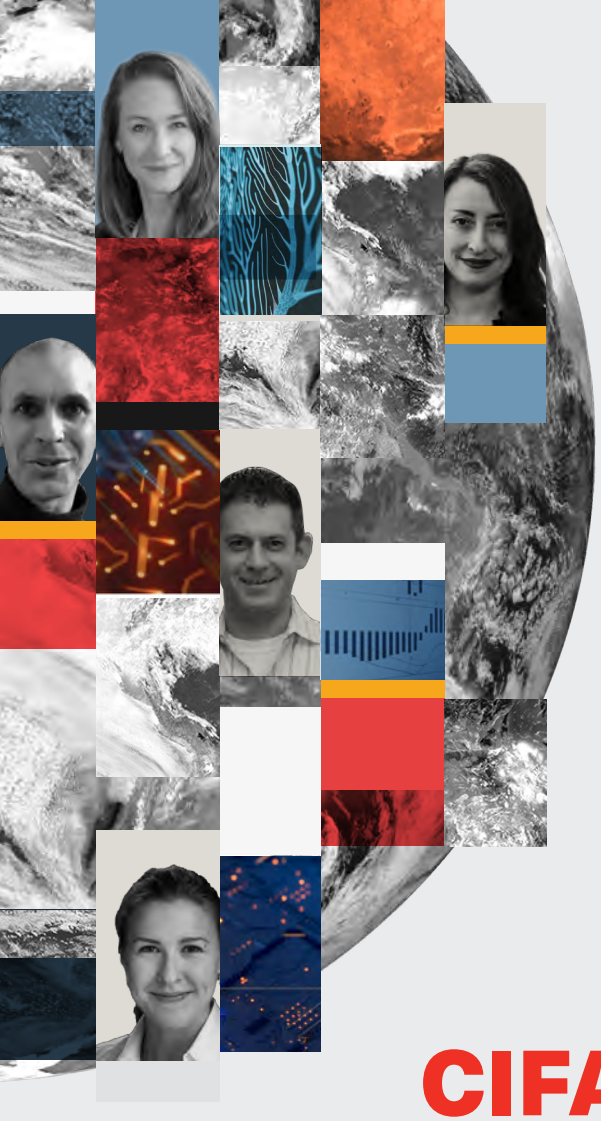
REACH

IDEAS TO CHANGE THE WORLD · WINTER 2022

THE NEXT GENERATION ISSUE

5 RISING STARS | EXPLORING THE GREAT UNKNOWN | THE POWER OF MENTORSHIP | A GIFT FOR THE FUTURE

CIFAR



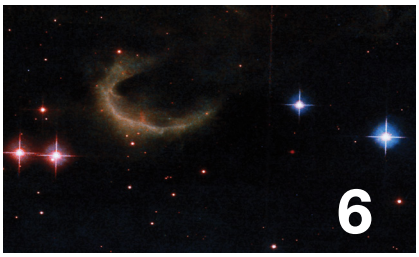
CIFAR VIRTUAL TALKS

Bold questions and brilliant minds converge at CIFAR's Virtual Talks — from the latest advances in solar energy, to the most cutting-edge developments in child and brain development.

Free, and open to the public, join us as we bring high-impact research from CIFAR fellows, chairs, scholars, and advisors to the forefront.

Explore our 2022 lineup and register today: cifar.ca/public-events

CONTENTS



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ABOUT CIFAR

CIFAR is a global research organization that convenes extraordinary minds to address the most important questions facing science and humanity.

We are supported by the governments of Canada, Alberta and Quebec, as well as foundations, individuals, corporations and Canadian and international partner organizations.

PRESIDENT'S MESSAGE

THE FUTURE LOOKS BRIGHT IN THE HANDS OF THE NEXT GENERATION OF SCIENTISTS

The world's very best researchers share one common goal: they have a passion for advancing our knowledge of the world in which we live, and in doing so, make the world a better place.

In my decades of experience as a scientist, science leader, mentor of young people, and leader of great science-based organizations — including my almost 10 years as President & CEO at CIFAR — exceptionally talented early-career scientists shine like a bright light in the night sky.

That is why we invest in programs and initiatives at CIFAR like the CIFAR Azrieli Global Scholars program to nurture that talent and encourage the world's most talented young scientists to realize their full potential.

This issue of *REACH* is a celebration of the next generation of researchers, the bold questions they look to answer, and their pursuit of excellence. You will read about some of the remarkable research being conducted by our rising stars at institutions around the world.

The next generation of researchers also needs our collective effort in breaking down barriers to success. That effort begins by acknowledging that there are systemic barriers to success that are not based on talent but on bias and unequal access to opportunity. It is within this context that we have formalized CIFAR's commitment to improving equity, diversity and inclusion. I encourage you to read the thoughtful essay by Ekua Quansah, CIFAR's new Head of Equity, Diversity & Inclusion.

We all benefit from mentorship. This is especially true for people pushing the boundaries of what's possible. Failure always looms large. That is why early-career researchers especially thrive with the support of organizations like CIFAR that provide meaningful connections and mentorship opportunities. In my own role as a mentor, I have felt immense pride in witnessing the contributions and achievements of the former trainees in my lab and the many other young people I have mentored over the years.

Since our last issue of *REACH* in 2019, our world has changed in profound ways. Leading CIFAR throughout the pandemic and being a virologist and member of Canada's COVID-19 Vaccine Task Force has given me a perspective on the central importance of fundamental science, global scientific collaboration, and the intimate, necessary relationship between science and politics, to address global challenges such as a global pandemic.

I have also been so impressed with how many of CIFAR's close to 400 fellows and advisors from more than 20 countries pivoted to contribute to the global scientific effort to save lives and end this pandemic as quickly as possible.

As we enter 2022, CIFAR marks its 40th year. After two long years of a global pandemic, we all need something to celebrate. What could be more appropriate than to celebrate a 40-year commitment to excellence, to humanity's innate curiosity about the world and Universe in which we live, and to science.

