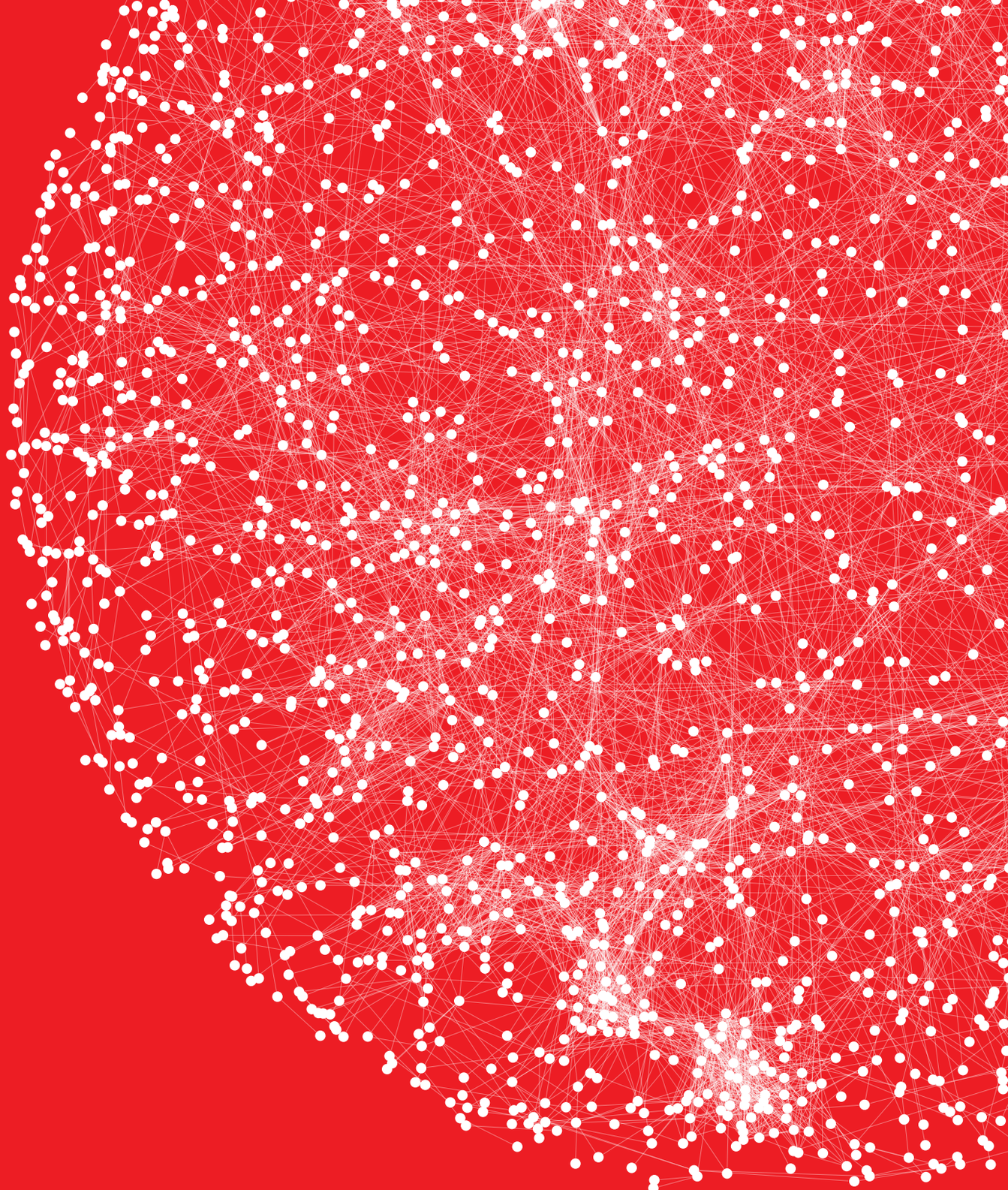
ANNUAL REPORT 2015/16



GLOBAL MOMENTUM

CIFAR

Map of genetic interactions in a yeast cell. By investigating networks of genetic interaction in model organisms, fellows in CIFAR's program in Genetic Networks aim to develop similar approaches and methodologies to better understand the genetic underpinning of human disease.

CIFAR

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GLOBAL MOMENTUM

MESSAGE FROM OUR CHAIR

I am extremely proud to serve as CIFAR's Board Chair, to oversee its important mission and to see it progress toward a new level of impact on a global scale.

CIFAR connects the world's best minds to catalyze cutting-edge research. Under its transformational plan, dubbed 'CIFAR 2.0,' it is expanding its role as a powerful convenor, creating new partnerships with other international research organizations, integrating the next generation of research leaders into its programs and, now, connecting researchers to an increasing number of leaders in community and industry, and to policy-makers in government.

In December 2015, I was reminded of just how important CIFAR's contribution is to our global society, when I accepted the Ideas Award on behalf of CIFAR from the Rotman School of Management's Creative Destruction Lab. It was an honour that recognized CIFAR for taking the risk over a decade ago to provide support to an area of research in artificial intelligence that was far from mainstream. Today, the deep learning approach to AI pioneered by CIFAR fellows in our program in Learning in Machines & Brains is revolutionizing industry worldwide, and its impact will be felt for many years to come. Three senior fellows, founding Program Director **Geoffrey Hinton** (University of Toronto and Google) and current Program Co-Directors **Yoshua Bengio** (Université de Montréal) and **Yann LeCun** (Facebook AI Research), are universally regarded as the fathers of deep learning, the basis for new approaches to everything from smart cars to drug development.

In order for CIFAR to achieve its extraordinary mission, countless individuals lend their support. I have the pleasure of working with a dedicated and insightful Board of Directors who volunteer their valuable time in service of CIFAR's mission. This year, we welcomed Lawrence Pentland to CIFAR's Board. I thank the many volunteers who advise CIFAR on our Research Council, *IdeasExchange* Advisory Council and new Global Academy Advisory Council.

On behalf of CIFAR, I wholeheartedly thank the numerous individuals, foundations and corporations for their financial support. The Knowledge Circle — our community of donors at the $2,000 level and above — joined CIFAR in Toronto and in Montreal to hear presentations from our fellows and to celebrate their extraordinary progress in transforming our world. It was a pleasure to bring our annual Board meeting to Montreal, so that CIFAR's directors could interact directly with Montreal's community of supporters.

We are extremely grateful to the Azrieli Foundation for their landmark gift of $10 million, which enables CIFAR to launch an international program for early-career researchers and to unite the best minds in global research to tackle the mystery of the brain and consciousness.

Essential to CIFAR's sustained success is the support it receives from the governments of Canada, British Columbia, Alberta, Ontario and Quebec. We are grateful for their commitment to strengthening CIFAR's mission and for recognizing that as CIFAR deepens its capabilities globally, it becomes even more valuable to Canadians, and to people everywhere. With the combined contribution of private and public support, CIFAR had the most successful year in fundraising in its history.

Finally, I would like to thank CIFAR's President and CEO Dr. Alan Bernstein for his efforts in guiding CIFAR in its transformation over the past four years, and the researchers, staff and leadership throughout the CIFAR enterprise who make CIFAR's mission a reality.

BARBARA STYMIEST
Chair, Board of Directors

GLOBAL MOMENTUM

MESSAGE FROM OUR PRESIDENT

The past year has been marked by extraordinary achievement.

With nearly 70 major awards and honours this year — including the Nobel Prize in Physics awarded to Associate Fellow Arthur McDonald (Queen's University) — CIFAR fellows are among the most highly honoured researchers in the world. If CIFAR were a university, our 'faculty' of nearly 400 fellows and advisors would be one of the most honoured and most cited of any in the world.

Other awards received include the Gerhard Herzberg Canada Gold Medal to R. Howard Webster Foundation Fellow **Victoria Kaspi** (McGill University), the MacArthur Fellowship, a.k.a. the "genius award," to Senior Fellow **Peidong Yang** (University of California, Berkeley), the SSHRC Gold Medal to Senior Fellow **Janet Werker** (University of British Columbia) and the Balzan Prize to Advisor **Joel Mokyr** (Northwestern University). I encourage you to read about all of the awards and honours on page 62.

CIFAR fellows are making important research advances. In 2015/2016, they produced more than 2,000 peer-reviewed publications, many of them game-changers in their field. In the Quantum Materials program, for example, fellows garnered new insights into the structure of copper oxides, solving a two decades-old mystery and bringing us one step closer to room-temperature superconductivity. CIFAR fellows in Genetic Networks led a study to identify genes that are essential to cancer cell survival, thereby identifying potential targets for cancer drug development.

CIFAR is continuing to extend our global presence. We held meetings with 14 partners in six countries, including Tsinghua University in China, the Collège de France in Paris, France, and the Max Planck Institute for Biochemistry in Germany. In April, I was joined by Senior Fellow **Alán Aspuru-Guzik** (Harvard University) in a series of meetings and talks in Mexico City on the future of energy at events hosted by the Energy Sustainability Fund of Mexico's Ministry of Energy.

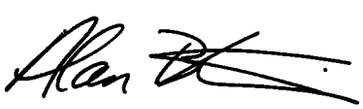
CIFAR remains deeply rooted in research and the enduring mission to forge new ways of thinking and creating entirely new fields of research. At the historic core of our vision is also a commitment to creating impact by sharing new knowledge and addressing real-life problems with our partners in the private sector, in the social services delivery sector and in government. Over the past year, CIFAR has significantly ramped up our *IdeasExchange* program, connecting over 3,700 knowledge users from business, government and civil society directly with CIFAR fellows. For example, Senior Fellow and Nobel Laureate **George Akerlof** (Georgetown University) delivered the inaugural CIFAR David Dodge Lecture, presented by Scotiabank, and I delivered the inaugural annual CIFAR Massey Talk on Science & Society, in partnership with Massey College.

We are also taking our convening model to a new level to address the important challenges of our time. In November 2016, we will be holding the CIFAR Forum on the Well-Being of the World's Children at Canada House in London, United Kingdom, with the support of Global Affairs Canada, the Bill and Melinda Gates Foundation and the Canadian Institutes of Health Research.

CIFAR could not achieve its mission without the generosity of wisdom and support from our Board of Directors, our donors and our partners. I am extremely grateful for the support we received this year from our long-standing supporters: the governments of Canada, Ontario, Alberta, Quebec and British Columbia, and the RBC Foundation. This year, we give special thanks to and welcome our newest major donor, the Azrieli Foundation, one of Canada's pre-eminent philanthropic foundations. Their landmark gift of $10 million to CIFAR will support both the Azrieli Program in Brain, Mind & Consciousness at CIFAR and our new CIFAR Azrieli Global Scholars program.

With a total revenue of $19 million, support for CIFAR grew by 27 per cent this year. This is due, in large part, to the leadership of our Board of Directors, led by Chair Barbara Stymiest. I am grateful for her counsel and the advice of all our directors in setting a renewed strategic direction that will help us to build on our historical excellence to chart new territory for the next five years.

Finally, I wish to extend my sincerest thanks to the entire CIFAR community — our fellows and advisors, Board members, advisory council members, funders, partners and staff. Our momentum comes from your passion, dedication and vision. With you, I look forward to the next five years of global excellence and impact at CIFAR.



ALAN BERNSTEIN
O.C., PhD, FRSC
President and CEO

YEAR IN REVIEW

The Azrieli Program in Brain, Mind & Consciousness at CIFAR engaged the Gryphon Trio in presenting Our Musical Brain, a public outreach event exploring the mental processes involved in making, listening and responding to music.

Introduction

At the core of CIFAR's mission is a deeply rooted commitment to excellence in research at the highest international level. This commitment is founded on the belief that addressing the complex problems and exciting scientific questions of today can be achieved only by forging new ways of thinking and opening up entirely new fields of research. Since 1982, we have been connecting the world's best minds through interdisciplinary research programs to tackle difficult and important questions of global significance. The work of our fellows and advisors has transformed our understanding of population health, the Earth's evolution, early brain development, artificial intelligence, the effect of institutions on prosperity and much more. CIFAR research programs emphasize areas in which Canadian researchers are among the world leaders.

Three years ago, CIFAR launched CIFAR 2.0, an organizational transformation designed to reaffirm CIFAR's original vision and ambitious goals. CIFAR 2.0 was launched in the context of a revolution in science and profound changes in how research is conducted and funded globally. Thus, while CIFAR remains deeply rooted in fundamental research and an enduring ambition to create disruptive new knowledge, we recognized that change was necessary to retain and build on our founding vision.

CIFAR 2.0 commits the organization to six very specific goals, including three points of accountability and three enabling operational priorities. Our points of accountability are the creation of transformative knowledge, engaging stakeholders so they are better positioned to act and nurturing the careers of the next generation of research leaders. To achieve these goals, CIFAR has committed to extending our global reach, engaging in partnerships with organizations that share our dedication to excellence in research and becoming a more outward-looking organization that attracts and retains an outstanding and passionate staff.

We made significant progress in fully implementing CIFAR 2.0 in 2015/2016, including the first complete year of activity of our four newest research programs launched through the 2013 Global Call for Ideas; the expansion of CIFAR's Change Makers series that brings CIFAR researchers into dialogue with stakeholder communities across Canada; and the launch of the new CIFAR Azrieli Global Scholars program for the development of research leaders at the junior faculty level.

Today, science is a global endeavour, and CIFAR must continue to build and extend its global presence. In 2015/2016, CIFAR fellows are based in 17 countries, including Canada. Many of CIFAR's research programs now hold international program meetings to engage with research communities in other countries. For example, this year CIFAR held its first meetings in China (Quantum Information Science) and Australia (Social Interactions, Identity & Well-Being).

CIFAR is also broadening its reach and impact by focusing on partnerships with like-minded organizations in Canada and around the world. We are building alliances with foundations, funders and other organizations that share our values and objectives. Similarly, an increasing number of knowledge user communities are working with us to ensure that research insights drive innovation and change in policy and practice.

The transformation through CIFAR 2.0 has led to one of our most successful years to date in securing financial support. In 2015/2016, the Government of Ontario agreed to double its funding commitment over the next five years, and CIFAR received its largest private-sector gift to date: a $10 million pledge from the Azrieli Foundation. The support from these and other generous supporters is allowing CIFAR to boldly move forward.

In 2015/2016, CIFAR embarked on a major initiative to host the CIFAR Forum on the Well-Being of the World's Children. The forum, which will take place in November 2016, is the most internationally diverse gathering of senior leaders in government, non-governmental organizations and advanced research ever convened by CIFAR. It will feature thought-provoking sessions and discussion led by CIFAR fellows and other global experts to generate insights and identify opportunities where research and coordinated global efforts will advance the well-being of the world's children. Our goal is to explore the possibility of launching, with partners, a future Global Call for Ideas focused on child well-being.

(top) CIFAR Senior Fellow Irene Bloemraad presents at the October 2015 meeting of CIFAR's program in Social Interactions, Identity & Well-Being.

(bottom) Andrew Yao, CIFAR Advisor and Dean of Tsinghua University's Institute for Interdisciplinary Information Sciences, speaks at the Quantum Information Science program meeting held in Beijing, China, in November 2015.

YEAR IN REVIEW

Impact Through Global Research Excellence

Connecting the World's Best

A central feature of each CIFAR research program is the sustained interaction among its fellows. Each program assembles a unique combination of researchers with different disciplinary perspectives and research approaches to collectively tackle a complex challenge facing the world. Programs hold one to three meetings per year over a five-year, renewable period. Sustained interactions create a 'safe' environment that becomes highly conducive to sharing preliminary ideas and sparking innovative new collaborations. Fellows are inspired to think creatively, disruptively and without limitations.

Crucial to success is the selection of researchers appointed to each research program. In 2015/2016, CIFAR appointed 39 new fellows from 33 institutions in nine countries. Research excellence is an expected attribute of our fellows. Every appointed fellow is a leader in his or her field or has demonstrated exceptional potential for leadership as an early-career researcher. Fellows must also demonstrate an ability to contribute new ideas, promote disruptive thinking and be willing to be challenged with unconventional conceptual frameworks or approaches. An attitude of openness to deep collaboration and the patience to effectively communicate across disciplines are essential.

In 2015/2016, the annual cycle of program interaction meetings brought together CIFAR fellows, advisors and guests from leading universities, research institutes and partner organizations. In total, CIFAR held 29 program meetings in seven countries across North America, Europe, Asia and Australia — the latter two being CIFAR firsts.

CIFAR's four newest research programs moved from the start-up phase into their first complete year of operation in 2015/2016. The programs — Azrieli Program in Brain, Mind & Consciousness, Bio-inspired Solar Energy, Humans & the Microbiome, and Molecular Architecture of Life — devoted their meeting time to building fellows' understanding of each other's research perspectives and approaches and to refining their collective research agendas. A total of 24 new appointments were made to the four programs during the year.

CIFAR provides modest financial support to fellows to use toward advancing their program's overarching research challenge. The funds are most often used to support trainees, obtain teaching release, fund research-related expenses or provide salary support. In 2015/2016, CIFAR provided over $8 million to 223 fellows.

Catalyzing Research Collaborations

Nearly 50 per cent of CIFAR fellows reported achieving a significant research advance in 2015/2016 that they felt was catalyzed or facilitated by participating in their CIFAR program. Fully 80 per cent said that their exposure to new perspectives, gained through their program participation, is a highly important influence on their research. Fellows published more than 2,000 peer-reviewed publications during the year, including journal articles, conference papers, books and chapters, of which at least 16 per cent were co-authored with one or more collaborators in their program. During the year, CIFAR featured on its website nearly 30 important research results by CIFAR fellows: **www.cifar.ca**. Below, we highlight three of many outstanding collaborative achievements.

Fellows in CIFAR's program in Quantum Materials settled a 20-year debate in physics by observing a radical change in the electronic structure of copper oxides at the mysterious point at which these materials become superconductors at low temperatures. This long-sought-after result was achieved through a sustained collaboration between CIFAR Senior Fellows **Doug Bonn**, **Walter Hardy** and **Ruixing Liang** (all University of British Columbia), Associate Fellow **Cyril Proust** (Laboratoire National des Champs Magnetiques Intenses in Toulouse, France) and Program Director and Senior Fellow **Louis Taillefer** (Université de Sherbrooke). Published in *Nature* in 2016, this discovery is expected to cause a major shift in the focus of future research in the field and represents a significant step toward learning how superconductivity may become possible at room temperature.

Senior Fellow **Jason Moffat** and Program Co-Director and Senior Fellow **Frederick Roth** (both University of Toronto) in CIFAR's program in Genetic Networks led a collaborative study exposing the weak points of several types of human cancers using a gene-editing technique that can turn genes on and off with pinpoint accuracy. Using CRISPR-Cas9 technology, they switched off 18,000 genes in human cancer cells, one by one, to determine which genes are essential for cancer cell survival. They studied tumours from several different types of cancer and identified genes that are important for each type. The research, published in *Cell* in 2015, helps to illuminate cancer cell vulnerabilities that the medical community may be able to exploit in developing targeted treatments. The work also moves forward a major program goal of advancing our understanding of the function of every gene in the human genome.

Collaborators in CIFAR's program in Social Interactions, Identity & Well-Being completed a series of studies showing that identification with social groups can restore a sense of personal control among individuals experiencing stress. The finding was observed across 47 different countries, as well as in groups that had experienced success or failure. The work was published in 2015 in the *Journal of Personality and Social Psychology*, the leading journal in the field, by Senior Fellows **Alexander Haslam** (University of Queensland) and **Nyla Branscombe** (University of Kansas), and past Global Scholars **Katharine Greenaway** (University of Queensland) and **Renate Ysseldyk** (Carleton University). Adding to a growing body of research in the program on the benefits that individuals can garner from their social group memberships, the work serves the research community and society by illuminating an effective way to manage stress and improve mental health.

To support and accelerate the process of developing a culture of deep collaboration, CIFAR piloted a new Catalyst Fund in 2015/2016, beginning with the four new programs. The Catalyst Fund designates funding in a program's budget to help facilitate high-risk, interdisciplinary research collaborations across its membership. Fellows were invited to submit brief proposals, which were adjudicated by the program advisory committees and CIFAR senior staff, selecting projects that demonstrated the greatest breadth, risk and potential to advance the program's themes and objectives. Proposed collaborations could be achieved through thematic workshops, extended visits by fellows or their students to each other's institutions and co-supervision of trainees, among many other possible mechanisms. The Catalyst Fund will now be extended to all research programs as they enter a new five-year cycle.

CIFAR Fellow Matilde Bombardini presents at the November 2015 meeting of CIFAR's program in Institutions, Organizations & Growth.

YEAR IN REVIEW

CIFAR Associate Fellow Arthur McDonald (left) receives his 2015 Nobel Prize in Physics.

EPA/Jonas Ekstromer

Major Awards & Honours

Over the past year, CIFAR fellows and advisors were recognized for their intellectual leadership through nearly 70 prestigious national and international awards and honours (see Appendix A), including a Nobel Prize.

