise the bar and test the limits of AI and deep learning. This work is invaluable to the people of Ontario and, coupled with your feedback, continues to be a great asset as we create a government framework for AI that is accountable, safe and rights-based."

Hon. Peter Bethlenfalvy, Ontario's Minister of Finance and Minister responsible for digital and data transformation

TEAM & LEADERSHIP

Vector 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 AT MARCH 31, 2022 ARE:

Ed Clark, Chair

Janet Bannister

Charmaine Dean

Janet L. Ecker

Chaviva Hosek

Nadir Mohamed

Michael Serbinis

Terrence Sullivan

Melanie Woodin

LEADERSHIP

AT MARCH 31, 2022

Garth Gibson
President & Chief Executive Officer

Ron Bodkin
Vice President, AI Engineering & Chief Information Officer

Gary Burlakoff
Director, Finance

Melissa Judd
Vice President, Research Operations & Academic Partnerships

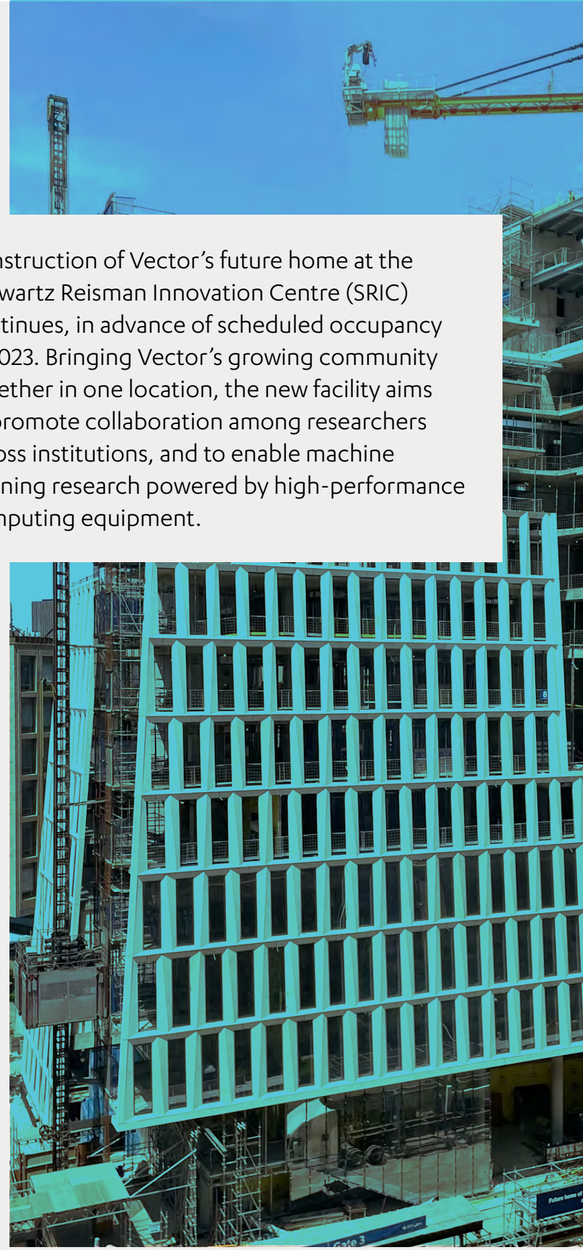
Cameron Schuler
Chief Commercialization Officer & Vice President, Industry Innovation

Roxana Sultan
Chief Data Officer & Vice President, Health

Graham Taylor
Interim Research Director *

Alan Veerman
Chief Operations Officer

Richard Zemel
Research Director**



Construction of Vector's future home at the Schwartz Reisman Innovation Centre (SRIC) continues, in advance of scheduled occupancy in 2023. Bringing Vector's growing community together in one location, the new facility aims to promote collaboration among researchers across institutions, and to enable machine learning research powered by high-performance computing equipment.