Our celebration of CIFAR's past appropriately begins with a look into the future: the next generation of researchers. I hope you enjoy this issue of *REACH* and I wish everyone a safe and healthy 2022.

DR. ALAN BERNSTEIN
OC, OOnt, PhD, FRSC/MSRC, FCAHS
President & CEO, CIFAR

CIFAR IN THE NEWS

Whether it's on the effects of social media on teens' mental health, or on the discovery of a radio burst in the Milky Way, CIFAR researchers and leadership are often called upon for expert commentary by top news outlets from across the globe. Read more at **cifar.ca/news**.

INFORMATION & MATTER

"People who learn quantum electrodynamics don't often sit in advanced organic chemistry classes and vice versa — there's a gap to be bridged. But of course that's also where a lot of exciting discoveries come from."

Prineha Narang, CIFAR Azrieli Global Scholar, Bio-inspired Solar Energy, in "Hybrid light–matter particles offer tantalising new way to control chemistry." *Chemistry World*, September 2020.

PAN-CANADIAN AI STRATEGY

"With laser focus on our priorities of health, the environment, EDI, and commercialization, our AI ecosystem can help propel us out of the social and economic challenges of the COVID-19 pandemic and position Canada as a leader in addressing the global challenges of the future."

Elissa Strome, Executive Director, CIFAR Pan-Canadian Artificial Intelligence Strategy, in "How AI can help Canada's post-pandemic recovery." *The Hill Times*, May 2021.

PANDEMIC RESPONSE: DR. ALAN BERNSTEIN

"When this pandemic is over, we need to renew our focus on the problems that faced our planet before COVID-19. If we can eradicate COVID-19 through science and global collaboration, just imagine what else we can do."

Dr. Alan Bernstein, President & CEO, CIFAR, in "I'm optimistic that we will have a COVID-19 vaccine soon." *The Atlantic*, August 2020.

Photos: John Narvalli and iStock (left page); courtesy of the researcher, Taylor Brandon (child with mother), and Ian Chen (Milky Way Galaxy) (right page)

LIFE & HEALTH

"Suddenly, hand sanitizer goes through the roof, we all wear masks and we don't touch anyone or anything. And from what we know, generally, that's probably not good from just an ordinary microbial exposure point of view."

Brett Finlay, Program Co-Director, Humans & the Microbiome, in "Why frequent use of hand sanitizer could make us sick down the road." *Globe and Mail*, April 2021.

EARTH & SPACE

"Here is something that gets close to the insane intensity of cosmic Fast Radio Bursts (FRBs), but that is happening not so far away. It's a fantastic opportunity to learn about at least one of the sources that could be causing FRBs."

Sarah Burke Spolaor, CIFAR Azrieli Global Scholar, Gravity & the Extreme Universe, in "Astronomers spot first fast radio burst in the Milky Way." *Nature*, June 2020.

INDIVIDUALS & SOCIETY

"These early life experiences literally get under the skin. That's why we think the secondary effects of the COVID-19 pandemic are going to be profound."

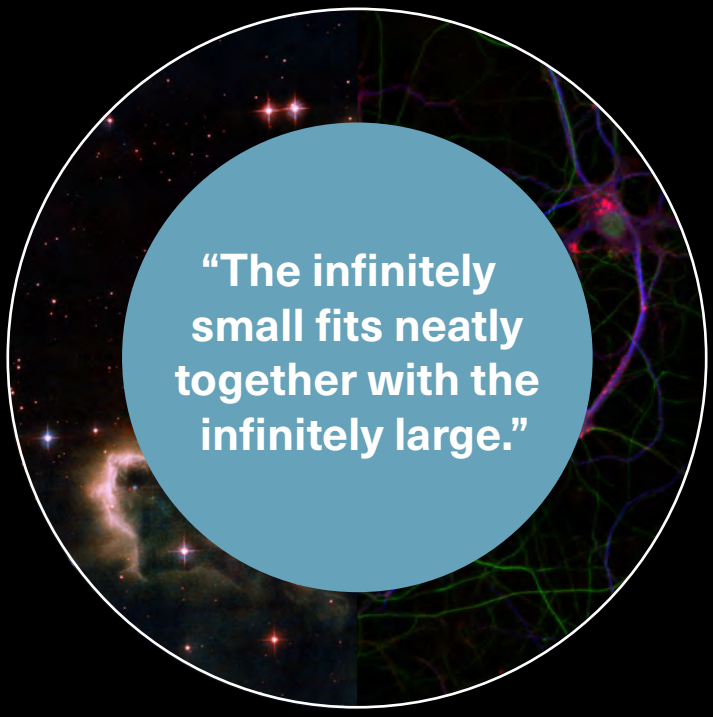
Michael Kobor, Fellow, Child & Brain Development, in "The kids aren't all right." *Axios*, May 2020.

EXPLORING THE GREAT UNKNOWN

KRISTA DAVIDSON

Photos: NASA (left background, right circle) and courtesy of Flavie Lavoie Cardinal (right background, left circle)

CIFAR researchers are using knowledge of astronomy to map the path of neurodegeneration in the human brain.



“The infinitely small fits neatly together with the infinitely large.”

The brain’s complexity is as deep and enigmatic as the cosmos, which has led a team of scientists at CIFAR to apply artificial intelligence (AI) techniques typically used to detect stars to identify neurodegeneration in the brain.

The idea for the project grew from a CIFAR meeting that brought together interdisciplinary researchers to examine the use of powerful algorithms in space and health applications. The approaches astronomers take to map stars in the sky could help neuroscientists pinpoint the macroscopic manifestations of neurodegenerative diseases such as Parkinson’s and ALS well before patients experience symptoms. Even more, it holds great promise for unlocking the mysteries surrounding both human and machine intelligence.