Arthur McDonald (Queen's University), Associate Fellow in CIFAR's program in Cosmology & Gravity, was co-recipient of the 2015 **Nobel Prize in Physics** with Takaaki Kajita of Japan for discovering neutrino oscillations, demonstrating that neutrinos have mass. Dr. McDonald was an Advisor to the Cosmology & Gravity program when he and his Sudbury Neutrino Observatory Collaboration reached this seminal finding in 2001. The team also received the 2016 **Breakthrough Prize in Fundamental Physics**, a $3 million award shared with four other international teams studying neutrino oscillations.

Other recipients of prestigious international awards included **Peidong Yang** (University of California, Berkeley), Senior Fellow in CIFAR's program in Bio-inspired Solar Energy, who won a prestigious **MacArthur Fellowship**. Nicknamed the 'genius award,' it provides unrestricted funds to individuals with an outstanding record of accomplishment and originality to further pursue their own creative, intellectual and professional inclinations.

Major Canadian research prizes awarded to CIFAR fellows during the year included the **Gerhard Herzberg Canada Gold Medal for Science and Engineering** to **Victoria Kaspi** (McGill University), the R. Howard Webster Foundation Fellow in CIFAR's program in Cosmology & Gravity, and the **SSHRC Gold Medal** to **Janet Werker** (University of British Columbia), Senior Fellow in CIFAR's program in Child & Brain Development and CIFAR Advisor to the Azrieli Program in Brain, Mind & Consciousness. Remarkably, three fellows were honoured as **Companions of the Order of Canada**, Canada's highest civilian honour: **Brenda Andrews** (University of Toronto), Senior Fellow in CIFAR's program in Genetic Networks; **Arthur McDonald**; and **Janet Rossant** (Hospital for Sick Children Research Institute), Program Co-Director and Senior Fellow in CIFAR's program in Humans & the Microbiome.

CIFAR itself received the inaugural **Ideas Award** from the Creative Destruction Lab at the Rotman School of Management in Toronto. The award recognized CIFAR for having a first-order impact on Canada's competitiveness in the world by advancing new ideas in science and technology. Presented by Toronto mayor John Tory, the award particularly highlighted CIFAR's early investment in machine learning. The award citation states, "Although there is now clear evidence that developments in this field are delivering significant economic impact [...] CIFAR provided critical support for many years when this line of scientific inquiry was considered peripheral, risky and unexciting among experts in the field."

Ongoing Portfolio Renewal

At regular intervals, CIFAR strategically reviews its entire research portfolio, ensuring that our programs are among the world's most outstanding, innovative, unique and promising endeavours.

As part of this assessment and renewal process, research programs are externally peer-reviewed every five years according to the highest international standards of scholarship. Three of CIFAR's research programs — Genetic Networks, Integrated Microbial Biodiversity, and Social Interactions, Identity & Well-Being — underwent their five-year term reviews in 2015/2016. CIFAR assembled panels of international experts to review each program's achievements and impact, as well as the quality and innovative nature of their proposals for a renewed five-year term. The results from these three reviews will be assessed, along with those from two upcoming program reviews in 2016/2017 — Cosmology & Gravity and Successful Societies — according to their relative merits and fit within the overall strategy for CIFAR's research portfolio.

CIFAR also undertook a comprehensive, institute-wide external performance evaluation conducted by Science-Metrix as part of our performance measurement strategy and in fulfillment of our Contribution Agreement with the Government of Canada. Their review affirmed the direction and priorities of CIFAR 2.0 and highlighted CIFAR's critical role in the Canadian research and innovation ecosystem. CIFAR participates in a Community of Practice on Science, Technology and Innovation Indicators, which consists of organizations that receive funds through Innovation, Science and Economic Development Canada, to share best practices and understand organizational synergies.

Expanding Our Global Reach

Partnerships

CIFAR continues to develop partnerships with leading public and private organizations in Canada and around the world that share our values and objectives. Partnerships create new opportunities for CIFAR to contribute to the global research landscape, and at the same time strengthen CIFAR's capacity to advance and deliver on our points of accountability. In the previous year, CIFAR established a broad and growing portfolio of multi-year partnership agreements with internationally based and Canadian organizations worth $17 million for 2015-2020 (executed and committed). These include executed agreements with organizations in the United States (Gordon and Betty Moore Foundation), Europe (Inria) and Canada (Brain Canada Foundation, Fonds de recherche du Québec, Genome Canada and Genome BC).

Expanded Relationships with Canadian Universities

One of CIFAR's goals is to strengthen Canadian research by connecting the country's most extraordinary minds with the world's best through our global research networks. Maintaining strong relationships with Canadian universities is foundational to our success.

In 2015/2016, CIFAR executed its first multi-year partnership agreement with a Canadian university. Western University will partner with CIFAR for five years in support of our Azrieli Program in Brain, Mind & Consciousness, led by Program Co-Directors **Adrian Owen** and **Melvyn Goodale**, both based in the Brain and Mind Institute at Western University.

Role in Canada's Science and Technology Ecosystem

CIFAR participated in several of Canada's Joint Committees on Science, Technology and Innovation Cooperation, including science and technology meetings with Germany, China, the European Union and Japan. At the China-Canada Joint Committee meeting, CIFAR presented a session on researcher mobility. Arising from the Government of Canada's bilateral Scientific and Technological Cooperation agreements with each of these countries, the joint meetings support and promote science, technology and innovation partnerships and future cooperation.

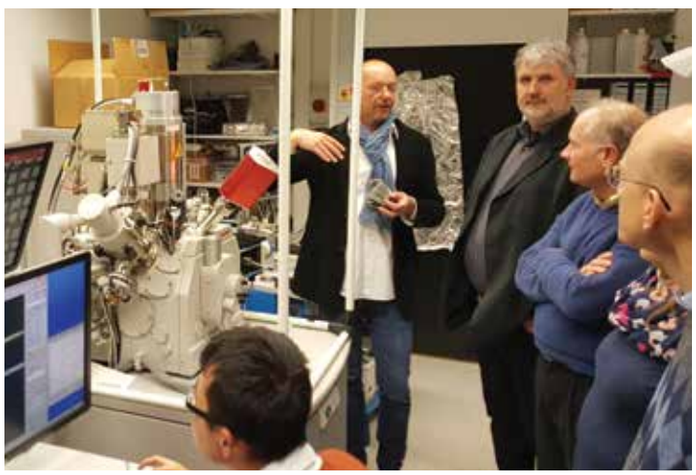
Program Meetings and Events with Global Partners

In partnership with local host organizations, CIFAR now routinely holds program meetings in locations around the world, strategically chosen to enable fellows to interact with globally significant research communities. Collaborating with other strategically aligned organizations to co-host program meetings, workshops and outreach-focused events also presents opportunities to lay the foundation from which to build future partnerships. In 2015/2016, CIFAR partnered with 14 leading research organizations and foundations in Australia, China, France, Germany, the United States and Canada, in support of program meetings and knowledge outreach events. Among these meetings, we highlight selected examples, including CIFAR's first to be held in China and Australia.

CIFAR's program in Quantum Information Science met in Beijing, China, in the fall of 2015, hosted by the **Institute for Interdisciplinary Information Sciences (IIIS)** at **Tsinghua University**. The institute is home to an internationally recognized research group in quantum information, and the meeting served to foster the relationships begun in a previous joint meeting held at the Institute for Quantum Computing in Waterloo, Canada, in 2014. Meeting in Beijing afforded the additional opportunity to include outstanding researchers from several other leading Chinese institutions. **Andrew Yao**, Dean of IIIS, was subsequently appointed to the advisory committee of CIFAR's program in Quantum Information Science.

Our program in Social Interactions, Identity & Well-Being met in Brisbane, Australia, in June 2016, in cooperation with the **University of Queensland**, where two program fellows are based. In addition to including outstanding researchers from several Australian institutions, the program also leveraged the opportunity to present a knowledge outreach symposium targeted to local policy makers, social innovators, educators and academics. This event is further highlighted on page 13.

The **Collège de France** in Paris partnered with CIFAR and the **Institute for Advanced Study in Toulouse (IAST)** to host a meeting of CIFAR's program in Institutions, Organizations & Growth in June 2016. The Collège is one of France's most renowned higher-education and research establishments, and the IAST is an ambitious interdisciplinary research institute facilitating the cross-fertilization of ideas across the social sciences. The meeting enabled CIFAR fellows to engage with numerous researchers from both organizations, as well as from Sciences Po in Paris.



Fellows of CIFAR's program in the Molecular Architecture of Life met at the Max Planck Institute of Biochemistry in Martinsried, Germany.

CIFAR's program in the Molecular Architecture of Life met in Martinsried, Germany, in April 2016 in partnership with the **Max Planck Institute of Biochemistry** to enable a robust engagement with this important research community. Fellows also invited selected researchers from other leading universities and Max Planck Institutes across Germany to participate. Meeting at this location presented CIFAR fellows and their guests the opportunity to see first-hand the technology that is central to the program's roadmap for understanding how life works at the molecular level.

Building New International Relationships

CIFAR is systematically building relationships with strategically aligned research organizations, corporations, foundations and governments around the world. In 2015/2016, CIFAR met with researchers and administrators from nearly 70 organizations based in 10 countries to promote our research networks and discuss potential partnership opportunities. For the first time, CIFAR conducted visits in Mexico and Kenya.

In conjunction with an invited keynote lecture he delivered in Mexico City on the future of energy, described on page 13, CIFAR President and CEO **Alan Bernstein** met with senior officials in the Government of Mexico and other important public sector, academic and philanthropic organizations in the country to explore opportunities for future collaboration on renewable energy. **Denis Thérien**, CIFAR Vice-President, Research and Partnerships, visited the Nairobi campus of Aga Khan University by special invitation, and leveraged the opportunity to meet with representatives from three other Kenyan and Africa-wide research bodies.

Connecting Research and Stakeholders

Knowledge Outreach

CIFAR's research programs are a continuous source of new discoveries and insights that have the potential to transform fields of research, or have immediate or long-term implications for the wider world. One of CIFAR's priorities is to develop a community of leaders in industry, policy and practice who can actively engage with our fellows and benefit from the knowledge discovered in our research programs.

This year, we continued to expand our *IdeasExchange* platform of engagements and online resources aimed at strengthening the decision-making capacity of leaders in a range of sectors. These activities, many of which were convened with partner organizations, made possible a variety of discussions between CIFAR fellows and those in the 'knowledge user' community.

Canadian policy-makers are among the groups that *IdeasExchange* seeks to engage. This year, CIFAR facilitated roundtable discussions with deputy ministers in the governments of Canada and Ontario, as well as briefings with cabinet ministers and various levels of civil servants in Ottawa, Toronto and Edmonton.

CIFAR continued to support meaningful conversations with other specialized groups that our programs have identified as important and influential in driving the impact of their research. For example, the Bio-inspired Solar Energy program welcomed a researcher from one of the world's largest energy companies as a guest participant, and the Genetic Networks program invited a curriculum expert to one of its meetings to better understand how insights from its program could be more effectively integrated into medical school curricula.

Change Makers

Change Makers brings together CIFAR researchers with leaders in government, business, education, civil society and the cultural sector to exchange fresh insights about addressing complex social issues. Through multidisciplinary presentations, resources and opportunities for networking, CIFAR is catalyzing new ways of thinking and acting that can drive change in some of our most vulnerable communities. These experiences are offered both in-person and online.

YEAR IN REVIEW

CIFAR Co-Associate Program Director and Senior Fellow Philip Oreopoulos presents at the CIFAR Change Makers workshop held in Toronto in partnership with the United Way Toronto and York Region.

CHANGE MAKERS: CIFAR'S NATIONAL DIALOGUE SERIES

(right and below right) The CIFAR Change Makers workshop in Calgary engaged a diverse community in discussions on how research-informed interventions can reach at-risk schoolchildren.

(left) CIFAR Successful Societies Program Co-Director and Senior Fellow Peter Hall speaks at the CIFAR Change Makers workshop held in Montreal in partnership with the McConnell Foundation.

- In November 2015, CIFAR partnered with the United Way Toronto and York Region to convene **Researching with the Community**, a workshop to foster discussion between researchers and leading social service providers on how best to collaborate to improve policies and programs that serve our communities. Presenters included researchers in CIFAR's program in Social Interactions, Identity & Well-Being, **Philip Oreopoulos** (University of Toronto) and **Kimberly Matheson** (Carleton University), and representatives from two United Way member agencies, Access Alliance Multicultural Health Services and West Neighbourhood House.

- In May 2016, CIFAR and the McConnell Foundation joined forces in Montreal to hold a workshop on **New Models for Thriving: How Social Innovation Supports Inclusive Societies**. CIFAR researchers and civic and government leaders came together to explore the challenges of inequality and opportunities to create more inclusive societies. Presenters included Program Co-Director **Peter Hall** (Harvard University) and **Jane Jenson** (Université de Montréal), both Senior Fellows in CIFAR's program in Successful Societies, and Michel Venne (Institut du Nouveau Monde).

- In June 2016, together with the Alberta Centre for Child, Family & Community Research, CIFAR presented a symposium in Calgary on **Combatting Early Childhood Adversity: Reaching Vulnerable Children at School Through Evidence-Based Research**. Two Senior Fellows in CIFAR's program in Child & Brain Development, Program Co-Director **W. Thomas Boyce** (University of California, San Francisco) and **Bryan Kolb** (University of Lethbridge), along with presenters from the Calgary Board of Education, led discussions with practitioners on how a biological understanding of individual differences and early life experiences can help to more effectively reach at-risk children in schools.

Events and Lectures

For the first time, CIFAR held knowledge outreach events outside of Canada. In Mexico, CIFAR President and CEO **Alan Bernstein** and Senior Fellow **Alán Aspuru-Guzik** (Harvard University) in CIFAR's program in Bio-inspired Solar Energy gave an invited keynote lecture on **Global Research Networks and the Future of Energy** in April 2016. Hosted by the Energy Sustainability Fund of Mexico's Ministry of Energy, the event attracted nearly 200 participants, including stakeholders from the public and private sectors.

In Brisbane, Australia, fellows from CIFAR's program in Social Interactions, Identity & Well-Being presented a symposium on **Building Better Lives: New Thinking on How Social Interactions Shape Human Behaviour and Well-Being**. Senior Fellows **John Helliwell** (University of British Columbia), **Philip Oreopoulos** (University of Toronto) and **Alexander Haslam** (University of Queensland) shared research insights from the program with leaders in public policy, health care, social services, the academic community and the general public. Co-sponsoring organizations included the University of Queensland and the Australian Research Council.

CIFAR launched the **CIFAR David Dodge Lecture** series. Sponsored by Scotiabank in honour of past CIFAR Board Chair David Dodge, the lecture features the work of a distinguished international figure in the field of economics. Nobel Laureate **George Akerlof** (Georgetown University), Co-Director and Senior Fellow in CIFAR's program in Social Interactions, Identity & Well-Being, gave the inaugural 2015/2016 lectures in Toronto and Ottawa to leaders in policy and business. The events included remarks from leaders of the Bank of Canada: Senior Deputy Governor Carolyn Wilkins in Toronto and Governor Stephen S. Poloz in Ottawa.

Stephen Poloz, Governor of the Bank of Canada, provides remarks at the CIFAR David Dodge Lecture in Ottawa, delivered by Nobel Laureate George Akerlof, Co-Director and Senior Fellow in CIFAR's Social Interactions, Identity and Well-Being Program.

CIFAR President and CEO Alan Bernstein, Massey College Master Hugh Segal and Massey College Junior Fellows Trevor Plint and Maripier Isabelle in discussion at the inaugural CIFAR Massey Talk on Science & Society.

Public Engagement

In addition to the targeted knowledge outreach dialogues, CIFAR held nine other public outreach events across Canada.

Among these, CIFAR launched the new **CIFAR Massey Talks on Science & Society**, an annual lecture series aimed at engaging public audiences in topical issues of importance to the world. The inaugural talk was delivered at the University of Toronto by CIFAR President and CEO **Alan Bernstein**, examining how science is transforming the way we think and the world we live in.

In its first collaboration with members of Canada's arts community, CIFAR partnered with the Royal Conservatory of Music in Toronto to showcase the research of two Senior Fellows and neuroscientists in the Azrieli Program in Brain, Mind & Consciousness, **Laurel Trainor** (McMaster University) and **Robert Zatorre** (McGill University). Hosted by mezzo-soprano and CBC Radio 2 personality Julie Nesrallah, **Our Musical Brain** explored the conscious and unconscious mental processes involved in making, perceiving and responding to music. The evening featured live musical performances by acclaimed chamber ensemble, the Gryphon Trio, coupled with scientific insights and real-time audience response-monitoring and interaction. This public event drew an audience of over 900 attendees, in addition to almost 700 viewers of the live webcast.

Online and Print Resources

The *IdeasExchange* platform supports a growing library of online resources through CIFAR's website to give interest groups and the public timely access to the research insights produced in our research programs. New online publications include *Research Briefs*, summarizing influential new research from CIFAR fellows, and *Symposium Debriefs*, highlighting notable insights for innovation and action from recent CIFAR exchanges. CIFAR's e-newsletter, *News & Ideas*, was issued seven times during the year, covering 28 stories of research discoveries and sent to an average of nearly 8,000 recipients per month. *REACH*, CIFAR's annual magazine, was distributed to 6,500 people. Visitors will also find an expanding library of video content, event listings and more. CIFAR's online content is fully integrated with its social media presence, which continues to increase its reach through followers, friends and content sharing.

Developing Research Leaders

Global Academy

New investigators play a critical role in driving change and pushing intellectual boundaries. CIFAR is committed to developing tomorrow's research leaders by engaging and mentoring them in the deep collaborations that CIFAR forms within its research programs. The Global Academy offers a range of opportunities for graduate students, postdoctoral fellows and assistant professors in Canada and across the globe, to learn from and collaborate with some of the world's top minds, positioning them to become the thought leaders of their generation.

CIFAR appointed a new Global Academy Advisory Council in 2015/2016 to support the ongoing development of Global Academy activities. The council reflects CIFAR's most globally representative body of advisors to date, consisting of distinguished leaders in research and early career development from India, China, Africa, Europe and the United States. Their names and affiliations are presented in Appendix B.

Candidates for the first cohort of CIFAR Azrieli Global Scholars took part in an interactive group interview process.

CIFAR Azrieli Global Scholars Program

Through generous funding support from the Azrieli Foundation, CIFAR launched the CIFAR Azrieli Global Scholars Program with an open call for applications in April 2016. This competitive and newly redesigned program targets ambitious new university faculty members around the world in their first five years of an assistant professor or equivalent appointment.

Successful candidates are integrated into one of CIFAR's research programs for two years and receive $100,000 in unrestricted research funding. As program members, Global Scholars interact closely and regularly with internationally renowned colleagues from diverse disciplines, sparking unexpected insights and innovative collaborations. They are also paired with a mentor in the program for available research- and career-related guidance.

Global Scholars across all research programs will meet as a peer group annually for interactive leadership and communication training to boost their existing capacity to become influential leaders within academia and beyond. CIFAR will also work with Global Scholars to help identify and support opportunities to engage with leading knowledge users across sectors in ways that will drive meaningful dialogue and mutual benefit.

In preparing for the program redesign and launch, CIFAR engaged in wide-ranging consultations across the research and leadership development sectors, globally. The consultation process assisted CIFAR in mounting a global promotion of the Global Scholars Program throughout April, which resulted in 193 applicants from 31 countries on six continents. In June, 29 short-listed candidates, selected for their research excellence and compatibility with CIFAR's research programs, attended an interactive group interview process to assess their communication skills, capacity to engage across disciplines, leadership strengths and potential to deliver impact within and beyond academia. The first cohort of 18 CIFAR Azrieli Global Scholars will be announced and in place for September 2016.

CIFAR Postdoctoral Fellows

Three CIFAR research programs elected to use a portion of their operating budget to support postdoctoral fellow positions co-supervised by two or more program fellows. These positions support specific collaborative projects designed to advance the program's research thematics. In most cases, the postdoctoral fellows are identified through a competitive process and appointed for a two-year (sometimes three-year) term. The trainees are expected to spend significant amounts of time with each co-supervisor's research group and present their work at a minimum of one program meeting per year. Each will complete a final report on their experience at the end of their term.

The three programs with new CIFAR Postdoctoral Fellows are Bio-inspired Solar Energy, Child & Brain Development and Molecular Architecture of Life. Each has appointed two co-supervised trainees thus far, with CIFAR investing $25,000 for each position. This amount is matched with co-funding sourced by the supervisors, or in the case of the Child & Brain Development program, with generous support from the Alva Foundation.

Summer/Winter Schools of Advanced Study

Several CIFAR programs hold annual summer or winter schools for their researchers' graduate and postdoctoral trainees. Student organizers invite CIFAR fellows and other distinguished researchers to lecture on cutting-edge topics not yet covered in regular university curricula. CIFAR also co-sponsors student schools with other organizations in fields related to its program themes.

The program in Learning in Machines & Brains held its largest summer school to date, opening its doors to trainees from both academia and industry in the burgeoning field of deep learning. Hosted at the Université de Montréal, the 153 attendees represented universities and research institutes in 16 countries and 18 global companies, including Samsung, Google and Amazon.com. Future summer schools in the program will continue this successful model.