* Effective August 2021
** April 2021 - June 2021

FINANCIALS

Vector is funded through multi-year commitments from different funding sources, including:

- Funding through the Government of Ontario's Ministry of Economic Development, Job Creation and Trade (MEDJCT) to establish the institute, deliver core programming, and support the development of the AI ecosystem, including workforce development, scholarships, and support to develop AI master's programs.
- Funding from the Government of Ontario's Ministry of Colleges and Universities for Vector's *Smart Health* initiative.
- Federal funding from the Government of Canada through the Pan-Canadian AI Strategy (PCAIS) – Talent and Research, administered by CIFAR, to support research and education, including the Canada CIFAR AI Chairs Program.
- Funding from the Government of Canada through the PCAIS – Commercialization, administered by Innovation, Science and Economic Development Canada (ISED), to support Vector's AI commercialization programming and activities, including the FastLane program.
- Industry sponsorships at various levels and commitments that support Industry Innovation programs and related initiatives.

To date, Vector had operated with a financial support model in which government funding was front-end loaded. This means that cash reserves are used in subsequent fiscal years to support normal business expenses in compliance with Transfer Payment Agreements and the objectives described in Vector's *Three-Year Strategy*.

Federal funding for the Pan-Canadian AI Strategy – Talent and Research was renewed in the federal Budget 2021, and funding support associated with that renewal is expected to begin in 2022–23. The federal Budget 2021 also announced support for each of the national AI institutes to accelerate the translation of AI research into commercial or other innovations, and this funding started at the end of 2021–22.

The Vector Institute's audited financial statements for the 2021–22 fiscal year are available on our website.

STATEMENT OF FINANCIAL POSITION

March 31	**2022**	2021
ASSETS		
Current		
Cash	**$50,635,501**	$52,926,452
Accounts receivable	**5,458,619**	6,512,151
Current portion of employee loans	**289,375**	313,377
HST receivable	**109,394**	-
Prepaid expenses	**2,897,941**	558,440
	$59,390,830	$60,310,420
Employee loans	**970,975**	1,267,429
Capital assets	**2,863,902**	5,512,552
	$63,225,707	$67,090,401
LIABILITIES AND NET ASSETS		
Current		
Accounts payable and accrued liabilities	**$3,623,949**	$3,623,393
HST payable	**-**	81,101
	3,623,949	3,704,494
Deferred rent	**209,429**	593,086
Deferred contributions	**5,069,837**	15,752,017
Deferred capital contributions	**2,692,021**	4,996,907
	$11,595,236	$25,046,504
Net Assets		
Unrestricted net assets	**51,630,471**	42,043,897
	$63,225,707	$67,090,401

FINANCIALS

The Vector Institute's audited financial statements for the 2021–22 fiscal year are available on our website.

PAN-CANADIAN ARTIFICIAL INTELLIGENCE STRATEGY RENEWED IN 2021

In the federal Budget 2021, the Government of Canada demonstrated its confidence in Canada's national AI institutes — Vector, Amii, and Mila — with the renewal of the CIFAR Pan-Canadian Artificial Intelligence Strategy and a commitment of $443.8 million in multi-year funding.

Highlights include specific commitments to help retain and attract top academic talent across Canada, provide dedicated computing capacity for researchers, and support the commercialization of AI innovations and research in Canada.

STATEMENT OF OPERATIONS

For the year ended March 31	**2022**	2021
REVENUE		
Government grants		
Province of Ontario	**$11,289,494**	$10,295,672
Government of Canada		
PCAIS - Talent and Research	**7,189,694**	6,837,982
PCAIS - Commercialization	**2,170,588**	-
Industry partners	**9,650,000**	11,136,667
Amortization of deferred capital contributions	**2,517,839**	4,270,645
Investment income	**384,156**	425,068
Fees for service	**400,577**	142,871
Disposal of capital assets	**-**	642,315
	$33,602,348	**$33,751,220**
EXPENSES		
Research and education	**8,442,600**	7,517,472
Industry skills training	**61,735**	88,545
Technology adoption	**4,746,437**	3,468,506
Business acceleration	**2,357,297**	1,400,983
General and administration	**3,463,680**	2,822,737
RAISE AI	**2,096,966**	2,163,193
Employee loans accretion expense (recovery)	**(14,543)**	30,073
Amortization	**2,861,602**	3,316,848
	$24,015,774	$20,808,357
Excess of revenue over expenses for the year	**$9,586,574**	$12,942,863