“In preparation for a meeting at CIFAR, I found myself studying images of the Universe and I realized they looked very similar to my microscopy images of the brain. The challenges were very similar for both, in terms of trying to identify objects that are difficult to find,” says Flavie Lavoie-Cardinal, an assistant professor at Université Laval and Canada Research Chair in Intelligent Nanoscopy of Cellular Plasticity.

“I thought perhaps the key to understanding one lies in understanding the other — the infinitely small seems to fit neatly with the infinitely large,” she says.

It was a moment of illumination that led to the formation of a team including Lavoie-Cardinal, CIFAR Azrieli Global Scholar Renée Hložek and two Canada CIFAR AI Chairs from Mila, Audrey Durand and Christian Gagné. The team successfully applied for a CIFAR Catalyst Fund, which provides funding for high-risk, high-reward projects at the earliest stages of research.

The goal of the project is to detect neurodegeneration so that health-care practitioners can apply preventative medicine versus curative medicine, but Lavoie-Cardinal, Hložek, Gagné and Durand all agree that the research has the potential to advance their fields of research.

“The Catalyst Funds from CIFAR were perfect for this type of collaboration because it gave us the rapid start required to prove to ourselves that we could do this,” says Hložek, an assistant professor in Astrophysics at the Dunlap Institute in the department of Astronomy and Astrophysics at the University of Toronto. Hložek is also a CIFAR Azrieli Global Scholar.

Lavoie-Cardinal’s team is collecting image samples of primary neuronal cultures from the hippocampus and the cerebral cortex of newborn mice. The team then prepares a transfection on the sample, a process of artificially introducing a DNA protein into the neurons from models of Parkinson’s or ALS. This process also allows the team to tag proteins of interest in neurons with molecules that emit light and can be detected using fluorescence microscopy. Super-resolution microscopic images capture synaptic structure with a resolution that is 10 times better than

standard optical microscopy, allowing scientists to observe otherwise non-visible patterns and identify potential anomalies.

The images bear many similarities to the type of data found in radio observational imaging. In astronomy, scientists extract signals from large volumes of data. The data is captured from different telescopes, resulting in varying configurations of the sky.

"When you're looking into a telescope you see only a projection of the brightest bursts of light in the sky. In this way, astronomy is similar to microscopy because you're presented with a nanoscale of one tiny cell at a time," says Hložek.

AI systems are highly successful in identifying patterns, but anomalies in the brain follow no discernible pattern, colour or shape. In addition, microscopes introduce noise to the data, which can make it challenging to distinguish a brain anomaly from an instrumental error — what is referred to as "noisy" data. Manual detection is impossible due to the number of images of the brain that one must capture to form the larger picture of the brain's synaptic structure and function.

"This project could transform the way machines learn."

The challenges are similar in astronomy in that telescopes also introduce noisy data in their images, but astronomers have been able to use machine learning to train systems on the parameters needed to weed out irrelevant data found in the sky.

"Machine learning is useful in this project because you can automate processes to find variations in the data. It can identify patterns and new structures for knowledge discovery," says Christian Gagné. Gagné is a full professor in the department of electrical and computer engineering at Université Laval and director of Institute Intelligence and Data.

The machine learning approaches that astronomers use to detect transient images in the Universe could be the breakthrough needed for neuroscience, but it can also advance our knowledge of machine intelligence. While machine learning has mastered tasks related to identifying patterns, it struggles, much like humans, with the unknown.

Durand and Gagné are employing both traditional and nontraditional approaches, including convolutional neural networks, a deep learning network that is useful for identifying patterns and eliminating irrelevant data; and generative adversarial networks (GANs), a framework in which two algorithms play against each other with the goal of "winning" while gathering important insights about their task, improving their performance without explicit guidance.

"This project could transform the way machines learn," says Durand, an assistant professor in computer science and software engineering at Université Laval. "The more we look at how objects behave across different images, rather than looking only at one fixed image, provides a lot of insight and information. It's common in both neuroscience and astrophysics, but less common for machine learning researchers who are working in computer vision, where many tasks rely on a single image.

"If we can get algorithms to extract concepts without much knowledge of their environment, it will bring artificial intelligence much closer to human intelligence," says Durand.

"There is so much we can do just in fundamental neuroscience to understand how the brain works by looking at anomalies. This project has the potential to not only advance our understanding of neurodegenerative disease in general, but to address molecular mechanisms in the brain," says Lavoie-Cardinal.

For Hložek, it represents an opportunity to perfect the algorithms used for detecting fast bursts in the sky and reduce the false detection rate.

"What we've learned so far is that while we're helping advance biological methods, they're actually informing our decisions around imaging in astronomy, which I didn't expect," says Hložek.

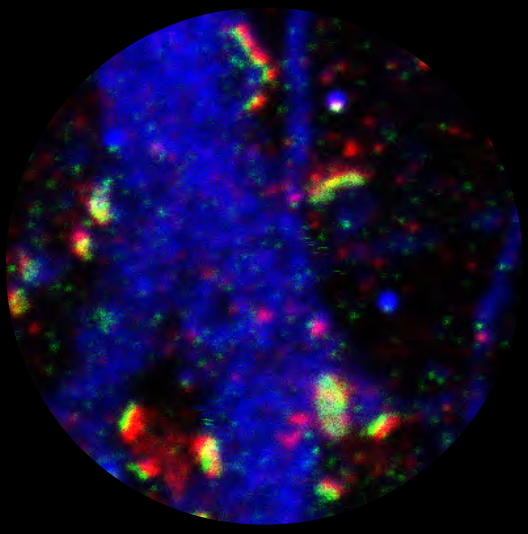


Image shows dopaminergic neurons (blue) — the most affected in Parkinson's disease — as well as postsynaptic protein PSD95 (green) and ipresynaptic protein, Bassoon (red).

Photos: NASA and courtesy of Flavie Lavoie-Cardinal (left); courtesy of the researchers (right)

EQUITY, DIVERSITY & INCLUSION DOES NOT COME AT THE EXPENSE OF RESEARCH EXCELLENCE

EKUA QUANSAH
Head of Equity, Diversity & Inclusion at CIFAR

Illustrations: **CORNELIA LI**

The murder of George Floyd and countless acts of anti-Black racism.