The program in Quantum Materials held its annual summer school in partnership with the Gordon and Betty Moore Foundation's Emergent Phenomena in Quantum Systems (EPiQS) initiative. Trainees from both organizations benefited from talks by leading researchers, networking opportunities and a presentation on science communication by Ivan Semeniuk, a prominent Canadian science journalist.

Dr. Naomi Azrieli, Chair and CEO, Azrieli Foundation and Dr. Alan Bernstein, President and CEO, CIFAR

Attendance at Program Meetings
All CIFAR research programs are encouraged to engage young scholars in a meaningful capacity that best suits the program's culture and goals. Several CIFAR programs have chosen to include graduate students and postdoctoral fellows in their interaction meetings, where they have opportunities to give talks, present posters, engage with their peers and informally interact with world research leaders in their field. In 2015/2016, 166 trainees from around the world participated in various CIFAR research program meetings.

Frontiers in Science Symposium
CIFAR partnered with the Royal Society of Canada and the Royal Society (London) to co-host the first UK–Canada Frontiers in Science Symposium. Held from March 13–16, 2016, in Whistler, British Columbia, this meeting brought together 36 outstanding early-career scientists and scholars (19 from the United Kingdom and 18 from Canada) representing a full range of academic disciplines. The meeting encouraged informal networking and discussions, and explored opportunities for international and cross-disciplinary collaborations. The meeting was considered a successful first effort toward developing a larger initiative around future Frontiers in Science symposia to be held around the world.

Building Long-Term Financial Sustainability

This was a year of exceptional growth in support for CIFAR. Revenue from all sources grew to $19 million, an increase of 27 per cent over the previous year. This growth was driven by a number of factors. CIFAR received the highest level of private-sector support in its history, including the largest single donation in our 34-year history, received from the Azrieli Foundation. We also launched several major research partnerships with leading research organizations and saw significant increases in support from the governments of Ontario and British Columbia.

A Visionary Gift to CIFAR
The Azrieli Foundation, one of Canada's pre-eminent philanthropic foundations, made a visionary gift of $10 million to CIFAR in 2015/2016.

The gift supports two critical areas of CIFAR's work: the Azrieli Program in Brain, Mind & Consciousness at CIFAR, which brings together leading researchers from around the world to explore the biological basis of human consciousness (see page 28); and the new CIFAR Azrieli Global Scholars Program, which provides funding and support to help early career scholars build their research networks and develop essential skills to become leaders in global research (see page 15).

In the words of Dr. Naomi Azrieli, Chair and CEO of the Azrieli Foundation, "The Azrieli Foundation seeks opportunities to foster excellence in science, investing in the work of both outstanding senior researchers and early career scholars. CIFAR's multidisciplinary and global approach to addressing the world's most complex issues makes them a perfect home for the collaborative research that can bring about breakthroughs in brain research."

CIFAR announced the Azrieli Foundation's generous gift at the **Our Musical Brain** event held in Toronto's Koerner Hall in June 2016. The evening's sold-out program, which showcased the transformative impact made by the Azrieli Foundation, combined musical performance with research presentations to explore what happens in our brains when we listen to music (see page 14).

YEAR IN REVIEW

Expanded Public Sector Support
CIFAR was very successful in building its engagement with governments in Canada in 2015/2016. We undertook a number of activities to connect research with leaders in the policy community at both the provincial and federal levels. Selected interactions included a CIFAR-led clean energy discussion in Calgary, a deputy ministers' roundtable on disruptive technologies and innovation for Ontario government officials, and participation in a science and technology panel discussion in Ottawa organized by the Chief Scientist of Quebec. CIFAR renewed its partnership with Ontario and British Columbia, with both governments increasing their investments in CIFAR's research programs, talent development and stakeholder engagement. We also expanded our engagement with Global Affairs Canada; in addition to participating in a number of meetings to support Canada's bilateral science and technology agreements, Global Affairs Canada is supporting the CIFAR Forum on the Well-Being of the World's Children, described on page 6.

Partnering to Build a Stronger Society
Since 1989, **BMO Financial Group** and CIFAR have partnered to create and share knowledge that supports healthy and resilient communities. This year, BMO — a leader in corporate philanthropy — built on this partnership with a new investment of $1.5 million in CIFAR's programs in Building Strong Societies, namely Institutions, Organizations & Growth, Social Interactions, Identity & Well-Being and Successful Societies. CIFAR fellows in these programs are investigating the social, institutional and cultural factors that can enhance prosperity, inclusion and resilience in our communities.

BMO's gift will enable CIFAR to share new discoveries and innovative approaches to challenging social issues with leading social innovators and policy-makers across Canada. "BMO proudly shares CIFAR's commitment to advancing healthy and prosperous communities," says Nada Ristich, Director, Corporate Donations. "We are committed to supporting organizations such as CIFAR working to build an inclusive and resilient Canada."

Recognizing Excellence
This year, CIFAR was pleased to announce four named appointments to recognize the generous contributions of some of our major donors:

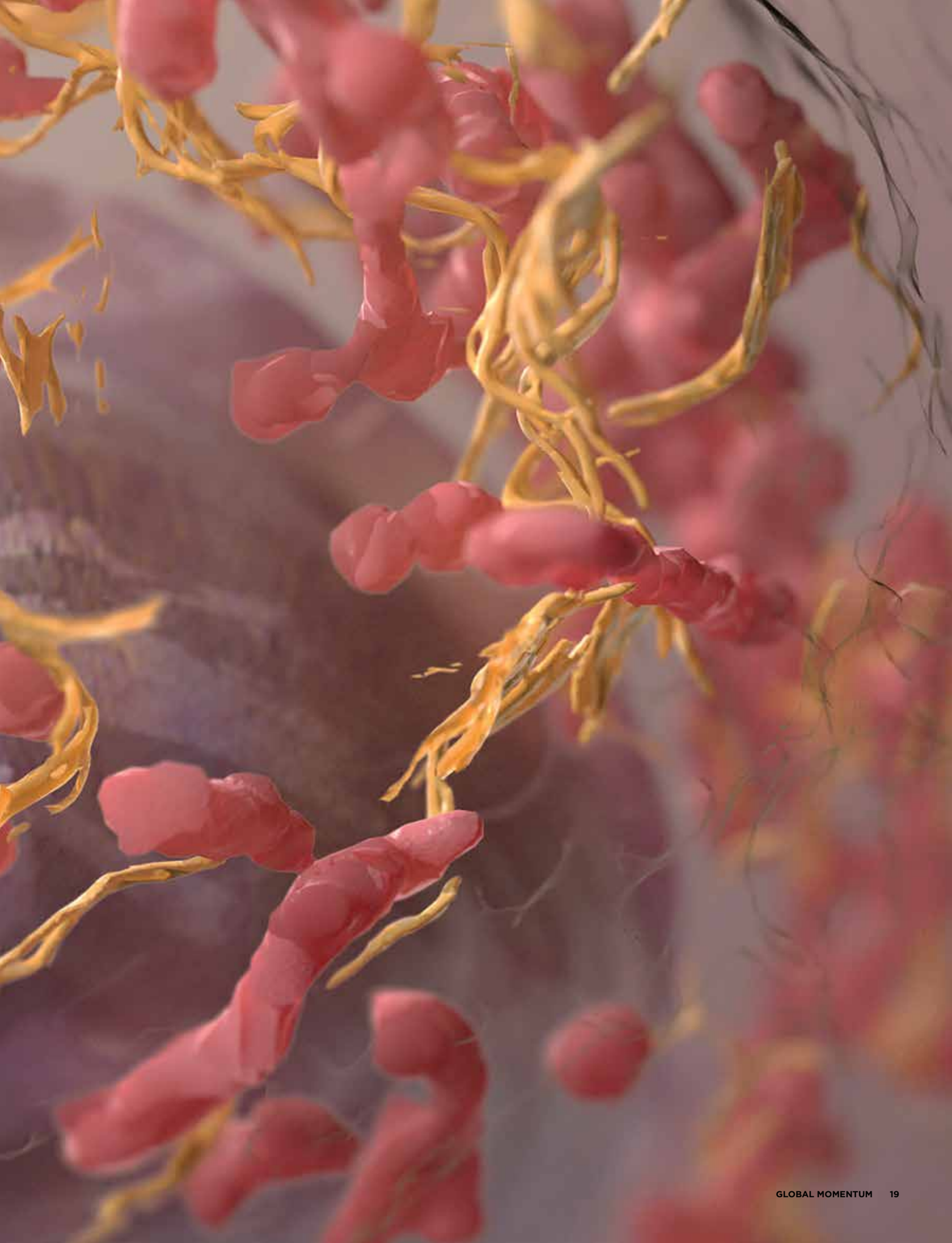
- Edward Sargent was named the **Heffernan Director in Bio-inspired Solar Energy** in recognition of Jerry and Geraldine Heffernan.
- Adrian Owen was named the **Koerner Fellow in the Azrieli Program in Brain, Mind & Consciousness at CIFAR** in recognition of Michael and Sonja Koerner.
- Melvyn Goodale was named the **Ivey Fellow in the Azrieli Program in Brain, Mind & Consciousness at CIFAR** in recognition of Richard M. Ivey.
- Marla Sokolowski was named the **Weston Fellow in Child & Brain Development** in recognition of the W. Garfield Weston Foundation and George Weston Limited.

Melvyn Goodale, Co-Director and Ivey Fellow in the Azrieli Program in Brain, Mind & Consciousness at CIFAR.

PERFORMANCE DATA

A summary of CIFAR's performance by key statistics according to three points of accountability. All data reported reflect CIFAR's status as of June 30, 2016.

CIFAR Fellows used a gene editing technology called CRISPR-Cas9 to identify genes that are essential for cell survival. The knowledge could be used to fight cancers like those caused by the melanoma cell pictured here. Image courtesy of Sriram Subramaniam, National Cancer Institute, National Institutes of Health.



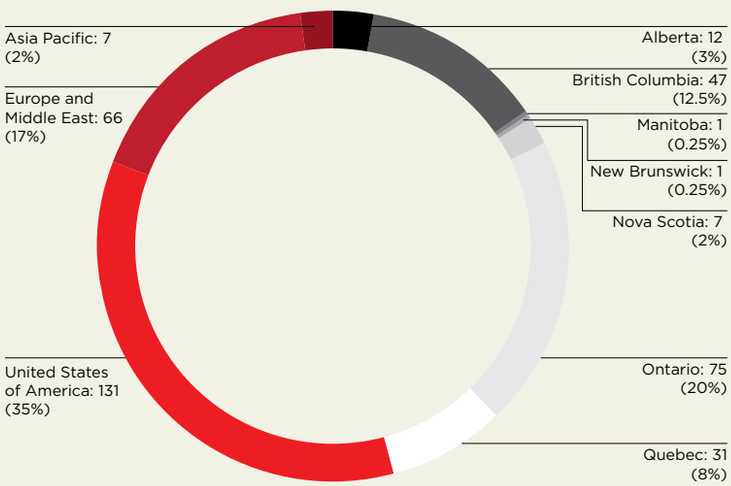
1 Create Transformative Knowledge

CIFAR's principal accountability is to create transformative knowledge through sustained interaction among fellows engaged in its global research networks. Each research program assembles a unique combination of researchers with different disciplinary perspectives and research approaches to collectively tackle a complex challenge facing the world.

Composition and Global Distribution of CIFAR Fellows

- 378 researchers, consisting of
  > 312 fellows
  > 66 advisors
- 39 new fellows from 33 institutions in 9 countries appointed to 8 programs in the current year
- Fellows and advisors are located in 17 countries, representing 27 institutions in Canada and 103 internationally
- 54% of fellows and advisors are based outside of Canada
  > 48% of fellows and 82% of advisors are based internationally

Distribution of CIFAR Researchers by Region



Distribution of CIFAR Researchers by Country and Institution

CANADA (174)

Alberta (12)
University of Alberta (6)
University of Calgary (5)
University of Lethbridge

British Columbia (47)
Simon Fraser University (4)
University of British Columbia (40)
University of Victoria (3)

Manitoba (1)
University of Winnipeg

New Brunswick (1)
University of New Brunswick

Nova Scotia (7)
Dalhousie University (7)

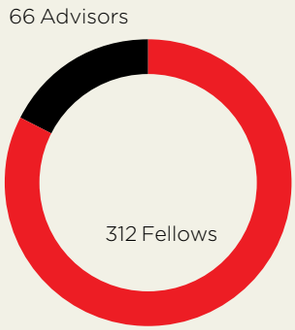
Ontario (75)
Carleton University
McMaster University (8)
Perimeter Institute for Theoretical Physics (3)
Queen's University (4)
Statistics Canada, Ottawa
The Hospital for Sick Children, Toronto (4)
University of Guelph (3)
University of Ottawa (3)
University of Toronto (32)
University of Waterloo (12)
Western University (3)
Wilfrid Laurier University

Quebec (31)
McGill University (14)
Université de Montréal (7)
Université de Sherbrooke (7)
Université du Québec à Chicoutimi
Université du Québec à Montréal
Université Laval

UNITED STATES OF AMERICA (131)

Arizona State University (2)
Brookhaven National Laboratory
Brown University
California Institute of Technology (2)
California Life Company
Case Western Reserve University
Columbia University
Cornell University
Duke University (3)
Facebook AI Research (2)
Georgetown University
Harvard University (13)
IBM Corporation
Institute for Advanced Study (2)
Johns Hopkins University (2)
Massachusetts Institute of Technology (6)
Monterey Bay Aquarium Research Institute
National Institutes of Health (2)
National Radio Astronomy Institute
New York University (4)
Northwestern University (3)
OpenAI
Pennsylvania State University
Princeton University (14)
Rice University
Rutgers University
Salk Institute for Biological Studies
San Diego State University
Stanford University (19)
The World Bank
Tufts University (2)
University of California, Berkeley (9)
University of California, Irvine
University of California, San Diego
University of California, San Francisco (2)
University of California, Santa Barbara (3)
University of Chicago (4)
University of Hawaii (2)
University of Illinois at Urbana-Champaign
University of Kansas
University of Maryland (4)
University of Michigan
University of Minnesota (2)
University of Montana
University of Oregon
University of Washington (3)
Washington University in St. Louis (2)

PERFORMANCE — DATA



378 researchers

major awards

Located in 17 countries

130 institutions

Researcher Excellence

- **CIFAR researchers in top 1%***
  > Fellows: **61%**
  > Advisory Committee Members: **55%**

* Percentage of CIFAR researchers contributing to top 1% of most-cited papers at world level from 2008–2013, based on data compiled by Science-Metrix.

- **67 major awards and honours received by 16% of CIFAR fellows and advisors.** See Appendix A for details (pages 62–65).

Program Activity

- **29 program interaction meetings held in 7 countries**
  > Attendance included 224 international guests from 15 countries
- **1 special-topic workshop supporting a program research theme**
- **CIFAR partnered with 14 organizations from 6 countries to support 12 program meetings and knowledge outreach events**
- **2,111 peer-reviewed publications**
  > 16% co-authored by two or more fellows
- **80% of CIFAR fellows say their exposure to new perspectives, gained through their program participation, is a highly important influence on their research**
  > 62% describe this exposure as unique to CIFAR
- **65% of CIFAR fellows started a new project in 2015/2016, directly catalyzed by their program participation**
  > 65% of these new projects were in collaboration with other CIFAR fellow(s) or meeting guest(s)
  > 74% were inspired by fellows' exposure to new perspectives and approaches within their CIFAR program

EUROPE AND MIDDLE EAST (66)

Austria
University of Innsbruck

Belgium
Université libre de Bruxelles

Czech Republic
Czech Academy of Sciences

Finland
University of Helsinki

France (12)
Collège de France (2)
École Normale Supérieure
École Polytechnique
Inria (2)
Inserm
Institut Pasteur (2)
Laboratoire National des Champs Magnetiques Intenses
Musée du quai de Branly
Sciences Po

Germany (16)
Kiel University
Max Planck Institute for Astrophysics
Max Planck Institute for Chemical Physics of Solids
Max Planck Institute for Intelligent Systems
Max Planck Institute for Polymer Research
Max Planck Institute for Quantum Optics
Max Planck Institute for Solid State Research (3)
Max Planck Institute for the Structure and Dynamics of Matter
Max Planck Institute of Biochemistry
Max Planck Institute of Psychiatry
RWTH Aachen
Technische Universität Dresden
University of Cologne
University of Ulm

Israel (3)
The Hebrew University of Jerusalem
Weizmann Institute of Science (2)

Italy (2)
Bocconi University
University of Milan

The Netherlands (4)
Centrum voor Wiskunde en Informatica
Leiden University
University of Amsterdam
Vrije Universiteit Amsterdam

Sweden (2)
Karolinska Institutet
Stockholm University

Switzerland (3)
École polytechnique fédérale de Lausanne (EPFL)
ETH Zürich (2)

United Kingdom (20)
Durham University
European Southern Observatory
King's College London (2)
London School of Economics & Political Science
Queen Mary, University of London
University of Cambridge (5)
University of Edinburgh (2)
University of Exeter
University of Glasgow
University of Oxford (4)
University of Sussex

ASIA PACIFIC (7)

Australia (2)
University of Queensland (2)

China (3)
Chinese Academy of Sciences
Tsinghua University
University of Hong Kong

Japan (2)
Kyoto University
RIKEN

2

Position Stakeholders to Act

CIFAR's research programs are a continuous source of new discoveries and insights that have the potential to transform fields of research, or have immediate or long-term implications for the wider world. CIFAR has a priority to develop a community of leaders in industry, policy and practice who can actively engage with our fellows and benefit from the knowledge discovered in our research programs.

140,445
unique visitors to the CIFAR website

6,500 followers on social media

3,750
people engaged in knowledge outreach and public events in person or by webcast

23
events worldwide

Knowledge Outreach and Public Engagement

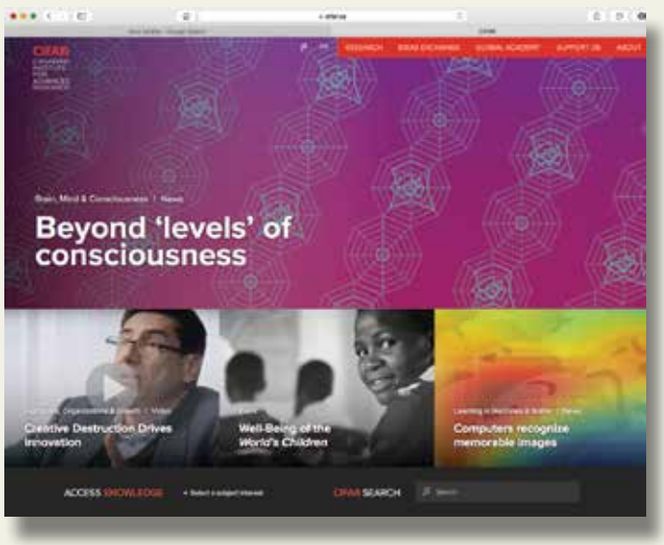
- **23 total engagements**
  - > 12 knowledge outreach engagements in Canada (Vancouver, Edmonton, Calgary, Ottawa, Toronto and Montreal)
  - > 8 public events in Canada (Ottawa and Toronto)
  - > 1 knowledge outreach event outside of Canada (Boston, USA)
  - > 2 public events outside of Canada (Brisbane, Australia, and Mexico City, Mexico)
- **Participant surveys highlighted:**
  - > 88% rated their experience as excellent or very good
  - > 85% came away with new ideas
  - > 72% made new contacts
  - > 78% plan to integrate their new knowledge into their work

Online and Print Resources

- **37 new online and print resources published, including:**
  - > 7 issues of *News & Ideas* e-newsletter, distributed to nearly 8,000 recipients per month
  - > Annual issue of *REACH* magazine, published in June 2015 and distributed to 6,500 recipients
  - > 11 research and symposium summaries
  - > 6 videos and 1 podcast
- **140,445 unique visitors to the CIFAR website and more than 6,500 followers on social media**

85%
of participants came away with new ideas

> **“ SUCH A GREAT AND RARE OPPORTUNITY FOR ALLIED PROFESSIONALS TO GET TOGETHER IN THE SAME ROOM, LEARN FROM THE EXPERTS AND THINK ABOUT THE IMPLICATIONS ...”**
>
> **– PARTICIPANT, CHANGE MAKERS WORKSHOP (CALGARY)**



3

Nurture the Next Generation of Research Leaders

CIFAR is committed to developing tomorrow's research leaders by engaging and mentoring them in the deep collaborations that CIFAR forms within its research programs. The Global Academy offers a range of opportunities for graduate students, postdoctoral fellows and assistant professors in Canada and across the globe, to learn from and collaborate with some of the world's top minds, positioning them to become the leading thought innovators of their generation.