The rise in xenophobia and anti-Asian racism amid COVID-19.

The uncovering of mass graves of Indigenous children in Canada.

These horrific acts only add to a long, unending history of racial violence. However, over the last few years they have, finally, led us to have a meaningful and painful discourse on oppression within our society and corresponding privilege, enabling a collective shift in our understanding of equity, diversity, and inclusion (EDI). Many of us are reflecting within ourselves — perhaps for the first time — about our biases, and how they inform our actions or how we treat others.

They have also spurred workplaces and organizations to renew their commitments to improving EDI, to enabling meaningful change, and to having — sometimes uncomfortable but urgently needed — discussions on the barriers that lead to underrepresentation and discrimination.

At CIFAR, we still have a lot of work to do. But it starts with a plan, a common understanding of what EDI means, and how the organization will hold itself accountable.

In Spring 2020, CIFAR's Board of Directors approved the *Action Plan on Equity, Diversity & Inclusio*n. CIFAR defines EDI as follows:

Equity means recognizing that there are systemic reasons for discrimination and marginalization and taking action to remove these barriers, with an understanding that fairness is required for equal outcomes. Diversity refers to the various dimensions of difference expressed amongst individuals and groups. Dimensions of diversity include, but are not limited to: race and ethnicity, gender, sexual orientation, disability, class, place of origin, immigration status, Indigenous identity, and more. Inclusion can be understood as a set of practices or policies that are deliberate in their efforts to ensure all individuals or groups can meaningfully participate.

The *Action Plan* provides a clear and comprehensive approach for improving EDI in all areas of the organization: from leadership and governance, to HR and talent, to our research community and programs. Each initiative is included in CIFAR's annual Operating Plan with a corresponding dedication of resources, and the expectation that several initiatives will be phased in over the next few years.

As the Head of EDI, I work with my colleagues to ensure that CIFAR remains committed to this work. I believe that it is paramount that CIFAR, a leading global research organization, is also a leading voice on EDI in the research community, moving beyond performative actions to creating systemic change.

Recently, CIFAR began data collection to set goals, identifying trends and areas for improvement, including asking program applicants to fill out a demographic census. These steps will help us to understand who is applying for our programs, how

Without EDI, we cannot achieve excellence — having researchers from different backgrounds and perspectives is what leads to bold questions and solutions.

to focus our outreach and if there are barriers we need to address in the selection process. We plan to expand this to our existing research programs, staff and our Board, with the addition of inclusion questions to assess work and research culture.

We are also starting to infuse EDI into our selection process in other ways, asking questions about how EDI will be incorporated into proposed research programs, as well as asking about applicants' knowledge and experience as it relates to EDI.

Throughout 2022, CIFAR will continue to re-examine our policies, procedures and practices. We will look at Board diversity and inclusion, workplace culture, research programs, and events. We will look at opportunities for members of the CIFAR community to actively learn and participate in conversations about EDI in the research community.

Speaking outside the walls of CIFAR and to the global research community as a whole, I cannot stress enough: **EDI does not come at the expense of research excellence.**

Without EDI, we cannot achieve excellence — having researchers from different backgrounds and perspectives is what leads to bold questions and solutions. In fact, numerous studies have shown that diverse teams are more innovative, engaged, and productive than homogenous teams.

That is why we must address the very real barriers faced by equity-deserving communities in research — especially if we want to foster, for years to come, a diverse and thriving CIFAR community of the next generation of researchers.

To do so, we must acknowledge that systemic biases exist in all aspects of our society, whether it's the justice system, or health care, or education, or within research. We must acknowledge that systemic biases and barriers lead to a drop in the number of researchers from equity-deserving communities as they move past the early-career stage. We must check our individual biases. We must support researchers early in their careers, to help them build the networks, mentors and sponsors to advance their academic journey. This support is important for all early-career academics, but particularly important for researchers from equity-deserving communities.

As an organization, we are at the beginning of our EDI journey, but my colleagues and I at CIFAR are committed to moving us forward.

Read CIFAR's EDI *Action Plan*:
cifar.ca/equity-diversity-and-inclusion

5 RISING STARS

KRISTA DAVIDSON AND LIZ DO

From understanding how algorithms see the world, to studying ancient Earth and planets for the origins of life — meet five early-career researchers who exemplify science curiosity and innovation.

The AI Pathfinder

COURTNEY PAQUETTE

Canada CIFAR AI Chair
Pan-Canadian AI Strategy
McGill University, Mila, Canada

Canada CIFAR AI Chair Courtney Paquette's research lies at the heart of fundamental artificial intelligence (AI) — optimizing how algorithms work.

While many scientists design algorithms that help intelligent agents see and interact in the world as humans do, Paquette's research focuses on understanding how algorithms see the world.

"I work on the theoretical understanding of algorithms — explaining how and why they work, and how to make them better," says Paquette, a core academic member of Mila and an assistant professor in McGill University's department of mathematics and statistics.

Paquette's research is building momentum for a new area known as continuous optimization, an approach that enables intelligent agents to continuously define the parameters needed to maximize an algorithm's performance, by adapting to evolving, real-world variables.

Traditionally, algorithms are measured by worst-case complexity, which measures an algorithm's performance by how long it takes to perform its task successfully. Paquette proposes a modern approach to the problem by taking into consideration many different variables that make up an algorithm's performance, such as time, energy and cost — an approach referred to as average-case complexity.

It's a paradigm shift that will change the future of machine learning research.

"I'm trying to change the way the research community analyzes the performance of algorithms," she says, adding that it has sparked a lot of dialogue within the machine learning community around how to measure complexity in an algorithm, and what makes an algorithm successful.

Paquette took the road less travelled to get to where she is today.

Originally from the Puget Sound outside of Seattle, Washington, Paquette was initially pursuing a business undergraduate degree at the University of Washington in Seattle, when she came across a course in supply chain management that sparked an interest in optimization.

"An amazing professor plucked me from the obscurity of some high-level undergrad course and encouraged me to try for a PhD. He mentored

“I’m trying to change the way the research community analyzes the performance of algorithms.”

Photo: Nadia Zheng

me and got me involved with a research project. His ability to see that potential in me inspired me to do that for others,” she says.

In Paquette, that mentorship fostered a passion for teaching and for training the next generation at McGill University, particularly women in science, technology, engineering and math (STEM). She is using her role as a Canada CIFAR AI Chair to create training opportunities for students such as summer research experiences for graduate and undergraduate students. It’s an opportunity to expose students to exciting problems.

“I try to support a lot of female undergraduates so that they realize that they can excel in the areas of math and computer science,” she says.

“CIFAR is a really good platform to grow my knowledge and research pursuits.”

The Ancient Earth Explorer

JIHUA HAO

CIFAR Azrieli Global Scholar 2021–2023

Earth 4D: Subsurface Science & Exploration

University of Science and Technology of China, China

Photo: courtesy of the researcher

How did life originate on Earth? It's a complex question that Jihua Hao is unravelling by modelling the surface environment of ancient Earth.

"It was a very different environment from now — no oxygen in the atmosphere, no vegetation on the land. To study Earth's earliest environmental conditions that could sustain life, I focus on the essential nutrients for life," explains Hao, a CIFAR Azrieli Global Scholar in the Earth 4D program and a senior research scientist at the University of Science and Technology of China in Hefei, Anhui, China.

Using experimental techniques and theoretical simulations, Hao mimics the planet's conditions 2.5 billion years ago and studies the chemistry of bio-essential elements, such as phosphorus, sulfur and metals that make up enzymes. He mainly simulates the behaviour of these bio-essentials under anoxic and acidic conditions.

As a PhD student, his work revealed that some nutrients may be more limiting than others in sustaining early life.

"I was so excited about these findings and look forward to contributing more to our understanding of life on ancient Earth," says Hao.

Hao is also applying his techniques to researching the habitability of other planets, including the chemistry of the ocean water inside Saturn's moon, Enceladus.

"Enceladus has a kilometres-thick layer of ice, but below that is liquid ocean. I was quite curious about the nutrients and organics in there. And that has led to some exciting findings that we hope to publish soon," he says.

Another project Hao is excited to work on is in collaboration with Bénédicte Ménez, Advisor in the Earth 4D program. They are using analytical and modelling techniques to understand how organics found in fluid-filled rocks were able to form.

"It is a peculiar setting for enriched organics to be found," explains Hao. "So the question is, if these organics can be synthesized naturally without the influence of life in the rock, then this could inform our understanding of how life started on Earth."

Though his work looks downwards into the subsurface and upwards to other planets, Hao is also looking ahead. He hopes to leverage the connections he's making through CIFAR to further his research and expand the field of astrobiology in China.

"I feel so honoured to be a Global Scholar," he says. "CIFAR is a really good platform to grow my knowledge and research pursuits. We don't have programs like this in China so far, so I hope to leverage this wonderful opportunity to become a leading expert in astrobiology. Then I can help cultivate its growth by mentoring my students as the future leaders in this field."

The “Self” Inquirer

SAHBA BESHARATI

CIFAR Azrieli Global Scholar 2021–2023

Brain, Mind & Consciousness

University of the Witwatersrand, South Africa

Sahba Besharati doesn’t just want to know how humans become aware of themselves and of others in the world; her research also explores how the brain changes following brain injury.

She is using different kinds of technologies — such as medical imaging and virtual reality (VR) — to look inside the brain and manipulate “self-experiences,” to explore what drives these innate human experiences of self-consciousness.

“People always call it ‘the hard problem of consciousness,’” explains Besharati, a CIFAR Azrieli Global Scholar in the Brain, Mind & Consciousness program, and a senior lecturer in cognitive neuroscience at the University of Witwatersrand. “But it’s like, the interesting problem of consciousness, right? I wouldn’t choose to study anything else about the brain. You don’t shy away from what’s hard.”

Based in Johannesburg, South Africa, Besharati first began her academic journey studying psychology and says she juggled between pursuing social or neuropsychology.

“And the brain just really spoke to me,” she says. “All of us on some level have been affected by brain damage, whether we know it or not. Perhaps it’s a father who’s had a stroke or a sister with epilepsy, or a grandfather with dementia. Later on, I realized how these personal reasons initially attracted me to the study of the brain and its disorders.”

In Besharati’s lab, she is currently setting up clinical-based work rooted within the South African context — the country has one of the highest numbers of neurodevelopmental, traumatic brain injury and stroke cases in the world. In studying disorders of consciousness following brain injury, she aims to link certain questions about bodily self-consciousness to specific areas and networks damaged in the right hemisphere.

To gain further insights into cross-cultural influences of consciousness and embodiment, Besharati’s group uses social experimental methods and brain-imaging. Recently, she is also exploring virtual reality to study implicit racial bias.

“Although reductionist in nature, immersive virtual reality can be used to actually put yourself in the body of another racial group, experimentally at least, which can lead to a reduction of your implicit racial bias,” she explains. “But they’ve only done this with caucasian participants and never drawn on Black or other racialized populations, and this “Western bias” is often found in the sciences, which often excludes really important questions. In this case, using cross-cultural groups and participants is critical, because your experience with race and racism would likely be really, really different and impact your results.”

Looking ahead to the next decade, she is excited to learn from — and collaborate with — her peers

“Everyone can benefit from knowing a little more about the brain and how it works.”

Photo: Bridget Corke

in the Brain, Mind & Consciousness program, and with researchers in other programs. She also hopes to make an impact as a mentor to early-career women researchers.