611 postdoctoral fellows

1,071 graduate students, including: 188 PhD candidates who graduated

193 CIFAR Azrieli Global Scholar applicants from 31 countries

CIFAR Global Academy

- **CIFAR Azrieli Global Scholars Program**
  - > Launched with $5 million in funding support from the Azrieli Foundation
  - > 193 applicants from 31 countries on six continents attracted through first global call for applications
  - > 35 candidates from 8 countries short-listed by CIFAR's research programs (29 attended in-person interactive group interview process in Toronto)
  - > 18 CIFAR Azrieli Global Scholars based in 5 countries selected to 8 research programs, to be announced in fall 2016
- **CIFAR Postdoctoral Fellows**
  - > 6 competitively awarded positions co-supervised by CIFAR fellows in support of high-risk, collaborative projects
  - > 3 programs supporting 'shared' postdocs to date (Bio-inspired Solar Energy, Child & Brain Development, Molecular Architecture of Life)

18 CIFAR AZRIELI GLOBAL SCHOLARS APPOINTED

CIFAR-Supported Summer Schools

Program	Summer School	Co-sponsors (in Addition to CIFAR)	Attendance	Location and Dates
Learning in Machines & Brains	CIFAR Deep Learning Summer School	Hosted by l'Université de Montréal	153	Montreal, Quebec, August 3–12, 2015
Quantum Information Science	15th Canadian Summer School on Quantum Information	Fields Institute; University of Toronto; Institute for Quantum Computing, University of Waterloo; Perimeter Institute for Theoretical Physics; Institute for Quantum Science & Technology, University of Calgary; CryptoWorks21; Epiq	63	Toronto, Ontario, August 10–14, 2015
Quantum Materials	CIFAR Quantum Materials Summer School	Gordon and Betty Moore Foundation	71	Toronto, Ontario, April 24–27, 2016

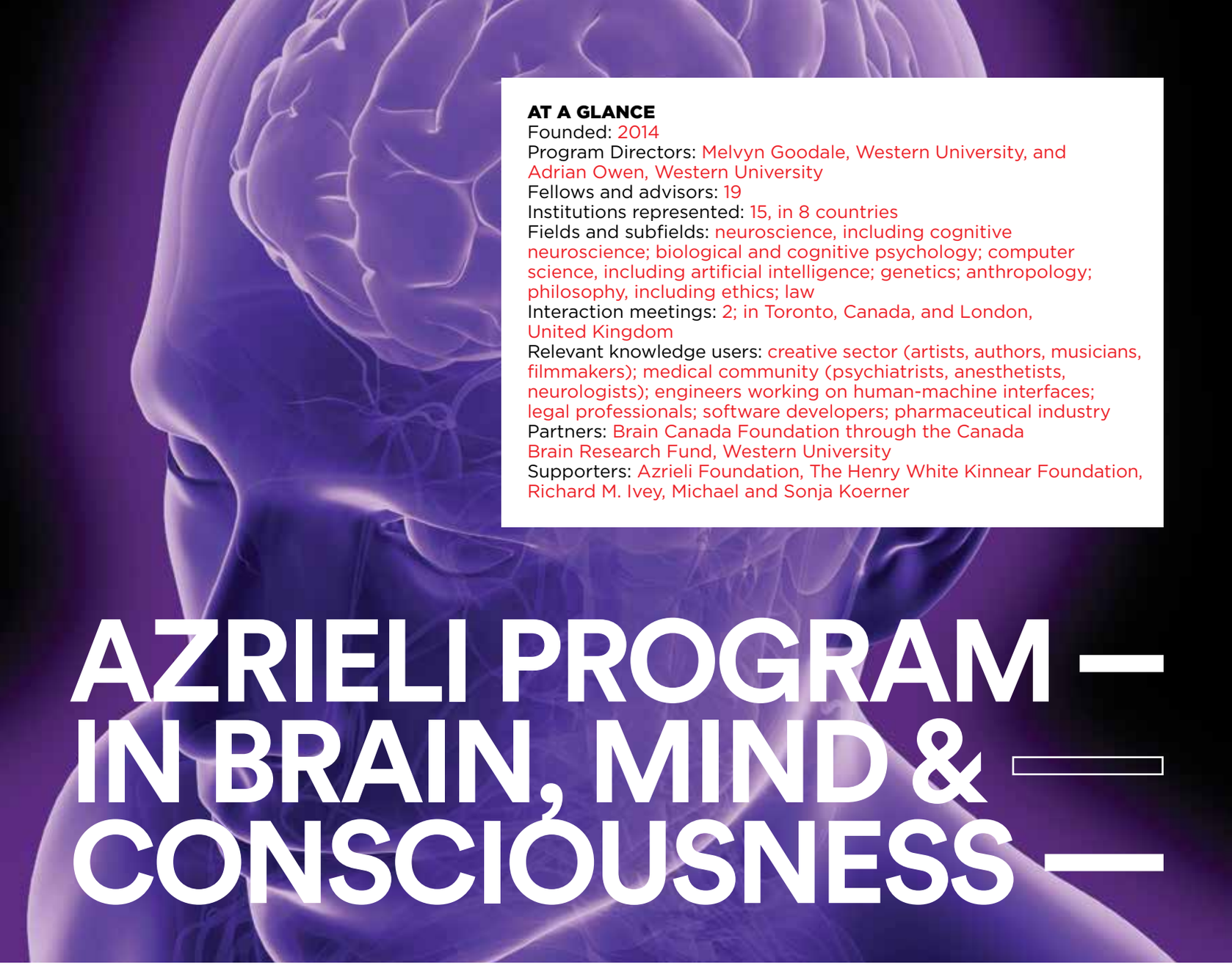
Additional Trainee Opportunities and Benefits

- **81% of CIFAR fellows reported their program participation benefited their trainees in 2015/2016.** For example:
  - > 41% had a student or postdoc attend a CIFAR meeting, providing close-range exposure to top researchers and new perspectives
  - > 34% had trainees directly engaged in a research collaboration with another CIFAR fellow
  - > 35% used a portion of their CIFAR research funds to support trainee salaries
- **166 graduate students and postdoctoral fellows attended CIFAR program meetings**
- **CIFAR fellows supervised 611 postdoctoral fellows and 1,071 graduate students, including 188 PhD candidates who graduated**

1,682 TRAINEES SUPERVISED

RESEARCH PROGRAMS ANNUAL HIGHLIGHTS

CIFAR fellows took a major step toward understanding the basic physics of superconductivity using the 90-tesla magnet system at the National Laboratory for Intense Magnetic Fields in Toulouse, France. Image courtesy of Nanda Gonzague, taken for Quanta Magazine.



AT A GLANCE
Founded: 2014
Program Directors: Melvyn Goodale, Western University, and Adrian Owen, Western University
Fellows and advisors: 19
Institutions represented: 15, in 8 countries
Fields and subfields: neuroscience, including cognitive neuroscience; biological and cognitive psychology; computer science, including artificial intelligence; genetics; anthropology; philosophy, including ethics; law
Interaction meetings: 2; in Toronto, Canada, and London, United Kingdom
Relevant knowledge users: creative sector (artists, authors, musicians, filmmakers); medical community (psychiatrists, anesthetists, neurologists); engineers working on human-machine interfaces; legal professionals; software developers; pharmaceutical industry
Partners: Brain Canada Foundation through the Canada Brain Research Fund, Western University
Supporters: Azrieli Foundation, The Henry White Kinnear Foundation, Richard M. Ivey, Michael and Sonja Koerner

AZRIELI PROGRAM IN BRAIN, MIND & CONSCIOUSNESS

Seeks to examine the neural underpinnings of consciousness, leading to better treatments for mental health disorders and insights into the most profound questions about human nature.

The Azrieli Program in Brain, Mind & Consciousness at CIFAR completed its first full year in 2015/2016. During the year, the program expanded its membership from nine to 19 researchers, including nine new senior fellows from seven countries.

The research agenda for this program is broad and ambitious, incorporating such issues as identifying the specifically human aspects of consciousness, the neural basis of these distinctively human traits, how they are acquired developmentally and whether machines can have consciousness. The program's first two meetings enabled progress on these issues by bringing together theorists and experimentalists across a broad range of disciplines — cognitive neuroscientists, neurologists, geneticists and other biologists, psychologists, computational scientists and philosophers — in contexts that facilitated the generation and exchange of new ideas and began to establish a common language and framework of investigation. Fellows began to identify highly focused thematics for the next four program meetings, including biomarkers of consciousness, the development of consciousness, artificial intelligence and the dynamics of consciousness.

The program also held its first public outreach event, attracting an audience of 900, plus nearly 700 viewers online, to explore how the human brain engages with music. Fellows developed plans for three upcoming major international initiatives, including a symposium on The Origins of Consciousness in conjunction with the 2016 Annual Meeting of the Japanese Neuroscience Society in Tokyo.

Research

- Following discussion at the December 2015 program meeting, Koerner Fellow **Adrian Owen** and Senior Fellow **Timothy Bayne** (both Western University) collaborated on a new paper that argued that the levels-based framework for conceptualizing global states of consciousness is untenable and developed in its place a multidimensional account of global states. The paper has already generated significant discussion in the literature.
  > **Bayne T**, Hohwy J, **Owen AM**. 2016. Are there levels of consciousness? Trends Cogn Sci. 20(6): 405-413.

- The program facilitated the recruitment of Senior Fellow **Lisa Saksida** from the University of Cambridge, United Kingdom, to Western University in Canada. Dr. Saksida is a world-renowned neuroscientist whose research seeks to understand the psychological processes underlying memory and perception. This move would not have occurred had it not been for the networking possibilities created by the Azrieli Program in Brain, Mind & Consciousness at CIFAR.

- CIFAR support of Senior Fellow **Axel Cleeremans** (Université libre de Bruxelles) is enabling the development of a neural network–based computational model of the meta-representational processes through which one network can re-describe what another network is doing. This relationship between a first-order mechanism and a higher-order mechanism is a crucial building block of conscious agents.

IdeasExchange

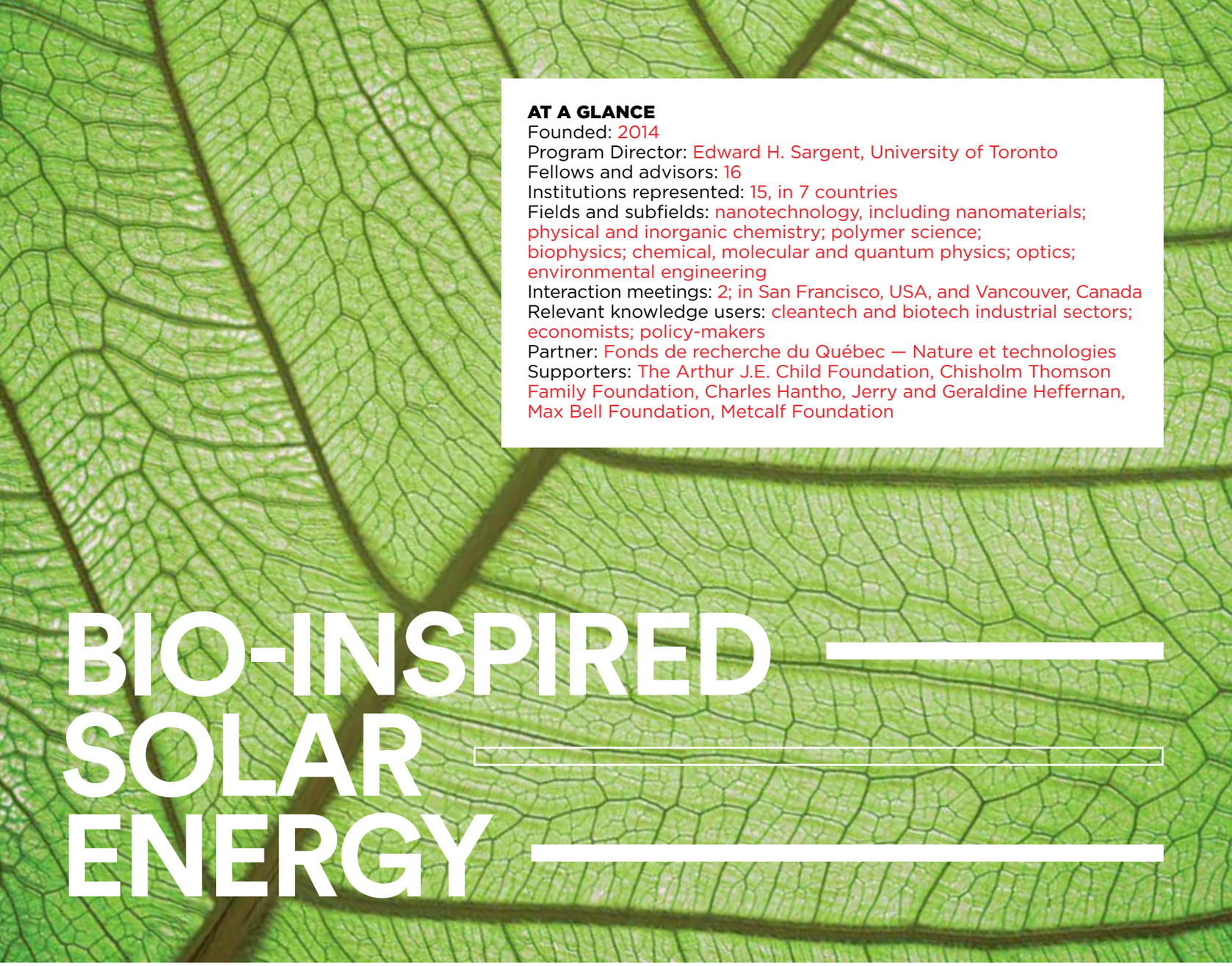
- The program initiated a public outreach event entitled **Our Musical Brain**, which combined musical performance and presentations to explore what happens in our brains when we engage with music. The sold-out event at Koerner Hall in Toronto featured performances by Canada's acclaimed chamber ensemble, the Gryphon Trio, along with mezzo-soprano Julie Nesrallah, who also served as host for the evening. Leading neuroscientists and CIFAR Senior Fellows **Laurel Trainor** (McMaster University) and **Robert Zatorre** (McGill University) gave presentations exploring the conscious and unconscious mental processes involved in making, perceiving and responding to music.

Global Academy

- The program has already begun to engage early-career researchers in their ongoing activities. Two postdoctoral fellows from Western University attended program meetings in the role of program reporters. The program also began planning for a 2017 Winter School to be held in Banff, Alberta. This event, held every two years, will be organized by program member trainees, and lecturers will be chosen to reflect the program's breadth of topics and disciplines. Attendees will be chosen through a highly competitive selection process.

To learn more: **https://www.cifar.ca/research/brain-mind-consciousness/**

Senior Fellow
Axel Cleeremans presents at the December 2015 meeting of the Azrieli Program in Brain, Mind & Consciousness at CIFAR.



AT A GLANCE
Founded: 2014
Program Director: Edward H. Sargent, University of Toronto
Fellows and advisors: 16
Institutions represented: 15, in 7 countries
Fields and subfields: nanotechnology, including nanomaterials; physical and inorganic chemistry; polymer science; biophysics; chemical, molecular and quantum physics; optics; environmental engineering
Interaction meetings: 2; in San Francisco, USA, and Vancouver, Canada
Relevant knowledge users: cleantech and biotech industrial sectors; economists; policy-makers
Partner: Fonds de recherche du Québec — Nature et technologies
Supporters: The Arthur J.E. Child Foundation, Chisholm Thomson Family Foundation, Charles Hantho, Jerry and Geraldine Heffernan, Max Bell Foundation, Metcalf Foundation

BIO-INSPIRED SOLAR ENERGY

Aims to improve our ability to use solar energy by learning lessons from the remarkable effectiveness of photosynthesis in plants, algae and photosynthetic bacteria.

The program in Bio-inspired Solar Energy completed the first year of its initial five-year term in 2015/2016. Aiming to make sustainable energy sources, such as solar and wind, cost-effective and ubiquitous, the program's scientific strategy involves studying how nature's photosynthetic organisms already achieve this goal, and seeking inspiration for new materials, chemistries, devices and systems from these compelling biological precedents.

During the year, the program held two successful program meetings, which helped to further refine the intellectual agenda of the program and expand the program's membership. Resulting from these interactions, the program grew to include 11 appointed fellows and five advisory committee members.

With newly designed support from CIFAR, the program ran a competitive process to identify, recruit and support three postdoctoral fellows and six graduate students, each of whom are being jointly supervised by two or more program fellows. These two-year positions will support specific, high-risk collaborative projects designed to advance the program's research thematics and strengthen the intellectual synergy among program members.

The program also held preliminary discussions with relevant industrial stakeholders by inviting three industrial representatives to participate in the program meeting held in Vancouver. The program has identified the energy sector as a highly relevant intellectual input to the program's research direction and is aiming to embed industrial influence by bringing key individual researchers from industry into the program to serve as links between advanced research and future commercial applications.

Research

- Fellows **Alán Aspuru-Guzik** (Harvard University), **Greg Scholes** (Princeton University) and CIFAR Advisor **Robert Blankenship** (Washington University in St. Louis) have formed a new collaboration to study the evolution of the Fenna-Matthews-Olson complex, a notable pigment-protein complex found in bacteria that mediates the conversion of light into energy. Probing the underlying mechanisms in this system may enable new understanding of natural and artificial photosynthetic systems and brings together experts in computational modeling, biochemistry and photophysics.

- In a recent collaboration, fellows **Chris Chang** and **Peidong Yang** (both University of California, Berkeley) successfully combined catalytic molecules and nanomaterials on a single platform to enhance the catalyst efficiency for the reduction of carbon dioxide to syngas, a valuable intermediate in the production of synthetic fuels.
  > Kornienko N, Zhao Y, Kley CS, Zhu C, Kim D, Lin S, **Chang CJ**, Yaghi OM, **Yang P**. 2015. Metal-organic frameworks for electrocatalytic reduction of carbon dioxide. J Am Chem Soc. 137: 14129-14135.

- The group of Heffernan Director and Senior Fellow **Edward Sargent** (University of Toronto) designed the most efficient catalyst for storing energy in chemical form by splitting water into hydrogen and oxygen (similar to photosynthesis). A key element of success was the use of a catalyst made of tungsten, iron and cobalt that was found to be over three times more efficient than the current state of the art.
  > Zhang B, Zheng X, Voznyy O, Comin R, Bajdich M, García-Melchor M, Han L, Xu J, Liu M, Zheng L, García de Arquer FP, Dinh CT, Fan F, Yuan M, Yassitepe E, Chen N, Regier T, Liu P, Li Y, De Luna P, Janmohamed A, Xin HL, Yang H, Vojvodic A, **Sargent EH**. 2016. Homogeneously dispersed, multimetal oxygen-evolving catalysts. Science. 352(6283): 333-337.

Other notable publications

- Mirkovica T, Ostroumovb EE, Annac JM, **van Grondelle R**, Govindjee, **Scholes GD**. 2016. Light absorption and energy transfer in the antenna complexes of photosynthetic organisms. Chem Rev. In press.

IdeasExchange

- In October 2015, Senior Fellow **Jillian Buriak** (University of Alberta) participated in a technical engagement session focused on innovation and technology as part of the Climate Leadership Discussions of the Government of Alberta's Climate Change Advisory Panel. She presented the goals and research directions of CIFAR's program in Bio-inspired Solar Energy, as well as insights from her own research. Approximately 30 participants attended the session, representing research funders, industry, government and innovation support agencies.

- Senior Fellow **Alán Aspuru-Guzik** (Harvard University) helped to facilitate an invitation to give a plenary lecture in Mexico City on **Global Networks: the Future of Energy**, together with CIFAR President and CEO **Alan Bernstein** in April 2016. Hosted by the Energy Sustainability Fund of Mexico's Ministry of Energy, and held at the National Autonomous University of Mexico, the event attracted nearly 200 participants, including stakeholders from academia and the public and private sectors.

Global Academy

- The program has begun training the next generation of research leaders by inviting students and postdoctoral fellows to participate in program meetings. The program also recently decided to use newly allocated support from CIFAR to recruit graduate students and postdoctoral fellows to be jointly supervised between program fellows in an effort to expose burgeoning researchers to multidisciplinary approaches and ideas.

To learn more: **https://www.cifar.ca/research/bio-inspired-solar-energy/**

Heffernan Director and Senior Fellow Edward Sargent speaks at the December 2015 meeting of CIFAR's program in Bio-inspired Solar Energy.

AT A GLANCE
Founded: 2003
Most recent renewal: 2012
Program Directors: W. Thomas Boyce, University of California, San Francisco, and Marla Sokolowski, University of Toronto
Fellows and advisors: 22
Institutions represented: 16, in 4 countries
Fields and subfields represented: behavioural, developmental, molecular and evolutionary biology; behaviour genetics; epigenetics; cognitive and developmental neuroscience; biological, cognitive and developmental psychology; psychiatry; biological anthropology; epidemiology; public and environmental health; social biomedical science
Interaction meetings: 3; in Montreal, Vancouver and Calgary, Canada
Relevant knowledge user groups: mental health practitioners; early childhood educators; judges and practitioners specializing in juvenile justice
Supporters: The Alva Foundation, George Weston Limited, Great-West Life, London Life and Canada Life, The Joan and Clifford Hatch Foundation, The W. Garfield Weston Foundation, 1 anonymous donor

CHILD & BRAIN DEVELOPMENT

Explores the core question of how social experiences and settings affect developmental biology and help set early trajectories of lifelong development and health.