“I have had really strong mentors and role models,” she says. “And as a woman in science, especially one who has grown up as a religious minority, a cultural and racial minority in a male-dominated discipline, and as a mother of two young children, I hope through my work I can be an example to other young, female scientists.”

Ultimately, she hopes to make the brain more understandable and accessible to everyone. “I think understanding the brain can be important for everyone. Regardless of brain injury, everyone can benefit from knowing a little more about the brain and how it works.”

The Quantum Chemist

KWABENA BEDIAKO

CIFAR Azrieli Global Scholar 2020—2022

Quantum Materials

University of California, Berkeley, United States

Kwabena Bediako works with extremely thin materials, exploiting their unique properties to address fundamental problems in energy conversion and conservation.

At the heart of energy conversion and conservation technologies are electrified interfaces — being able to efficiently drive a charge along an interface, from a solid, into an electrolyte, is what ultimately determines how efficiently energy is stored.

"Now, if you can control the physics of the solid, if you can control how the electrons interact with each other and with ions, that can strongly impact this interfacial charge transfer," explains Bediako, a CIFAR Azrieli Global Scholar in the Quantum Materials program and an assistant professor at the University of California, Berkeley.

That is where quantum materials come in. These solids or crystals are so thin, their properties are radically and unusually different from what one would find in three-dimensional materials. Learning to control the physics — their constituent atoms, electrons and other particles — and how they interact together in these very thin materials, could lead to designing more efficient energy conversion and conservation technologies.

But that is just one of the energy problems Bediako is looking to solve through quantum materials. He is also looking to address the accelerating energy consumption of electronic devices.

"If you consider all our communication technology, our portable electronic devices, all those data centres, all the information that we send back and forth — that already generates about as much carbon dioxide as the aviation industry," explains Bediako. "And this was pre-COVID. This is before we learned that, hey, we could have all our meetings and events over Zoom and stream everything from home."

He is looking at how to synthesize materials with interesting physical properties that could lead to lower-power electronic devices and more energy-efficient computing.

"One of our projects in the group is to explore how some of the unique physical properties of materials like graphene and other atomically thin layers might help us to design new catalysts for fuel cells or electrolyzers," says Bediako.

Born and raised in Ghana, West Africa, Bediako went to the U.S. for university. He had initially aspired to be an aeronautical engineer, but,

“I got really driven to find a better solution to storing solar energy.”

Photo: Shannon Kelli

motivated by articles on the imminent climate crisis, he started to pursue chemical engineering before deciding on chemistry.

“I got really driven to find a better solution to storing solar energy.”

He hopes to foster that drive in his trainees as well. “The primary impact I hope to see in the next five to 10 years is seeing my students and postdocs develop successful careers of their own, in whatever industry or field that might be. As educators, our best product is the people we mentor and train. The science that we do, who knows what it inspires in the future. I hope we can learn some new lessons about how to control electronic interactions and chemistry in materials, and if we can do that, I am confident it will lead to some really impactful technology as well.”

The Children's Health Leader

MEGHAN AZAD

Fellow

Humans & the Microbiome

University of Manitoba & Children's Hospital Research Institute of Manitoba, Canada

How does breast milk affect a baby's microbiome? It's one of the many questions Meghan Azad is focused on answering through her work on infant nutrition and the microbiome in child growth and development.

"People have been studying breast milk for a long time. But to be honest, not that many people. It's surprising when you think about it, given how important breast milk is to our species," explains Azad, a Fellow in the Humans & the Microbiome program and an associate professor at the University of Manitoba. She is also a Tier 2 Canada Research Chair in the Developmental Origins of Chronic Disease.

The list of what Azad analyzes in breast milk is a long one and combines her expertise in molecular biology, epidemiology, statistics and nutrition.

"We look for various nutrients, enzymes, hormones, antibodies, immune factors, microbes, metabolites, and so on. The idea is, if we analyze everything in the milk and then look at it all together, we can understand how breast milk influences the microbiome, gut health, immunity and growth. It's the new way of thinking about human milk as a 'biological system.'"

Azad's work in this area garnered attention from the Bill & Melinda Gates Foundation. She is currently leading an international study comparing breast milk in different settings and examining how breast milk is related to the growth of infants. The study is supported by Azad's human milk biorepository at the Manitoba Interdisciplinary Lactation Centre (MILC), which she co-directs with colleague Dr. Nathan Nickel at the Manitoba Centre for Health Policy.

Azad is also deputy director of the CHILD Cohort Study, a national pregnancy cohort study following 3,500 families to understand how early life experiences shape lifelong health. The study began more than a decade ago, collecting information from pregnancy onwards, with children in the study now nearing their teenage years.

And amid the COVID-19 pandemic, Azad is among the many researchers to study its effect on the human population. Supported by a CIFAR Catalyst Fund, Azad collaborated with Humans & the Microbiome fellows Katherine R. Amato and Maria Gloria Dominguez-Bello on how the pandemic might affect infants' microbiomes.

Photo: Dean Casavechia

“From a pretty early age, I knew I wanted to do this as a career.”

“Our focus is on early life — babies are born sterile, and then they get colonized by the first microbes they meet. We are wondering, during a pandemic when everything is super clean and family and friends aren’t coming into contact with the baby, how might that have an impact on the developing microbiome?”

Azad, who grew up in Winnipeg, says her interest in children’s health goes back to when she was 10, after being diagnosed with asthma.

“At one of my appointments, the doctor talked to my parents and asked if they would involve me in a clinical trial for a new asthma drug,” she explains. “I would record my lung function every day and I’d go in to the hospital for tests, and I started asking, ‘why am I doing this?’ And the answer was to help other kids with asthma, because this is a research study. From a pretty early age, I knew I wanted to do this as a career.”

THE POWER OF MENTORSH

LIZ DO

Dr. Alan Bernstein's leadership has transformed science policy, CIFAR's advancements over the last decade, and the next generation of researchers.

His former trainees, now leaders in their fields, share stories on the profound impact of Dr. Bernstein's mentorship on their careers.