2015/2016 proved a strong and eventful year for the program in Child & Brain Development. Fellows came together in three program meetings and held an outreach activity associated with CIFAR's Change Makers series. Two new fellows were appointed who expand the range of research expertise in the group, bringing new ideas and perspectives from different subfields in neuroscience. Two new shared postdoctoral fellows were appointed, each of whom will join two program fellows in driving new collaborative research projects. The program will host a prestigious Marbach Conference in April 2018, based on their successful proposal submitted this year. These conferences, held annually by the Jacobs Foundation, support multidisciplinary specialist discussions on issues in child and youth development and on the transfer of research findings into practice.

This year, a strong focus of the program has been on identifying new research directions and opportunities where the group is best positioned to have impact. This effort has included incorporating new topics and themes into program meetings, such as the human 'connectome' — a term referring to brain areas, their anatomical connections and their functional interactions — and large-scale approaches to mining rich biological data. The program also explored potential new inter- and intra-program collaborations, identified additional areas of expertise that could benefit the program and examined future ways to disseminate the knowledge created from the program.

Research

- Work by fellows **Joel Levine** (University of Toronto), **W. Thomas Boyce** and CIFAR Advisor **Nancy Adler** (both University of California, San Francisco) and others found that relationships among children may not be as hierarchical as often assumed. Applying a new social network analysis approach derived from Levine's studies of social behaviour in flies, they observed some hierarchy in kindergarten classrooms, but also many interactions that did not follow rank. The finding adds complexity to our understanding of relationships and could help distinguish normal versus concerning behaviour in children at an early age.
  > Golemiec M, Schneider J, **Boyce WT**, Bush NR, **Adler N**, **Levine JD**. 2016. Layered social network analysis reveals complex relationships in kindergarteners. Front Psychol. 7: 276.

- A collaboration between fellows **Megan Gunnar** (University of Minnesota) and **Michael Kobor** (University of British Columbia) showed that early adverse life conditions have effects that are still observable years after marked improvements in children's living conditions. The study combined Gunnar's research on a US-based cohort of adopted children exposed to substantial early-life adversity in Eastern Europe with Kobor's advanced technology to measure epigenetic marks. Their analysis found that the adopted children's immune cells showed patterns of gene methylation different from those of children born into well-resourced homes, suggesting an increased risk for poor health outcomes.
  > Esposito EA, Jones J, Doom JR, MacIsaac JL, **Gunnar MR**, **Kobor MS**. 2016. Differential DNA methylation of peripheral blood mononuclear cells in adolescents adopted as young children from orphanages in Russia and Eastern Europe. Dev Psychopathol. 5: 1-15.

- Discussions on epigenetics and development at CIFAR program meetings led Senior Fellow **Bryan Kolb** (University of Lethbridge) and collaborators to design rat experiments studying how preconception stress on future fathers affects the subsequent neuro-development and behaviour of their eventual offspring. The study resulted in direct evidence that preconception paternal stress modifies brain architecture in developing offspring, which may contribute to later neurodevelopmental disorders.
  > Harker A, Raza S, Williamson K, **Kolb B**, Gibb R. 2015. Preconception paternal stress in rats alters dendritic morphology and connectivity in the brain of developing male and female offspring. Neuroscience. 303: 200-210.

Other notable publication

- Bruderer AG, Danielson DK, Kandhadai P, **Werker JF**. 2015. Sensorimotor influences on speech perception in infancy. P Natl Acad Sci USA. 112(44): 13531-13536.

IdeasExchange

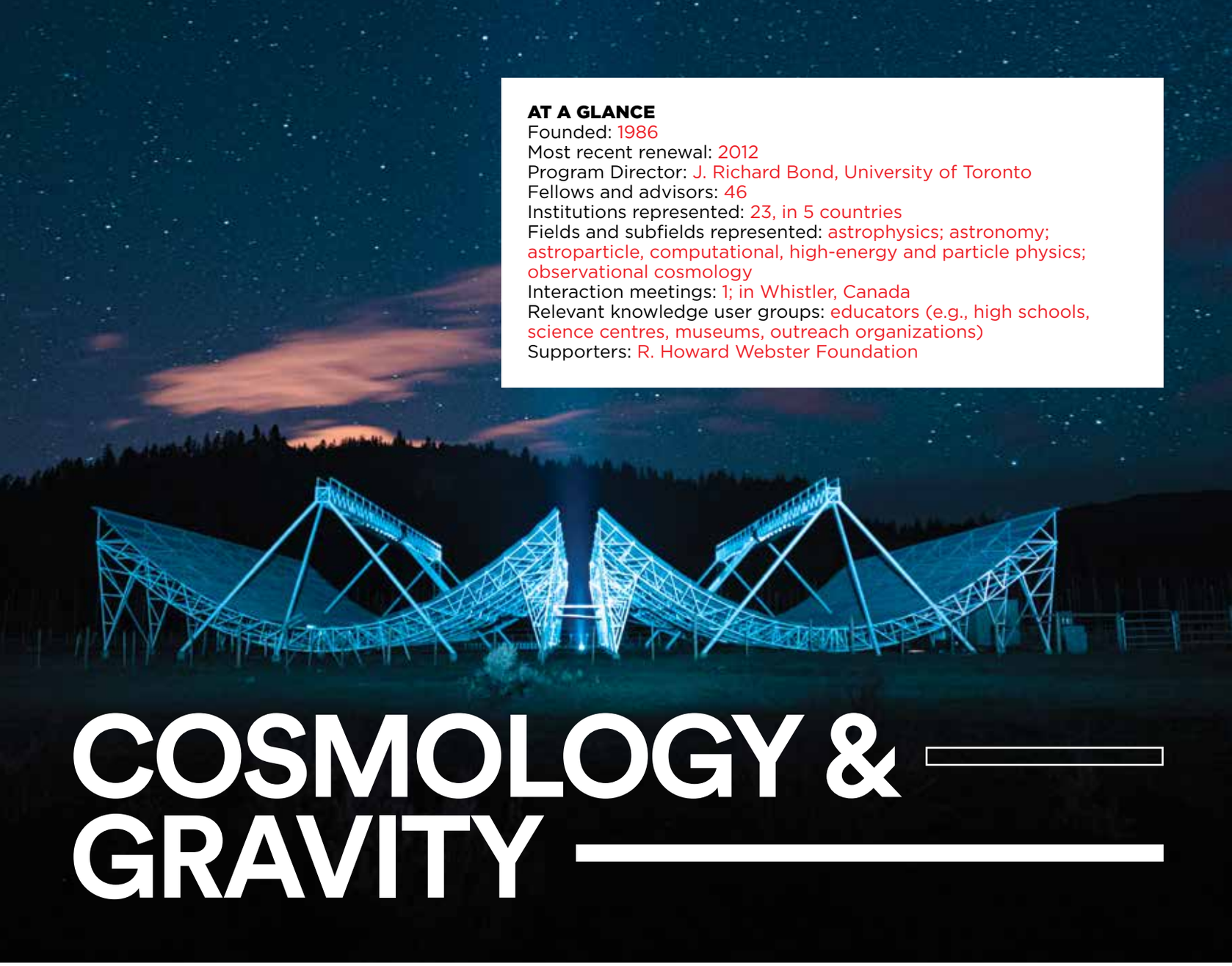
- Program fellows engage across a wide variety of stakeholder groups, including physicians, parents, educators, policy-makers and many more. In 2015/2016, fellows took part in a CIFAR Change Makers symposium, where researchers and leading practitioners shared insights on early childhood adversity and its impacts on academic achievement, health and well-being, and how to create research-informed interventions to better reach at-risk children in school environments. The event was held in partnership with the Alberta Centre for Child, Family & Community Research.

Global Academy

- This year, the program appointed two postdoctoral fellows, each co-supervised by a pair of program fellows, to help facilitate high-risk collaborative research projects. These two-year appointments are co-funded by CIFAR and the Alva Foundation. The post-docs will attend and present research at the program meetings.

To learn more: **https://www.cifar.ca/research/child-brain-development/**

Fellow Sara Mostafavi at the October 2015 meeting of CIFAR's program in Child & Brain Development.



AT A GLANCE
Founded: 1986
Most recent renewal: 2012
Program Director: J. Richard Bond, University of Toronto
Fellows and advisors: 46
Institutions represented: 23, in 5 countries
Fields and subfields represented: astrophysics; astronomy; astroparticle, computational, high-energy and particle physics; observational cosmology
Interaction meetings: 1; in Whistler, Canada
Relevant knowledge user groups: educators (e.g., high schools, science centres, museums, outreach organizations)
Supporters: R. Howard Webster Foundation

COSMOLOGY & GRAVITY

Attempts to tell a comprehensive story of the structure and evolution of the universe, from its first moment of existence to its ultimate fate.

The first direct observation of gravitational waves made earlier this year by the Laser Interferometer Gravitational-wave Observatory (LIGO) collaboration opened up the possibility of understanding fundamental physics and the very early universe through gravitational-wave observations. The program in Cosmology & Gravity capitalized on this recent finding, positioning it as a key focus for its annual program meeting in spring 2016. The meeting engaged scientists from within and outside of the program to explore new opportunities as the field advances into a budding era of gravitational-wave astronomy. Fellows also explored the frontiers of our knowledge of neutron stars, black holes and fast radio bursts, dark matter and galaxies, cosmology and fundamental theory. Discussions focused heavily on identifying key challenges and state-of-the-art science that might serve as the focus for the program's upcoming renewal proposal.

The 2015/2016 year was also notable for the many prestigious honours awarded to program fellows, including some of the highest recognitions bestowed in a field or country. Highlights included the Nobel Prize in Physics to **Arthur McDonald** (Queen's University); the Gerhard Herzberg Canada Gold Medal for Science and Engineering to **Victoria Kaspi** (McGill University); the Crafoord Prize in Astronomy to **Roger Blandford** (Stanford University); and the Friedrich Wilhelm Bessel Research Award to **Harald Pfeiffer** (University of Toronto) and **Ludovic van Waerbeke** (University of British Columbia). A full listing appears in Appendix A.

Research

- Fellow **Harald Pfeiffer** (University of Toronto) contributed to the breakthrough LIGO study, which detected gravitational waves left over from the collision of two black holes more than a billion years ago. This landmark discovery may finally allow physicists to complete the task Einstein set out to do almost a century ago: unify all the fundamental forces into a theory of everything. Dr. Pfeiffer helped to detect and validate the gravitational-wave findings, and is one of several CIFAR fellows in the Cosmology & Gravity program who are approaching the search for gravity waves from different perspectives and disciplines.
  > LIGO Scientific Collaboration and Virgo Collaboration, including Abbott BP, **Pfeiffer HP**. 2016. Observation of gravitational waves from a binary black hole merger. Phys Rev Lett. 116: 061102.

- In a collaboration led by R. Howard Webster Foundation Fellow **Victoria Kaspi** (McGill University), CIFAR fellows obtained a multimillion dollar grant from the Canada Foundation for Innovation to build an instrument that will enable the Canadian Hydrogen Intensity Mapping Experiment (CHIME) telescope, designed for other purposes, to detect fast radio bursts. Only a handful of these seemingly random bursts of radio waves of unknown origin have been discovered, but CHIME's vast sky-scanning capacity may help to detect many more. Contributors to the project include fellows **Matthew Dobbs** (McGill University), **Mark Halpern**, **Ingrid Stairs**, **Gary Hinshaw** (all University of British Columbia), and **J. Richard Bond** and **Ue-Li Pen** (both University of Toronto).

Other notable publication

- The NANOGrav Collaboration, including Arzoumanian Z, **Kaspi VM**, **Ransom SM**, **Stairs IH**. 2015. The NANOGrav nine-year data set: observations, arrival time measurements, and analysis of 37 millisecond pulsars. Astrophys J. 813(1).

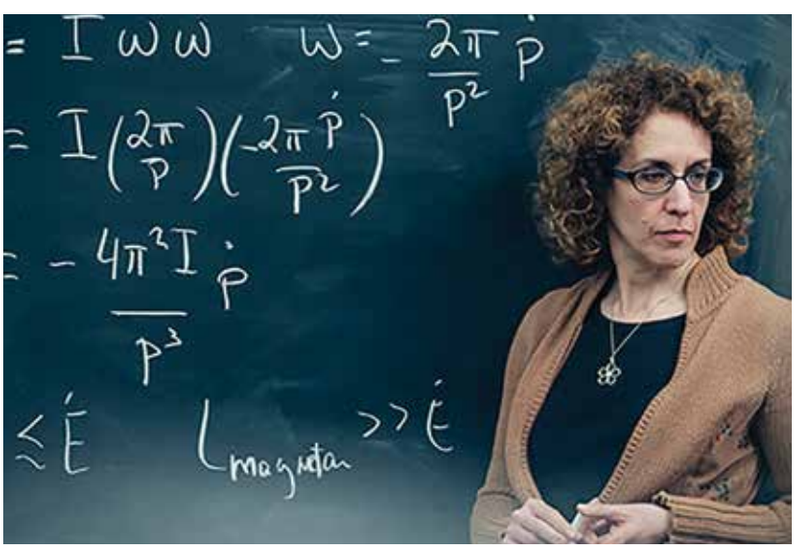
IdeasExchange

- Program fellows regularly engage in outreach activities aimed at the general public and more specialized audiences. The program has identified educators, such as those in schools, planetariums and outreach organizations, as key audiences that can put the knowledge it generates into action, as well as the great potential to broaden its outreach efforts through various media channels. The program has begun to explore new ways to engage with these audiences.

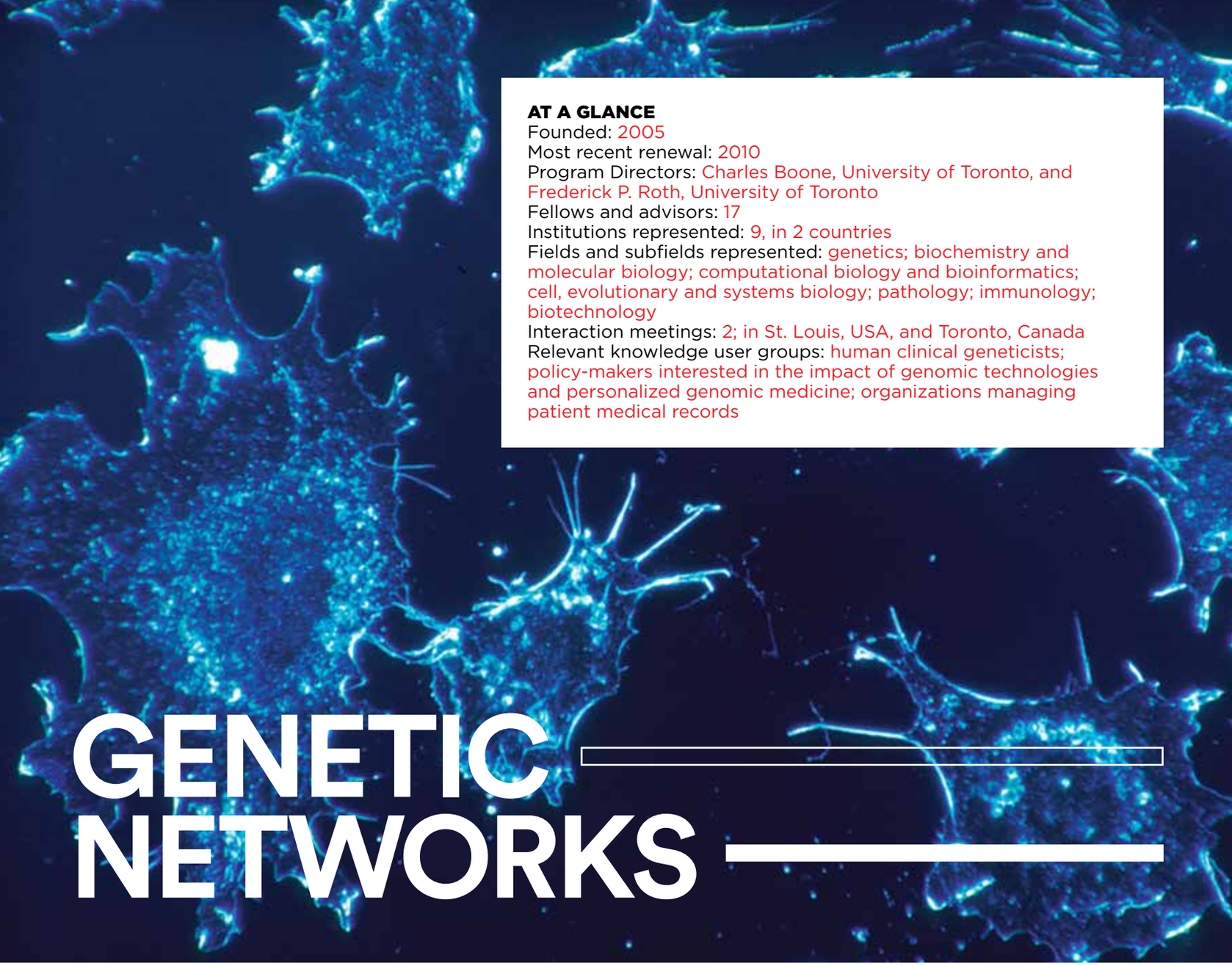
Global Academy

- Fellows in the program collectively supervise nearly 150 highly qualified personnel each year. Fellows engage these early career researchers in the CIFAR model of research in a variety of ways, where possible, including bringing them to program meetings, supporting them on collaborative projects with other fellows, engaging them in discussion with researchers from outside of their traditional research areas, and supporting interaction and movement among other fellows' research groups.

To learn more: **https://www.cifar.ca/research/cosmology-gravity/**



R. Howard Webster Foundation Fellow Victoria Kaspi received the 2016 Gerhard Herzberg Canada Gold Medal for Science and Engineering.



AT A GLANCE
Founded: 2005
Most recent renewal: 2010
Program Directors: Charles Boone, University of Toronto, and Frederick P. Roth, University of Toronto
Fellows and advisors: 17
Institutions represented: 9, in 2 countries
Fields and subfields represented: genetics; biochemistry and molecular biology; computational biology and bioinformatics; cell, evolutionary and systems biology; pathology; immunology; biotechnology
Interaction meetings: 2; in St. Louis, USA, and Toronto, Canada
Relevant knowledge user groups: human clinical geneticists; policy-makers interested in the impact of genomic technologies and personalized genomic medicine; organizations managing patient medical records

GENETIC NETWORKS

Devoted to mapping the biological networks that translate genomes into complex traits and improving our fundamental understanding of biological systems to enable new treatments and preventive measures.

The program in Genetic Networks experienced a diverse range of activities over the past year. The program underwent a planned leadership change to have Senior Fellow **Charles Boone** serve as Program Co-Director with **Frederick Roth**. The program also held two program meetings: one at Washington University in St. Louis, USA, and the other in Toronto, Canada, both of which had strong participation of graduate students and postdoctoral fellows. Program fellows used these meetings as an opportunity to discuss the program's future scientific plans as they near the end of their current five-year research term. The program has decided to pursue a stronger integration of human genetics. Their goal is to leverage the knowledge obtained through their investigation of genetic networks in model organisms and apply the approaches, understanding and methodologies to better understand the genetic underpinning of human disease. As such, the fellows used their meetings as a strategic opportunity to engage researchers from the human genetics community. Program meetings were also used as a strategic opportunity to enhance the program's ties with the Japanese genetic networks community by inviting several Japanese researchers from RIKEN and the University of Tokyo.

The program also underwent a five-year external review to assess its achievements over its second full program term. To assess the program and its proposal for renewal, an international review panel consisted of subject-matter experts from the United Kingdom, the United States, Germany and Canada.

Research

- Fellows **Charles Boone**, **Brenda Andrews** (both University of Toronto) and **Chad Myers** (University of Minnesota) finished mapping genetic interactions between more than 20 million double mutant strains in yeast. The analysis encompassed over 95 per cent of all genes in the yeast genome and identified about one million interactions, providing the first complete genetic interaction map for any organism. The mapped network reveals a hierarchical model of cell function, as well as general principles of genetic networks. As such, it is expected to serve as an atlas for mapping analogous networks in more complex biological systems. This work is currently submitted for publication.

- Fellows **Jason Moffat** and **Frederick Roth** (both University of Toronto) and collaborators worked on a research project that switched off nearly 18,000 human genes, or approximately 90 per cent of the human genome, allowing the researchers to identify particular genes essential for cell survival. The results of this study were published in *Cell*.
  > Hart T, Chandrashekhar M, Aregger M, Steinhart Z, Brown KR, MacLeod G, Mis M, Zimmermann M, Fradet-Turcotte A, Sun S, Mero P, Dirks P, Sidhu SS, **Roth FP**, Rissland OS, Durocher D, Angers S, **Moffat J**. 2015. High resolution CRISPR screens reveal fitness genes and genotype-specific cancer liabilities. Cell. 163(6): 1515-1526.

- Fellows **Andrew Fraser**, **Brenda Andrews**, **Charles Boone**, **Jason Moffat** (all University of Toronto), **Philip Hieter** (University of British Columbia) and **Chad Myers** (University of Minnesota) initiated a major new collaboration. Using insights from the complete yeast genetic network and a combination of genetic and chemical tools, the team will select genes to screen for genetic interactions in *C. elegans*, a human haploid cell line, and in different cancer cell lines.

Other notable publications

- Bailey ML, Singh T, Mero P, **Moffat J**, **Hieter P**. 2015. Dependence of human colorectal cells lacking the FBW7 tumor suppressor on the spindle assembly checkpoint. Genetics. 201: 885-895.
- Sun S, Yang F, Tan G, Costanzo M, Oughtred R, Hirschman J, Theesfeld CL, Bansal P, Sahni N, Yi S, Yu A, Tyagi T, Tie C, Hill DE, Vidal M, **Andrews BJ**, **Boone C**, Dolinski K, **Roth FP**. 2016. An extended set of yeast-based functional assays accurately identifies human disease mutations. Genome Res. 26(5): 670-680.

IdeasExchange

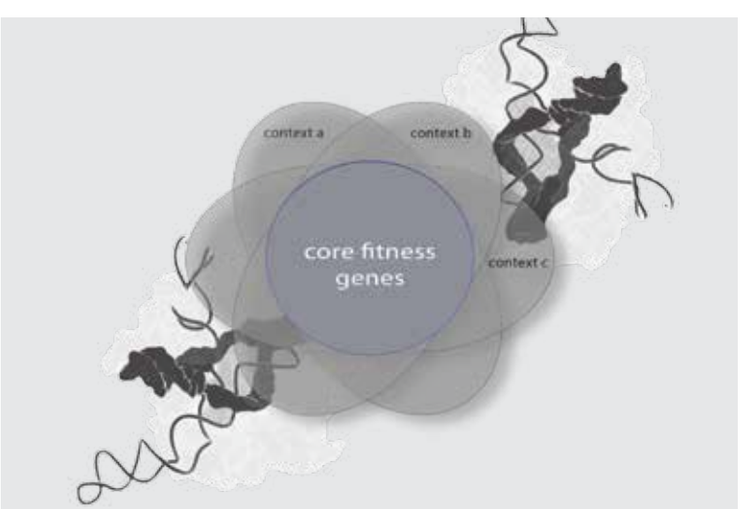
- At their program meeting in Toronto, fellows invited Dr. Hanna Faghfoury, a physician from the University of Toronto medical school responsible for the medical genetics undergraduate curriculum, to discuss how knowledge and insights emerging from the program could contribute to medical school curriculum development. The program has also begun developing the framework for a workshop that will aim to better understand how to extract meaningful data from personal genomes.

Global Academy

- The program regularly integrates graduate students and postdoctoral fellows into its meetings. Fellows' trainees, as well as trainees from the local academic community hosting a Genetic Networks program meeting, are invited to participate by presenting a poster or talk.

To learn more: **https://www.cifar.ca/research/genetic-networks/**

The "Daisy" model of gene essentiality. Image provided by CIFAR Senior Fellow Jason Moffat.



AT A GLANCE
Founded: 2015
Program Directors: B. Brett Finlay, University of British Columbia, and Janet Rossant, The Hospital for Sick Children, Toronto
Fellows and advisors: 17
Institutions represented: 16, in 7 countries
Fields and subfields: microbiology; developmental and evolutionary biology; bacteriology; immunology; history; cultural and medical anthropology
Interaction meetings: 2; in Niagara-on-the-Lake, Canada, and Paris, France
Relevant knowledge users: medical community (practitioners, medical schools); public health agencies; nutritional community; government policy-makers; global health agencies
Partners: Brain Canada Foundation through the Canada Brain Research Fund, Fonds de recherche du Québec — Santé, Genome BC, Genome Canada
Supporters: Jon and Nancy Love Foundation at Toronto Foundation, Manulife, Trottier Family Foundation

HUMANS & THE MICROBIOME

Examines the human microbiome — the microbes that live in and on us — and the role it plays in human development and behaviour, as well as how it is affecting our evolution and society.

2015/2016 marked the first official term year of the CIFAR program in Humans & the Microbiome. Over the year, the program expanded its membership to 12 fellows and five advisory committee members from diverse disciplines and geographic areas. Together, fellows refined and advanced their program's research goals and directions by committing to focus on five themes over their five-year term, namely: i) globalization and modernization, ii) microbiome and human development, iii) microbiota and host co-evolution, iv) microbiota transmission and v) education and outreach. Through support from CIFAR, a subset of fellows have developed a successful proposal to conduct a collaborative, proof-of-concept project that will investigate the impact of colonial rule on the human microbiome and how developments in hygiene and medicine have shaped the human microbiome. The team will attempt to identify appropriate methodologies required to analyze ancient microbiomes, identify appropriate anthropological samples and address ethical and technical challenges involved with ancient genetic material in the context of the human microbiome. During year, the program also began to refine its knowledge outreach plans and focus an approach to engage medical schools and medical professionals in conversation on the microbiome.

RESEARCH PROGRAMS
ANNUAL HIGHLIGHTS –

Research

- A high-risk, collaborative, proof-of-concept research project involving ancient microbiome samples was approved in the program. Fellows working on this project include **Tamara Giles-Vernick** and **Philippe Sansonetti** (both Institut Pasteur), **B. Brett Finlay** (University of British Columbia), Frédéric Keck (Musée du quai de Branly) and **Hendrik Poinar** (McMaster University).

- A new research project was started this year involving fellows **Sven Pettersson** (Karolinska Institutet) and **Janet Rossant** (Hospital for Sick Children, Toronto). Their study will use germ-free mouse models to assess whether maternal gut microbes influence fetal brain development.

Notable publication

- **Keck F**. 2016. Avian preparedness: An anthropology of bird watchers and virus hunters. Forthcoming from University of California Press.

IdeasExchange

- In this first term year, the program devoted considerable time to discussing opportunities to engage knowledge users. The program is developing plans for the coming year to engage the medical school community in discussing recent findings and opportunities to consider the microbiome in the medical curriculum.

- Fellows of the program had a proposal accepted to lead a 90-minute symposium on **Microbes and Humans: Effects on Health, Disease and Society** at the 2017 Annual Meeting of the American Association for the Advancement of Science (AAAS).

Global Academy

- The program engaged a graduate student from the University of British Columbia to fill the role of program reporter at two program meetings, providing written summaries of presentations and discussions. The program is considering the most effective opportunities to engage trainees in collaborations with fellows going forward.

To learn more: **https://www.cifar.ca/research/humans-the-microbiome/**

CIFAR fellows in discussion at the November 2015 meeting of CIFAR's program in Humans & the Microbiome.

AT A GLANCE
Founded: 2004
Most recent renewal: 2014
Program Director: Torsten Persson, Stockholm University
Fellows and advisors: 24
Institutions represented: 13, in 6 countries
Fields and subfields represented: economics; political science; economic and political history; social psychology; anthropology
Interaction meetings: 3; in Toronto, Canada (twice), and Paris, France
Relevant knowledge user groups: policy-makers (federal and provincial governments); international institutions such as the International Monetary Fund, the World Bank and the International Labour Office; international development organizations
Supporters: BMO Financial Group, Maxine Granovsky and Ira Gluskin, Scotiabank, 1 anonymous donor

INSTITUTIONS, ORGANIZATIONS & GROWTH

Takes an integrated approach to basic questions, such as what makes some countries rich and others poor; what makes some societies violent and others peaceful; what makes some states strong and others weak; always examining the crucial roles of different types of institutions.

The program in Institutions, Organizations & Growth experienced a highly productive year in 2015/2016. Fellows and invited guests came together for three program meetings, including two held in Toronto and one in Paris. A wide spectrum of themes was discussed at these meetings, ranging across different aspects of voter behaviour and elections, the self-selection of individuals into politics, the structure and organization of societies, the role of co-operation in social order, the drivers of cultural and institutional change, and connections between social change and economic growth.

In June 2016, the program partnered with the Collège de France and the Institute for Advanced Study in Toulouse (IAST) in holding its spring interaction meeting in Paris, France. The Collège is one of France's most renowned higher-education and research establishments, and the IAST is an ambitious interdisciplinary research institute facilitating the cross-fertilization of ideas across the social sciences. The meeting enabled CIFAR fellows to engage with numerous researchers from both organizations, as well as from Sciences Po in Paris.

Alongside their program meetings in Toronto, several program fellows engaged in CIFAR-facilitated opportunities to share their expertise and exchange ideas with officials in the Government of Ontario and leaders from Toronto's business and academic communities. These and other knowledge outreach events, held in conjunction with various partner organizations, are highlighted further on page 41.

Research

- Senior Fellow **Guido Tabellini** (Bocconi University) completed a study with collaborator Francesco Passarelli, exploring how political unrest, as an emotional reaction to unfair treatment, influences public policy. Dr. Tabellini credits his interactions with program fellows with leading him to incorporate elements of psychology and behavioural economics into his analysis of political interactions.
  > Passarelli F, **Tabellini G**. Forthcoming. Emotions and political unrest. J Polit Econ.

- Senior Fellow **Elhanan Helpman** (Harvard University) developed a new analytical framework that emphasizes the impact of international trade on residual wage inequality; that is, inequality not explained by worker characteristics. Discussing his ideas at a number of program meetings over the past four years was influential in leading Dr. Helpman and his collaborators to formulate this new model.
  > **Helpman E**, Itskhaki O, Muendler M, Redding S. Forthcoming. Trade and inequality: from theory to estimation. Rev Econ Stud.

- Gluskin-Granovsky Fellow **Timothy Besley** (London School of Economics & Political Science) and Program Director and Senior Fellow **Torsten Persson** (Stockholm University) released a working paper exploring the extent to which an established culture of democratic values is important to the strength of democratic institutions. The co-authors analyzed data on political histories of democratic institutions and found that citizens are more supportive of democratic values in countries that have experienced stable periods of democracy than in countries where autocracy has been the norm.
  > **Besley T**, **Persson T**. 2016. Democratic values and institutions. LSE and IIES Working Paper. Available online.

Other notable publications

- **Fearon JD**, Humphreys M, Weinstein JM. 2015. How does development assistance affect collective action capacity? Results from a field experiment in post-conflict Liberia. Am Polit Sci Rev. 109(3): 450-469.
- **Jackson MO**, Nei S. 2015. Networks of military alliances, wars, and international trade. Proc Natl Acad Sci USA. 112(50): 15277-15284.
- O'Hara NN, Mugarura R, Potter J, Stephens T, **Rehavi MM**, **Francois P**, Blachut PA, O'Brien PJ, Fashola BK, Mezei A, Beyeza T, Slobogean GP. 2016. Economic loss due to traumatic injury in Uganda: The patient's perspective. Injury. 47(5): 1098-1103.

IdeasExchange

- Fellows of the program met with deputy ministers in the Government of Ontario to discuss how policy can support the growth and flourishing of innovative firms and disruptive-technology sectors in advanced manufacturing economies. Fellows also met with Global Affairs Canada to discuss global development projects and evaluation.

- Senior Fellow and Nobel Laureate **George Akerlof** (Georgetown University) presented to groups of policy and business leaders as part of CIFAR's inaugural David Dodge Lecture series. Two lectures were given: one in Toronto, hosted by the Economic Club of Canada, and the other in Ottawa, hosted by the Conference Board of Canada.

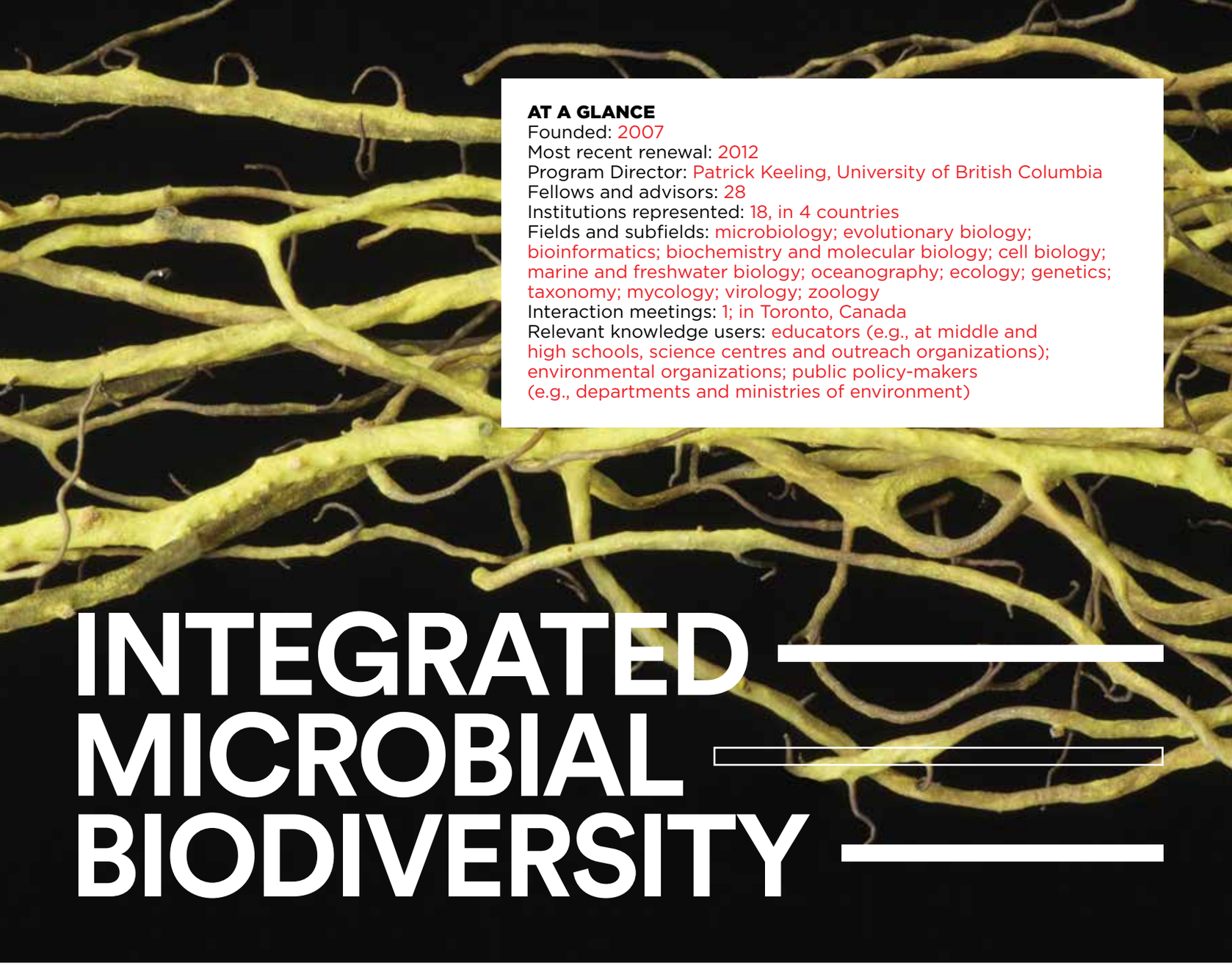
- At the invitation of the Consulate General of France in Toronto, Senior Fellow **Philippe Aghion** (Collège de France) spoke about innovation policy at an intimate dinner with business and academic leaders from Toronto.

Global Academy

- The program continued to mentor a number of past CIFAR Global Scholars by inviting them to program meetings, where two had the opportunity to present their latest work.

To learn more: **https://www.cifar.ca/research/institutions-organizations-growth/**

Senior Fellows Daron Acemoglu and Patrick Francois engage in the October 2015 meeting of the program in Institutions, Organizations & Growth.



AT A GLANCE
Founded: 2007
Most recent renewal: 2012
Program Director: Patrick Keeling, University of British Columbia
Fellows and advisors: 28
Institutions represented: 18, in 4 countries
Fields and subfields: microbiology; evolutionary biology; bioinformatics; biochemistry and molecular biology; cell biology; marine and freshwater biology; oceanography; ecology; genetics; taxonomy; mycology; virology; zoology
Interaction meetings: 1; in Toronto, Canada
Relevant knowledge users: educators (e.g., at middle and high schools, science centres and outreach organizations); environmental organizations; public policy-makers (e.g., departments and ministries of environment)

INTEGRATED MICROBIAL BIODIVERSITY

Explores the diverse microbial world that surrounds and permeates human life. Program members are transforming our understanding of biodiversity and changing approaches to medicine and health, environmental sustainability and evolutionary biology itself.

The program in Integrated Microbial Biodiversity achieved substantial research advances in 2015/2016. In April, the program held its second CIFAR-supported field study, SeaFar16, at the Caribbean Research & Management of Biodiversity (CARMABI) field station in Curaçao. The study afforded a subset of program fellows the opportunity to conduct exploration-driven research as a group. Participants learned from each other's experimental systems and approaches through collaborative dialogue, sample collection, onsite analysis and experimental design. This interaction included a creative component as portions of the field study were filmed using video-enabled drones, submarines and digital cameras. This footage will be combined along with fellow interviews to produce a series of short video documentaries. Targeting a variety of stakeholder audiences, these documentaries will highlight the collaborative nature, discovery research components and environmental underpinnings that the program has achieved during its tenure.

In June 2016, the program also underwent an external peer review as it approached the end of its second five-year term. The review took place in Toronto, Canada, concurrent with the program's annual meeting. To assess the program's achievements over the past five years and its proposal for an additional term, an international review panel consisted of subject-matter experts from the United Kingdom, the United States and Germany. Their collective assessment will be competitively considered alongside those of other CIFAR programs undergoing review in 2016.

Research

- A special issue of the *Proceedings of the National Academy of Sciences* was released in August 2015, resulting from the Integrated Microbial Biodiversity program–led Sackler colloquium that took place in 2014. The *PNAS* issue includes nine research articles involving the work of CIFAR fellows. Overall, the colloquium and its resulting publications have led to a major change in understanding how two organisms interact within an endosymbiotic partnership.

- A CIFAR-supported collaboration between their trainees helped CIFAR fellows **John Archibald** (Dalhousie University) and **Julius Lukeš** (Czech Academy of Sciences) to complete a genomic and microscopy-based exploration of an enigmatic, single-celled 'kinetoplastid' endosymbiont living inside a common marine amoeba. They discovered that the kinetoplastid sustains itself by 'drinking' the interior liquid of the amoeba in which it resides. This type of endosymbiont-host connectivity has never been previously observed, and provides expanded knowledge of the complex ways in which single-celled microbes interact in the context of endosymbiosis.
  > Cenci U, Moog D, Curtis BA, Tanifuji G, Eme L, **Lukeš J**, **Archibald JM**. 2016. Heme pathway evolution in kinetoplastid protists. BMC Evol Biol. 16: 109.

- In a collaborative project, CIFAR fellows **Alastair Simpson** and **Andrew Roger** (both Dalhousie University) examined two salt-loving protozoans and completed the first examination of the genomic changes that are induced by very-high-salt living conditions. They found a particular evolutionary signature in the protein sequences in these organisms and uncovered several clues that may explain how these organisms counterbalance the salt in their environment. This work is currently submitted for publication.

Other notable publications

- Orsi WD, Smith JM, Liu S, Liu Z, Sakamoto CM, Wilken S, Poirier C, **Richards TA**, **Keeling PJ**, **Worden AZ**, **Santoro AE**. 2016. Diverse, uncultivated bacteria and archaea underlying the cycling of dissolved protein in the ocean. ISME J. (8 March 2016).
- Flegontov P, Michálek J, **Janouškovec J**, Lai DH, Jirků M, Hajdušková E, Tomčala A, Otto TD, **Keeling PJ**, Pain A, Oborník M, **Lukeš J**. 2015. Divergent mitochondrial respiratory chains in phototrophic relatives of apicomplexan parasites. Mol Biol Evol. 32(5): 1115-1131.

IdeasExchange

- During the program's second CIFAR-supported field study to Curaçao, fellows provided interviews and filmed video footage to be edited into short documentaries tailored for different stakeholder audiences, such as educators, policy-makers and environmental organizations. These documentaries will be shared and distributed through a variety of channels.

Global Academy

- The program in Integrated Microbial Biodiversity trains the next generation of researchers by embedding them into its annual program meeting. Each year, graduate students and postdoctoral fellows working in the labs of program fellows participate in a dedicated poster session during the meeting, and several trainees give research presentations during the main sessions. In 2015/2016, trainees of participating CIFAR fellows were also invited to participate in the Curaçao field study to gain exposure and experience in the full breadth of research being conducted by the program.

To learn more: **https://www.cifar.ca/research/integrated-microbial-biodiversity/**

Fellows and trainees in the Integrated Microbial Biodiversity program collect sand samples and small invertebrates for microbiome surveys during their SeaFar16 field study in Curaçao.