HIP

> **“Throughout the history of science, it’s been early-career researchers who have made breakthrough advances and revolutionized thinking about an important problem.”**
>
> **DR. ALAN BERNSTEIN**
> President & CEO, CIFAR

Before co-founding Moderna Inc., a biotech company that would take centre stage in COVID-19 vaccine development, Derrick Rossi was a young master’s student in Dr. Alan Bernstein’s lab.

“I remember he was a very bright guy but hadn’t yet settled on a career path,” recalls Bernstein, President & CEO of CIFAR. “He came to me and asked, ‘What should I do next?’ I said, ‘You know, you can either go on to do your PhD, or you could take a year off and decide what you want to do. And if I can help you with whatever you want to do next, I will.’”

Shortly afterwards, with support from Bernstein, Rossi decided to take some time off, hitchhiking through East and Central Africa, before living and working in Paris, France.

“Alan was a great mentor and superb science thinker. I don’t know how many times I saw him ask exactly the most probing and insightful question at a seminar he happened to attend. Truly an impressive scientist and inspiring role model,” says Rossi.

Bernstein’s transformative influence can be found in his leadership at CIFAR, in science and in health research, and in his mentorship of former trainees such as Rossi.

“The next generation are so critical to the future of science,” says Bernstein. “Throughout the history of science, it’s been early-career researchers who have made breakthrough advances and revolutionized thinking about an important problem. Early-career researchers have at least two advantages: they don’t own the past and they don’t have a vested interest in what’s gone before.”

Alexandra Joyner, a world expert in mouse developmental genetics at the Sloan Kettering Cancer Institute in New York, describes Bernstein as a master communicator, who helped develop her into a clearer and more confident communicator in both giving talks and writing papers.

“He also helped me learn how to look at the big picture and watch for exciting new areas to explore,” says Joyner. “He encouraged me to take risks in my science.”

Taking risks in science is at the core of Bernstein’s mentorship philosophy. He believes it is paramount to allow students to be creative and learn by failure.

“I give my students a very long leash to fail,” he says. “We all learn from our mistakes. We all learn from our successes, too. So it’s important for

students to have failures and to have successes. It's our job as mentors to make sure that they don't choose a problem that is impossible, but one that is doable and important — and then support them in any way we can."

Robert Rottapel is now a senior investigator and co-leader of the Ovarian Cancer Translational Research Initiative at the Ontario Institute for Cancer Research. As a postdoctoral fellow in Bernstein's lab, he recalls that the greatest gift he got from Bernstein was the lesson that science is a human activity.

"The success of research is measured by the character and creativity of the people who you work with," says Rottapel. "Alan created an environment of intense creativity, a demand for excellence and an ambition to make a difference in science. The level of scientific, personal and social interaction within his lab was intense and profound. It is something that I have tried to replicate in my own laboratory."

Both Rottapel and Joyner have now mentored their own generations of leaders, carrying Bernstein's values, lessons and research expertise forward.

Joyner remembers that soon after graduation, Bernstein told her he worried that her drive as an independent researcher would be too focused on the projects at hand, depriving her of the necessary mentoring time and the dedicated time she would need for her trainees, to help them grow.

"It was a wake-up call that I have tried to keep in mind throughout my 35-plus years running a lab," says Joyner.

In September 2021, Bernstein announced that he would not be seeking renewal for a third five-year term at CIFAR. The reason is once again a nod to the next generation. CIFAR is set to celebrate its 40-year anniversary, an opportunity to celebrate the past but also to look ahead and achieve greater goals.

"My reason for not seeking a third term is quite straightforward and goes back to what I believe about the importance of the next generation and the future of science and science-based organizations like CIFAR. This is a great organization that plays a critically important and unique role in the global research landscape. I feel very proud of what everyone on the CIFAR team has accomplished over the past nine-and-a-half years. This is the right time for fresh leadership and new perspectives to take CIFAR to the next level," says Bernstein.

"Alan created an environment of intense creativity, a demand for excellence and an ambition to make a difference in science."

ROBERT ROTTAPEL
Senior investigator and co-leader, Ovarian Cancer Translational Research Initiative, Ontario Institute for Cancer Research

"[Dr. Bernstein] also helped me learn how to look at the big picture and watch for exciting new areas to explore."

ALEXANDRA JOYNER
Member, Developmental Biology Program, Sloan Kettering Cancer Institute

A GIFT FOR THE FUTURE

Jacqueline Koerner speaks with Leslie McCarley, CIFAR's Vice-President, Advancement. Koerner is a Fellow, Morris J. Wosk Centre for Dialogue, Simon Fraser University, a CIFAR donor and Vice-Chair of CIFAR's Board of Directors. Through her research, professional and volunteer experiences, and philanthropy, she is committed to creating meaningful livelihoods and just societies in a globalized economy.

You are the second generation of Koerners to support CIFAR, and yet you and your parents learned about CIFAR and joined our donor community separately. What is it about CIFAR that appealed to you — and your parents?

I grew up in a family that greatly values formal education. My parents were immigrants, so there was also an expectation that my sisters and I give back. My family often reminded me: "Canada took us in. We owe Canada everything."

My parents moved to Toronto in the 1950s, in the postwar period of industrial growth and progressive public investments. I believe that CIFAR was born into that wave of developing Canada: economically, intellectually and institutionally. Both of my parents value academic research and express this through their philanthropy.

What inspired you to follow your parents' lead and donate to CIFAR?

Former UBC president and CIFAR Board Member Martha Piper approached me to join the Board, and I thanked her for that. I was inspired by CIFAR's approach, seeing how similar it was to my vision of what research could be and should be.

I have had a long interest in academics. When I finished my master's degree, I wanted to jump right into a PhD, but my supervisor suggested that I go out into the world and experience it first. I'm glad I did. When I finally went back — attending at the same time as my four children — I realized how many big questions I had, how hard it was to suss them out, and how critical different perspectives were in not only answering my questions but refining them.