AT A GLANCE
Founded: 2004
Most recent renewal: 2014
Program Directors: Yoshua Bengio, Université de Montréal, and Yann LeCun, New York University and Facebook AI Research
Fellows and advisors: 36
Institutions represented: 23, in 8 countries
Fields and subfields: computer science, including artificial intelligence and machine learning; neuroscience; bioinformatics and computational biology
Interaction meetings: 1; in Montreal, Canada
Relevant knowledge users: industry, including entrepreneurs and start-ups, with interests in deep-learning-based technologies and applications
Partners: Brain Canada Foundation through the Canada Brain Research Fund, Facebook, Google Inc., Inria
Supporters: Geoffrey Hinton, Céline and Jacques Lamarre

LEARNING IN MACHINES & BRAINS

Aims to contribute to the understanding of the computational and mathematical principles that enable intelligence through learning, be it in brains or in machines.

The program in Learning in Machines & Brains (formerly Neural Computation & Adaptive Perception) advanced one of its core research directions, deep learning, by making it the central theme of its annual program meeting in December 2016. This choice reflected a strong surge of interest within the program and the machine learning community at large, driven by a rapid series of outstanding successes in recent years that have seen deep learning embraced by global information companies like Google and Facebook, and the placement of CIFAR fellows at their research helms.

The program meeting took place in Montreal during the two days preceding the annual Neural Information Processing Systems (NIPS) conference, the premier venue for the presentation of research in machine learning and neural networks. As in most years, the program used this strategic timing to leverage the attendance of many of the world's leading researchers at both events. Program Co-Directors **Yoshua Bengio** and **Yann LeCun** subsequently drew a record audience of about 2,000 at a NIPS tutorial on deep learning.

The program meeting was supported in partnership with the Brain Canada Foundation and Inria, through multi-year agreements.

From its early days, the program has convened an annual summer school for its fellows' graduate and postdoctoral trainees. Student organizers invite CIFAR fellows and other distinguished researchers to lecture on cutting-edge topics not yet covered in the regular university curricula. In 2015/2016, the program opened its doors to host the largest-ever summer school in deep learning, attracting participants from around the world, coming from both academia and industry.

RESEARCH PROGRAMS
ANNUAL HIGHLIGHTS –

Research

- Senior Fellow **Nando de Freitas** (University of Oxford) collaborated with Google DeepMind intern Scott Reed to propose the 'neural programmer-interpreter': a recurrent and compositional neural network that learns to represent and execute programs. Inspired by CIFAR Advisor **Geoffrey Hinton**'s (University of Toronto & Google) work on programmable neural networks, they investigated a way to build agents that learn with fewer data, learn new programs incrementally and can transfer knowledge to new domains. This research earned the Best Paper Award at the 2016 International Conference on Learning Representations.
  > Reed S, **de Freitas N**. 2016. Neural Programmer-Interpreters. ICLR 2016.

- Fellows **Hugo Larochelle** (Université de Sherbrooke) and **Aaron Courville** (Université de Montréal) developed a new approach that uses significantly fewer computations to train neural networks to recognize objects in images, while maintaining a state-of-the-art performance level. This work provides a step toward making the training of large, high-performance neural networks achievable in research labs and industry that lack extensive computational resources. The team credits its inspiration to research in attention mechanisms in neural networks, developed in the program.
  > Almahairi A, Ballas N, Cooijmans T, Zheng Y, **Larochelle H**, **Courville A**. 2016. Dynamic Capacity Networks. ICML 2016.

- Statistical inference and learning are increasingly used to render automated decisions, ranging from targeted advertising to the issuing of bank loans. Fellows **Richard Zemel** (University of Toronto) and **Max Welling** (University of Amsterdam) developed computational methods aimed at producing fair decisions that are not unduly biased for or against specific subgroups in the population. They developed formulations of fairness as an optimization problem with two competing goals: to encode data as well as possible, while obfuscating any information about membership in a specific group.
  > Louizos C, Li Y, Swersky K, **Welling M**, **Zemel RS**. 2016. The variational fair autoencoder. ICLR 2016.

IdeasExchange

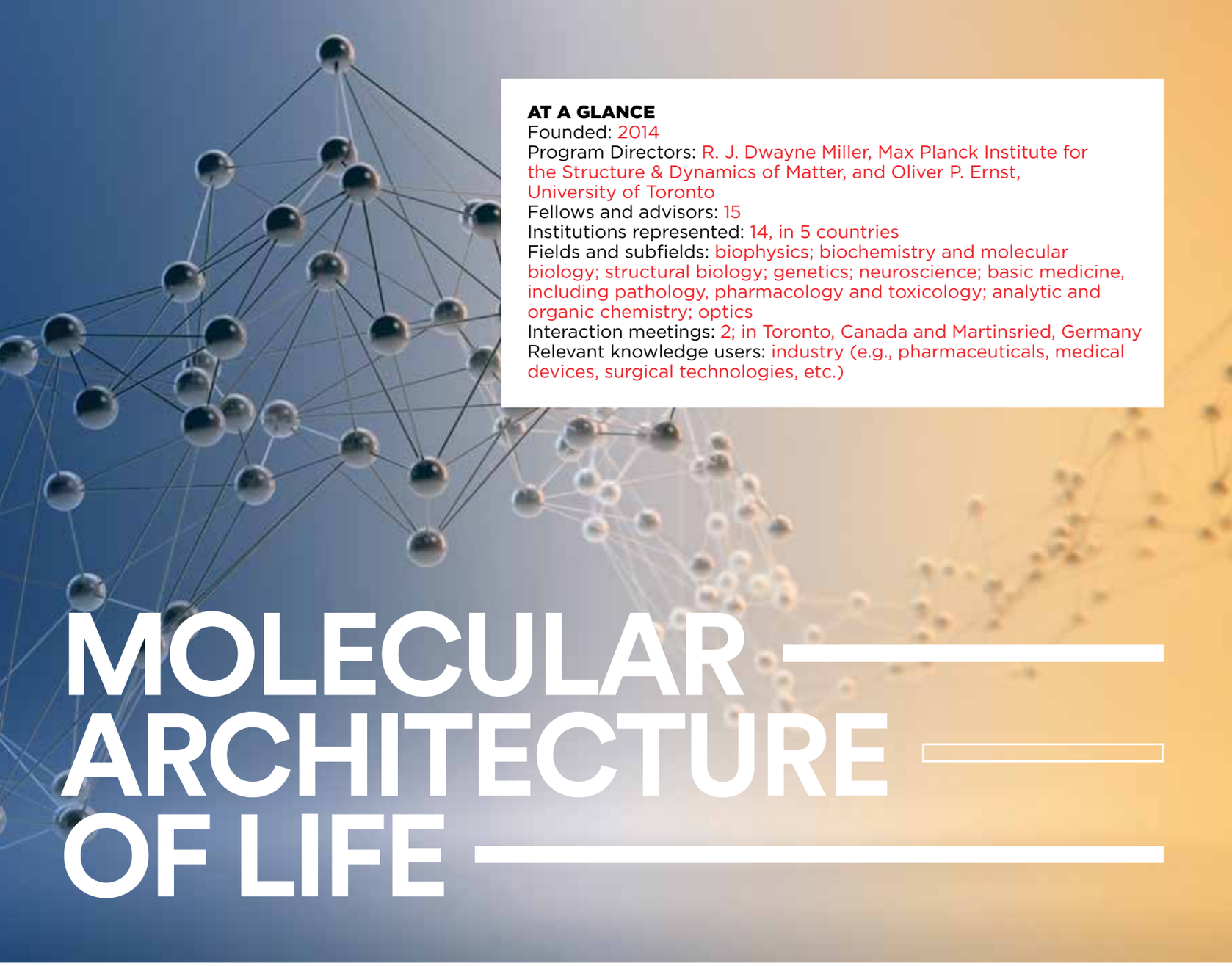
- In May 2016, CIFAR partnered with RBC to present a moderated panel discussion in Toronto featuring Senior Fellow **Brendan Frey** (University of Toronto) and other participants from the investment and technology sectors to explore how artificial intelligence may disrupt the financial industry in future years. Over 500 individuals attended, in addition to a global audience reached by WebEx broadcast.

Global Academy

- The program held the largest deep learning summer school ever organized. Conducted over ten days in August 2015 at the Université de Montréal, it attracted more than 150 graduate students and postdoctoral fellows from universities and research institutes in 16 countries and from 18 global companies, including Samsung, Google and Amazon.com. The event was co-organized by program fellows **Yoshua Bengio** and **Roland Memisevic** (both Université de Montréal) and included numerous other fellows as lecturers.

To learn more: **https://www.cifar.ca/research/learning-in-machine-and-brains/**

Senior Fellow
Joëlle Pineau presents at the December 2015 meeting of CIFAR's program in Learning in Machines & Brains.



AT A GLANCE
Founded: 2014
Program Directors: R. J. Dwayne Miller, Max Planck Institute for the Structure & Dynamics of Matter, and Oliver P. Ernst, University of Toronto
Fellows and advisors: 15
Institutions represented: 14, in 5 countries
Fields and subfields: biophysics; biochemistry and molecular biology; structural biology; genetics; neuroscience; basic medicine, including pathology, pharmacology and toxicology; analytic and organic chemistry; optics
Interaction meetings: 2; in Toronto, Canada and Martinsried, Germany
Relevant knowledge users: industry (e.g., pharmaceuticals, medical devices, surgical technologies, etc.)

MOLECULAR ARCHITECTURE OF LIFE

Seeks to untangle the details of the complex molecular processes that underlie all living systems, with implications for everything from our understanding of evolution to our ability to treat disease.

The program in the Molecular Architecture of Life completed its first full term year in 2015/2016. During the year, the program increased its membership from ten to 15 researchers from Canada, the United States, Germany, the United Kingdom and Switzerland. Fellows launched five new collaborative projects within the group and with meeting guests.

The year's two program meetings were critical to assessing and validating that the technology is now in place to define a larger project for biology: making a molecular map of the cell. This project — comparable in scope and impact to the Human Genome Project — will require a massive international effort.

Even with the necessary techniques in place, the correlation of the data, its reduction to simple physical mechanisms of organization and the mathematical/theoretical modelling of networks that control living systems will require enormous human resources. The program in the Molecular Architecture of Life has identified and begun exploring key model systems to which these new technologies can be applied, in order to lay the groundwork for developing the molecular map of the cell. Moreover, fellows have begun to identify and engage with the leading international researchers, potential research partners and end users who will be critical to advancing this work. The program's next meeting, to be held in China in partnership with the Chinese Academy of Science, will begin this discussion in earnest as a first step toward determining the level of co-operation that can be achieved to reach this grand goal.

Research

- Transmission electron microscopy (TEM) had been assumed unamenable as a technique for imaging live cells, as it could cause electron-induced damage to the sample. This year, the research group of Program Co-Director and Senior Fellow **Dwayne Miller** (Max Planck Institute for the Structure & Dynamics of Matter) developed a new liquid sampling concept that permitted them to use TEM to successfully image DNA hybridization at the single molecule level. The work is a significant breakthrough that improves on the capabilities of super-resolution microscopy, which received a Nobel Prize in 2014.

- Program Co-Directors and Senior Fellows **Oliver Ernst** (University of Toronto) and **Dwayne Miller**, with other collaborators, discovered that the first molecular reaction in vision generation happens much faster than any previously known biological process, occurring at the very limits of what is theoretically possible in biological functions. The team also found that the vibrational motions of the molecules help direct the chemical reaction. These findings are important to elucidating the most critical details of how molecular receptors receive information precisely and relay it onward, in this case to our brains where we process images.
  > Mueller C, Marx A, Epp SW, Zhong Y, Kuo A, Balo AR, Soman J, Schotte F, Lemke HT, Owen RL, Pai EF, Pearson AR, Olson JS, **Ernst OP**, **Miller RJD**. 2015. Fixed target matrix for femtosecond time-resolved and in situ serial micro-crystallography. Struct Dyn. 2(5): 054302.
  > Johnson PJM, Halpin A, Morizumi T, Prokhorenko VI, **Ernst OP**, **Miller RJD**. 2015. Local vibrational coherences drive the primary photochemistry of vision. Nature Chem. 7: 980-986.

- Protein-ligand interactions are fundamental to almost all processes occurring in living organisms. New collaborations among program fellows, including **Krzysztof Palczewski** (Case Western Reserve University), **Wolfgang Baumeister** (Max Planck Institute for Biochemistry), **Dwayne Miller**, CIFAR Advisor **Daniel Müller** (ETH Zurich) and others, have brought together the know-how for sample preparation, data collection and analysis required to capture 'molecular movies' — extremely complex, billion-dollar experiments that will allow the team to explore and understand the otherwise inaccessible processes behind protein-ligand interactions.

IdeasExchange

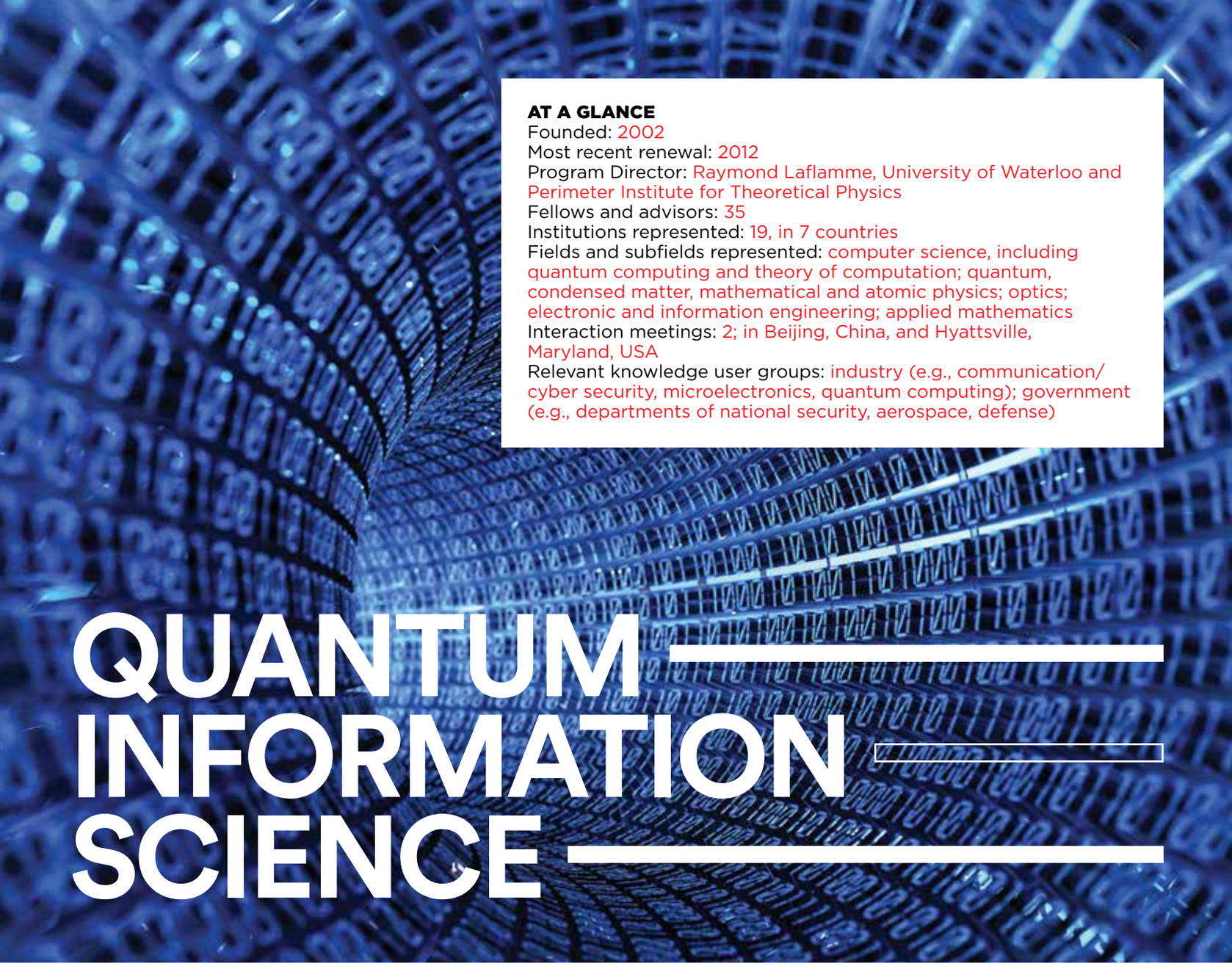
- The technological developments arising from this program have the potential to transform how we understand and treat human diseases. One example is a new laser surgical method, developed by the Miller group, which is the first to eliminate the formation of scar tissue in the healing process. Discussions over the past year have identified several potential key partner/knowledge user groups, such as pharmaceutical and medical device companies, and round tables to engage these groups will begin in the coming year.

Global Academy

- The program engaged two postdoctoral fellows to serve as program meeting reporters and provide written summaries of each presentation after the meeting. Fellows committed to hosting a satellite meeting for postdocs and graduate students in the fellows' research groups, in conjunction with one of next year's program meetings. The satellite meeting will be organized by a group of senior trainees and will facilitate an overlap of participation in both events.

To learn more: **https://www.cifar.ca/research/molecular-architecture-of-life/**

The program in the Molecular Architecture of Life met at the Max Planck Institute of Biochemistry in Martinsried, Germany, in April 2016.



AT A GLANCE
Founded: 2002
Most recent renewal: 2012
Program Director: Raymond Laflamme, University of Waterloo and Perimeter Institute for Theoretical Physics
Fellows and advisors: 35
Institutions represented: 19, in 7 countries
Fields and subfields represented: computer science, including quantum computing and theory of computation; quantum, condensed matter, mathematical and atomic physics; optics; electronic and information engineering; applied mathematics
Interaction meetings: 2; in Beijing, China, and Hyattsville, Maryland, USA
Relevant knowledge user groups: industry (e.g., communication/cyber security, microelectronics, quantum computing); government (e.g., departments of national security, aerospace, defense)

QUANTUM INFORMATION SCIENCE

Unites computer scientists and physicists in an effort to harness the strange and fascinating properties of the quantum world, where the mere act of observing an object changes its nature, with the aim of building quantum computers.

2015/2016 was an exciting year for the program in Quantum Information Science. The program strengthened its intellectual ties with the quantum information science community in China by holding its fall 2015 program meeting in Beijing, in partnership with the Institute for Interdisciplinary Information Sciences (IIIS) at Tsinghua University. Researchers from all over China, representing numerous leading research institutions, participated in the meeting to interact with CIFAR fellows. This opportunity also resulted in the appointment of **Andrew Yao**, Dean of IIIS, to the program's advisory committee. The program continued its engagement with the global research community by holding its spring 2016 meeting at the University of Maryland and interacting with researchers and trainees at its Joint Center for Quantum Information and Computer Science.

Several CIFAR fellows from this program, **Alexandre Blais, David Poulin** and **Michel Pioro-Ladière**, are part of the team at the Université de Sherbrooke that will lead an ambitious research program in quantum studies that was successfully awarded funding through the inaugural Canada First Research Excellence Fund (CFREF) competition in 2015. Out of 42 proposals submitted, the Sherbrooke project and another quantum physics proposal from the University of British Columbia, also led by numerous CIFAR fellows, were among the five research projects awarded funds, resulting in a $100 million investment by the Government of Canada in this research area.

Research

- Performing quantum measurement is a complicated feat, as the act of measuring disturbs the very system being measured. It remains a crucial open problem for creating a quantum computer. Fellow **Alexandre Blais** (Université de Sherbrooke), past CIFAR Global Scholar **Nicolas Didier** (McGill University) and a collaborator proposed a simple, yet dramatically powerful, modification to a standard approach for studying quantum measurement in superconducting circuits. Their new idea attracted much attention in the field, and several teams are testing it with experiments.
  > **Didier N**, Bourassa J, **Blais A**. 2015. Fast quantum nondemolition readout by parametric modulation of longitudinal qubit-oscillator interaction. Phys Rev Lett. 115(20): 203601.

- A study by Senior Fellow **Barry Sanders** (University of Calgary) and trainees of Program Director and Senior Fellow **Raymond Laflamme** and Fellow **Joseph Emerson** (both University of Waterloo) investigated a method of benchmarking quantum information processing devices to assess their quality. Using specific examples, they demonstrated an essential and appropriate metric for assessing experimental progress toward building a fault-tolerant quantum computer.
  > Sanders YR, Wallman JJ, **Sanders BC**. 2015. Bounding quantum gate error rate based on reported average fidelity. New J Phys. 18(1): 012002.

- Senior Fellow **Andrew Childs** (University of Maryland) and collaborators developed a quantum algorithm for linear systems with dramatically improved performance as a function of an allowed error. This algorithm may lead to new applications of quantum computers and has also already been applied in the study of quantum computational complexity.
  > Berry DW, **Childs AM**, Kothari R. 2015. Hamiltonian simulation with nearly optimal dependence on all parameters. Proc 56th IEEE Symp FOCS. 792-809.