CIFAR encourages big-picture thinking between and across disciplines and applying knowledge gained in practical ways that can change the world. It's boundless.

A central part of CIFAR's model is mentorship. How does that connect with your experience?

At CIFAR, researchers from disparate fields come together and introduce dynamic thinking and divergent approaches to the same problem. In essence, they give — and are given — new perspectives and "books" to add to their collections. CIFAR is unique.

Mentors, especially cross-disciplinary mentors, can also be incredibly powerful. They challenge you to think in new ways, support your growth, and excel in specific domains.

As a Director and now as Vice-Chair of the Board of Directors, you advocate for CIFAR's work on the global stage. Why is that important to you and the next generation of donors?

When we moved to an open call, a "Global Call for Ideas" — asking people what should be studied — that transition was very important to me as a Director of CIFAR. We closed our third Global Call for Ideas, and I'm thrilled to see the diversity of themes and applicants as we move forward.

In addition to the academic pedigree of CIFAR, there's this whole other space, which is really about engaging as humans together in bold and significant questions. And that's why I'm interested in CIFAR, sit on the Board, donate, and have hope for what's to come — together is the only way that we can change the world for the benefit of humanity and our shared planet.

Photo: Lucas Finlay

WORKING IN PARTNERSHIP

CIFAR is committed to doing more to ensure that early-career researchers and underrepresented groups are included across our global community, programs and initiatives. To make it happen, we collaborate with visionary foundations, individuals, corporations, governments and organizations to ensure that aspiring researchers see themselves reflected at CIFAR.

> ***"Our longstanding partnership with CIFAR has helped them to engage diverse AI researchers from around the world."***
>
> Valerie Chort, Vice-President of Corporate Citizenship & Sustainability, RBC and Executive Director of RBC Foundation

Since 1988, RBC has partnered with CIFAR to improve people's lives in Canada and across the world. Our shared desire to bolster support for early career researchers and increase the diversity of representation in research has helped CIFAR advance the identification, recruitment, mentoring, training, support and retention of promising and underrepresented talent.

"Ensuring all future and present leaders have equal and equitable opportunity today is critical to our collective future success," says Valerie Chort, vice-president of Corporate Citizenship & Sustainability at RBC and executive director of RBC Foundation. "Our longstanding partnership with CIFAR has helped them to engage diverse AI researchers from around the world, bolstered in more recent years by joint innovation between the Pan-Canadian AI Institutes and Borealis AI. As a result, their innovative research is helping to build more inclusive companies and communities that can achieve their greatest potential."

With the support of RBC Foundation, CIFAR is enabling cross-disciplinary research that advances our understanding of the principles that underlie learning, whether in brains or machines. CIFAR researchers have opportunities to provide and receive mentorship, training, networking and collaboration with an interdisciplinary global network of brilliant minds, including Turing Award winners.

Together, RBC and CIFAR are nurturing, developing and growing a diverse workforce of researchers who are well-positioned and equipped to tackle the biggest questions facing science and humanity.

VOICES OF THE NEXT GENERATION

The CIFAR Azrieli Global Scholars program recruits early-career researchers and supports their research, collaborations and networks. We asked former and current global scholars about the work they do, the impact they hope to make, and their dream project.

Why is fundamental research important to you?

"All major groundbreaking advances have come from fundamental research. While it's impossible to know what applications such research will have and when they will happen, it's perhaps the most guaranteed investment in the long term. We will never be able to solve the problems of tomorrow if we focus all our resources on finding solutions to the specific problems of today. Some fraction of resources must always go to fundamental research. No matter how much we would have invested in candle research, we would never have invented the light bulb without fundamental research."

IAIR ARCAVI
CIFAR Azrieli Global Scholar 2019–2021
Gravity & the Extreme Universe
Tel Aviv University, Israel

What difference do you hope to make as a researcher and educator in the next five to 10 years?

"Science needs to be promoted better and in a much more attractive way. It is our responsibility to give the public an understanding of what scientists are doing and sort the truth from the hype. As my research work — innovative microscope technology to study how embryos grow and develop — is very visual, it will be exceptionally appealing to the public. In my lab, we put an emphasis on how we present our findings and I hope more scientists will pay more attention to the importance of science communication."

JENNIFER ZENKER
CIFAR Azrieli Global Scholar 2019–2021
Humans & the Microbiome
Monash University, Australia

Why is interdisciplinary research important to addressing complex problems?

"I think innovation dies in intellectual or disciplinary-specific silos. Going to talks or speaking with researchers outside my immediate area of expertise always produces so many questions and ideas for me, from 'Oh great, that analytic technique sounds perfect for what we're doing,' to 'This theoretical argument just undermined half a decade of research and they don't even know it.'

"One real challenge is to get the vocabularies to align, as even within fields we can become boxed into our linguistic niches pretty easily and end up talking past each other. But forcing ourselves to have interdisciplinary conversations provides at least some degree of inoculation against insularity, forcing us to explain to others without our specialized vocabulary both what we are doing and why we think it is important."

MEGAN PETERS

CIFAR Azrieli Global Scholar 2019–2021
Brain, Mind & Consciousness
University of California, Irvine, United States

What is a blue-sky project you'd love to take on in the future?

"We live in an era where misinformation threatens to dominate discourse. I live in a province where it crushes me to watch people's subscription to misinformation literally cost lives, let alone millions of dollars. I think it is imperative to develop a research program that figures out the most meaningful way to combat this.

"One aspect of this research program that would most excite me is the embracing of quantitative and qualitative. I have always wanted to propose a CIFAR event that brings together scientists and authors to create fictions designed to convey scientific truths. I think narrative is a powerful medium for convincing people, so why not use it to convince them of the truth."

CRAIG CHAPMAN

CIFAR Azrieli Global Scholar 2016–2018
Brain, Mind & Consciousness
University of Alberta, Canada

FROM CIFAR TO YOU

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