Other notable publications

- **Poulin D**, Hastings MB, Wecker D, Wiebe N, Doherty AC, Troyer M. 2015. The trotter step size required for accurate quantum simulation of quantum chemistry. Quantum Inf Comput. 15: 361-384.
- Ma X, Jackson T, Zhou H, Chen J, Lu D, Mazurek MD, Fisher KAG, Peng X, Kribs D, Resch KJ, Ji Z, **Zeng B**, **Laflamme R**. 2016. Pure state tomography with the expectation value of Pauli operators. Phys Rev A. 93(3): 032140.

IdeasExchange

- Fellows in the program interact frequently with the Communications Security Establishment Canada on the implications of quantum science in such areas as cryptography. Program Director and Senior Fellow **Raymond Laflamme** was invited to present insights from the program's research at the Canadian Association for Security and Intelligence Studies (CASIS) Symposium on **The Cyber Challenge** in September 2016. The symposium will engage other leaders from academia, as well as from industry and government.

Global Academy

- Together with the Fields Institute and other partners, the program supported the 15th Canadian Summer School on Quantum Information, held in Toronto in August 2015. Fellows **Ashwin Nayak** (University of Waterloo) and **Aephraim Steinberg** (University of Toronto) were among the co-organizers, and invited lecturers included Fellows **Peter Høyer** (University of Calgary), **Barbara Terhal** (RWTH Aachen University), **Joseph Emerson** and **John Watrous** (both University of Waterloo).

- At the program's spring meeting held at the University of Maryland, CIFAR fellows participated in a poster session organized by trainees at the Joint Center for Quantum Information and Computer Science.

To learn more: **https://www.cifar.ca/research/quantum-information-science/**

Senior Fellow Barry Sanders presents at the CIFAR Quantum Information Science program meeting held at Tsinghua University in Beijing, China, in November 2015.

AT A GLANCE
Founded: 1987
Most recent renewal: 2012
Program Director: Louis Taillefer, Université de Sherbrooke
Fellows and advisors: 64
Institutions represented: 31, in 7 countries
Fields and subfields: condensed matter and quantum physics; atomic, chemical and computational physics; nanomaterials and materials engineering
Interaction meetings: 2; in Montreal and Toronto, Canada
Relevant knowledge users: industry (e.g., quantum computing, power transmission, transportation, magnetic medical imaging, wireless communications)
Partner: Gordon & Betty Moore Foundation

QUANTUM MATERIALS

Invents and explores materials whose novel and unusual electronic properties, like superconductivity, could revolutionize technology.

The program in Quantum Materials experienced a year marked by significant research advances and expanded engagement with key research communities. During two interaction meetings, fellows discussed several key topics related to the program's themes, including cold atomic gases, high-temperature superconductivity, spin liquids and topological materials.

The program engaged in extensive international partnership activities, including the continuation of a joint venture with the Gordon and Betty Moore Foundation's EPiQS initiative. Through this relationship, EPiQS-supported researchers and their trainees participated in the program's meetings and annual summer school. In addition, the program established intellectual synergy with France's quantum materials community, integrating leading researchers from the country into its meetings. The program will engage an expanded network of French quantum researchers by holding a meeting at the Collège de France in Paris next year. The program also had notable interaction with the Japanese quantum materials community. CIFAR fellows **Yoshi Maeno** (Kyoto University), **Yoichi Ando** (University of Cologne) and CIFAR Advisor **Hide Takagi** (Max Planck Institute for Solid State Research) belong to a multi-institutional Japanese research team that was awarded a grant for their proposed 'Topological Materials Science (TMS)' project through Japan's MEXT. This grant has led to the creation of a 'TOPO-Q' network and has enabled TMS researchers to engage with CIFAR's Quantum Materials program.

The long-standing convening and collaborative power of the program was evident this year via the results of the inaugural Canada First Research Excellence Fund (CFREF) competition. Of the 42 proposals put forward, two quantum physics proposals from the Université de Sherbrooke (UdeS) and the University of British Columbia (UBC) were among the five CFREFs awarded, resulting in a $100 million investment by the Government of Canada in this research area. Notably, CIFAR fellows **Alexandre Blais**, **Patrick Fournier**, **Louis Taillefer** and **André-Marie Tremblay** (UdeS), and **Andrea Damascelli**, **Ian Affleck**, **Doug Bonn**, **Joshua Folk**, **Marcel Franz** and **George Sawatzky** (UBC) led and developed these proposals. CIFAR is recognized as contributing to the proposals' success by raising the profile of Canadian quantum research and establishing a strong, trusted and sustained platform of dialogue, synergy, idea-generation and collaboration among the world's top quantum researchers through its quantum programs.

Research

- Fellows **Louis Taillefer** (Université de Sherbrooke), **Cyril Proust** (LNCMI, France), **Doug Bonn**, **Ruixing Liang** and **Walter Hardy** (all University of British Columbia), along with other collaborators, identified a quantum phase transition in copper-oxides that is associated with the termination of the 'pseudogap.' This landmark discovery was found to result in a dramatic reduction of superconductivity in cuprates.
  > Badoux S, Tabis W, Laliberté F, Grissonnanche G, Vignolle B, Vignolles D, Béard J, **Bonn DA**, **Hardy WN**, **Liang R**, Doiron-Leyraud N, **Taillefer L**, **Proust C**. 2016. Change of carrier density at the pseudogap critical point of a cuprate superconductor. Nature. 531: 210-214.

- Using nuclear magnetic resonance, Senior Fellow **Takashi Imai** (McMaster University) and collaborators presented the first experimental evidence of a 'spin-liquid' state of matter at near absolute zero temperature in the quantum material herbertsmithite. This was the first experimental evidence that a spin liquid state of matter exists. The finding may advance a new field of study and contribute to the understanding of other states like superconductivity.

- A collaborative effort between Associate Fellows **Ian Fisher** and **Steve Kivelson** (both Stanford University) resulted in a study that provides evidence for the presence of a nematic quantum critical point in optimally doped iron-based superconductors and suggests a potential role of nematicity in enhancing superconductivity.
  > Kuo HH, Chu JH, Palmstrom JC, **Kivelson SA**, **Fisher IR**. 2016. Ubiquitous signatures of nematic quantum criticality in optimally doped Fe-based superconductors. Science. 352(6288): 958-962.

Other notable publication

- Achkar AJ, Zwiebler M, McMahon C, He F, Sutarto R, Djianto I, Hao Z, **Gingras MJP**, Hücker M, Gu GD, Revcolevschi A, Zhang H, Kim YJ, Geck J, **Hawthorn DG**. 2016. Nematicity in stripe-ordered cuprates probed via resonant x-ray scattering. Science. 351(6273): 576-578.

IdeasExchange

- Early conversations took place between program fellows and industrial representatives involved in wind turbine manufacturing. The discussions focused on uncovering potential applications of cuprate superconductors.

- A private event at the Centre des sciences de Montréal highlighted the recent discovery of the quantum phase transition made by CIFAR fellows.

Global Academy

- The program committed significant efforts in 2015/2016 toward training the next generation of quantum materials leaders. The program held its annual summer school in Toronto, Canada attracting over 70 participants. The agenda was developed by a group of trainees supervised by CIFAR fellows and included research lectures, interactive poster sessions, career development sessions and significant informal interaction time. Summer school participants were also invited to attend the program meeting held immediately afterward, extending their opportunity to interact with program fellows and explore research themes for future collaborative and/or training endeavours.

To learn more: **https://www.cifar.ca/research/quantum-materials/**

Associate Fellow Subir Sachev, Program Director Louis Taillefer and Program Reporter Nicolas Doiron-Leyraud in discussion at the October 2015 meeting of CIFAR's program in Quantum Materials.

AT A GLANCE
Founded: 2005
Most recent renewal: 2011
Program Directors: George Akerlof, Georgetown University, and John Helliwell, University of British Columbia
Fellows and advisors: 21
Institutions represented: 15, in 3 countries
Fields and subfields: economics, including economic theory; social, positive, organizational, clinical and cognitive psychology; political science, including comparative politics; sociology
Interaction meetings: 3; in Montreal and Toronto, Canada; and Brisbane, Australia
Relevant knowledge users: medical, health and social service professionals; educators; economists; public policy-makers (e.g., education, seniors, health, employment and social services)
Supporters: BMO Financial Group, Scotiabank, 1 anonymous donor

SOCIAL INTERACTIONS, IDENTITY & WELL-BEING

Develops a new approach to understanding economic and social issues by exploring the complex ways in which health, happiness and well-being are shaped by social identities and interactions.

Understanding and improving the social supports of well-being was a recurring theme at this year's meetings of the program in Social Interactions, Identity & Well-Being. Fellows are studying social underpinnings of well-being in numerous contexts, such as educational attainment, mental health and personal happiness.

Immigration was another prominent and timely theme of exploration for the program, and was the theme of the fall 2015 program meeting in Montreal. Fellows are actively studying various themes and concepts related to immigration such as the integration of immigrants, measuring immigrants' sense of belonging, happiness, and the positive impacts of citizenship on their families.

The *World Happiness Report Update 2016*, co-edited by Program Co-Director and Senior Fellow **John Helliwell**, drew considerably from the program's research into measuring and understanding happiness and its main sources within and among nations.

The program held CIFAR's first program meeting in Australia, in June 2016, leveraging the convening of the 3rd International Conference on Social Identity and Health in Brisbane, Australia. The ICSIH conference included research presentations by numerous CIFAR fellows, advisors and their graduate students. Several esteemed researchers from around Australia joined the program meeting as guests. Between the two events, fellows presented a public symposium, sharing research insights from the program with 94 participants from a range of sectors.

The program underwent an external peer review in February 2016. CIFAR convened an international panel of subject-matter experts to evaluate the program's achievements and its proposal for a third five-year term. This assessment will be competitively considered alongside those of four other CIFAR programs undergoing review in 2016.

Research

- Senior Fellows **Alexander Haslam** (University of Queensland) and **Nyla Branscombe** (University of Kansas), with past CIFAR Global Scholars **Katharine Greenaway** (University of Queensland) and **Renate Ysseldyk** (Carleton University) and other collaborators, completed a series of studies showing that identification with social groups can restore a sense of personal control among individuals experiencing stress. The finding was observed in longitudinal and experimental studies and seen across 47 different countries, adding to the program's growing body of research on the benefits to individuals of social group membership.
  > Greenaway KH, **Haslam SA**, Cruwys T, **Branscombe NR**, Ysseldyk R, Heldreth C. From "we" to "me": Group identification enhances perceived personal control with consequences for health and well-being. 2015. J Pers Soc Psychol. 109(1): 53-74.

- A study by fellows **Lara Aknin**, **John Helliwell** (both University of British Columbia) and past Global Scholar **Guy Mayraz** (University of Melbourne) examined the emotional consequences to individuals who receive a charitable donation request. The results revealed some emotional cost to those who choose not to donate, or to donate little. However, the net impact on the group receiving the donation opportunity is positive, as the substantial fraction of donors who give generously receives significant emotional rewards.

- CIFAR Senior Fellow **Rafael Di Tella** (Harvard University) completed his first experimental study and attributed its success to interactions, support and education he received from colleagues in the program. He and his collaborators found that a key enabler of selfish behaviour and mistrust is ambiguity about other people's motivations and actions. This work contributes to research showing that beliefs about others are a key determinant of how societies decide to organize.

Other notable publications

- **Fortin NM**, **Oreopoulos P**, **Phipps S**. 2015. Leaving boys behind: Gender disparities in high academic achievement. J Hum Resour. 50(3): 549-579.
- **Helliwell J**, Layard R, Sachs J. 2016. World Happiness Report 2016, Update. New York (NY): Sustainable Development Solutions Network.

IdeasExchange

- Senior Fellow **Philip Oreopoulos** (University of Toronto) took part in a CIFAR Change Makers workshop in Toronto, held in partnership with the United Way Toronto and York Region in November 2015. Researchers and leading community service providers explored how best to collaborate to improve policies and programs.

- The program also presented a symposium on **Building Better Lives: New Thinking on How Social Interactions Shape Human Behaviour and Well-Being** in Brisbane, Australia, in June 2016 for leaders in public policy, health care, social services, the academic community and the general public.

Global Academy

- As program fellows become immersed in new perspectives and research approaches through program-enabled interactions, they share their insights with students and post-doctoral fellows whose own lines of thinking become changed. Three past postdoctoral fellows nurtured within the program had central authorship roles in important publications with program fellows in 2015/2016, providing strong evidence of direct and indirect benefits to them and to the program.

To learn more: **https://www.cifar.ca/research/social-interactions-identity-well-being/**

Senior Fellows
Philip Oreopoulos and Shelley Phipps speak at the October 2015 meeting of the program in Social Interactions, Identity & Well-Being.

AT A GLANCE
Founded: 2002
Most recent renewal: 2012
Program Directors: Peter A. Hall, Harvard University, and Michèle Lamont, Harvard University
Fellows and advisors: 19
Institutions represented: 16, in 3 countries
Fields and subfields: sociology, including demography, social stratification, social theory and cultural sociology; political science, including comparative politics, political economy and comparative public policy; organizational, cultural and social psychology; political philosophy; history; economics
Interaction meetings: 3; in Boston and Princeton, USA; and Montreal, Canada
Relevant knowledge users: community organizations focused on addressing inequality, resilience and inclusion; public policy-makers
Supporters: BMO Financial Group, 1 anonymous donor

SUCCESSFUL SOCIETIES

Explores the roots and effects of social inequalities and asks the question: What makes a society successful?

The program in Successful Societies experienced a significant year of growth, exploration and research progress. During its present five-year term, the program is examining the social and cultural processes that lie behind the production and reproduction of inequality. Careful deliberation and dialogue among program fellows and advisors, with support from CIFAR, led to the successful recruitment of five new fellows and one new advisor to the program. These appointments bring an extended range of new perspectives to the program, including expertise in the anthropology of Canada's First Nations, in immigration and social cohesion, and in patterns of social development and ethnic conflict in South Asia.

The program piloted a new interaction format during its three program meetings during the year, enabling extended periods of discussion focused on papers in progress authored by program fellows. Resulting from these engaging and fruitful discussions, the program began to conceptualize a new collective volume that will focus on ways in which social and cultural processes interact to produce and mitigate inequality. Fellows will collaborate on chapters representing the program's wide-ranging disciplinary perspectives and approaches.

The program also spent the year preparing for the conclusion of its five-year term. In collaboration with CIFAR, the program identified and recruited an international expert panel of reviewers that will assess the program's past achievements and future proposal in September 2016.

Fellows engaged in several knowledge outreach opportunities, including a CIFAR Change Makers event in Montreal, in which researchers joined civic and government leaders in exploring the challenges of inequality and opportunities to create more inclusive societies.

RESEARCH PROGRAMS
ANNUAL HIGHLIGHTS –

Research

- Fellows began the intellectual planning for a new collective volume that will examine how social and cultural processes interact to generate and mitigate various kinds of inequality from the micro- to macro-levels of society. For instance, how does rising income inequality impact access to critical goods and services, such as education? The volume will pay close attention to ways in which institutional frameworks and cultural repertoires condition social outcomes. With chapters written collaboratively by program fellows, the work will provide a unique multidisciplinary contribution of perspectives to the literature about inequality.

- Senior Fellow **David Grusky** (Stanford University) was a member of a team that developed an $8-billion-per-year program aimed at reducing poverty. The program has the potential to appear as a ballot initiative in the 2018 California election. Notably, political scientists in the CIFAR program in Successful Societies contributed insights and feedback during the course of this effort.

- Senior Fellow **Will Kymlicka** (Queen's University) and colleague Keith Banting completed an edited volume, *The Strains of Commitment: Solidarity in Diverse Societies*, to be published by Oxford University Press. The work addresses the challenge of sustaining solidarity in increasingly diverse societies and seeks to bring leading social science research to bear on issues of public debate. The manuscript includes contributions by Senior Fellow **Irene Bloemraad** (University of California, Berkeley) and Program Co-Director and Senior Fellow **Peter Hall** (Harvard University). Draft chapters were the focus of discussion at a program meeting last year.

Other notable publications

- Boix Mansilla V, **Lamont M**, Sato K. 2016. Shared cognitive-emotional-interactional platforms: Markers and conditions for successful interdisciplinary collaborations. Sci Technol Hum Val. 41(4): 571-612.
- Hacker JS, **Pierson P**. 2016. American amnesia: How the war on government led us to forget what made America prosper. New York (NY): Simon & Schuster.
- Red Bird B, **Grusky DB**. 2016. The distributional effects of the Great Recession: Where has all the sociology gone? Annu Rev Sociol. Accepted.

IdeasExchange

- Program Co-Director **Peter Hall** and Senior Fellow **Jane Jenson** (Université de Montréal) participated in a CIFAR Change Makers event in Montreal in May 2016. This workshop focused on **New Models for Thriving: How Social Innovation Supports Inclusive Societies** and had strong attendance and discussion by civic and public leaders.

- In November 2016, the Weatherhead Center for International Affairs at Harvard University hosted a panel discussion led by Program Co-Director **Michèle Lamont** (Harvard University), featuring the program in Successful Societies' approaches toward the study of inequality. The panel included fellows **David Grusky**, **Peter Hall**, **Will Kymlicka** and CIFAR Advisor **Hazel Markus** (Stanford University) and engaged faculty and graduate students from across disciplines.

Global Academy

- The program engaged three graduate students to serve as program meeting reporters and provide written summaries of the presentations and discussions that took place. Most fellows have doctoral students whose research is influenced by the ideas flowing from the collective discussions within the program.

To learn more: **https://www.cifar.ca/research/successful-societies/**

Senior Fellow Jane Jenson presents her work at the CIFAR Change Makers workshop in Montreal in May 2016.

FINANCIAL OVERVIEW

CIFAR fellows found that among people in 47 countries, a strong identification with a social group can restore a sense of control to individuals experiencing stressful circumstances.

Financial Overview

CIFAR's revenue totaled $19 million for the year, an increase of $4.1 million (27%) over 2015. The year-over-year increase consisted of $2.0 million from the private sector and $2.4 million from the governments of Ontario and British Columbia, less a $0.3 million decrease in investment income. The overall increase in revenue was in response to increased funding obtained for the four new programs that were in the start-up phase during 2015 and increased activity across CIFAR's existing programs and support functions.

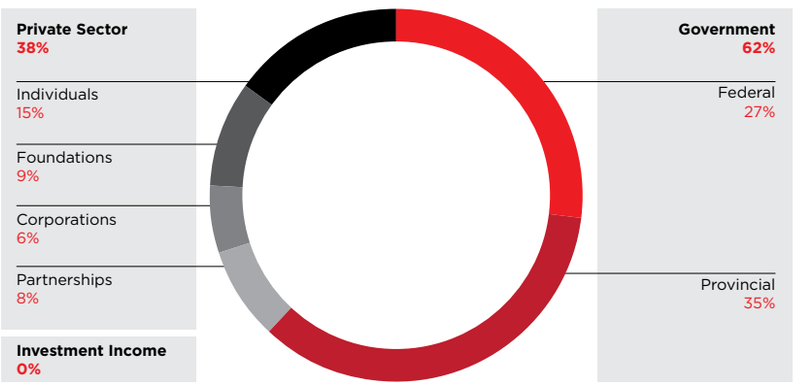
CIFAR expenses totalled $19 million, an increase of $3.2 million (20%), of which direct program spending totalled $10.8 million, up $1.7 million (19%) for the 14 research programs supported within the year and the CIFAR Azrieli Global Scholars Program. Other program initiatives, including knowledge outreach and indirect program expenses, totalled $5.1 million, up $1 million (24%), while non-program spending totalled $3.1 million, up $0.5 million (19%), for advancement, governance and administration to support the organization.

CIFAR concluded the year with a strong balance sheet. Total assets at the end of the year totalled $28.3 million, represented primarily by cash and short-term investments ($10.2 million), equities ($15.2 million), receivables ($2.1 million) and capital assets ($0.3 million). Net assets after accounting for liabilities were $17.6 million.

The audited financial statements for the year ended June 30, 2016, are available at **www.cifar.ca/about/accountability**.

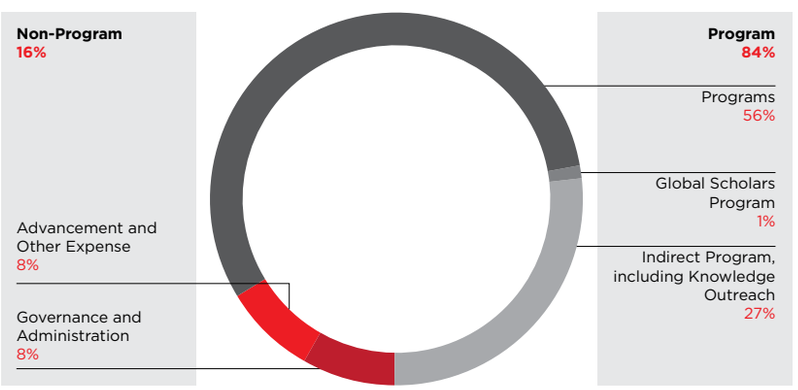
Income

for the year ending June 30, 2016



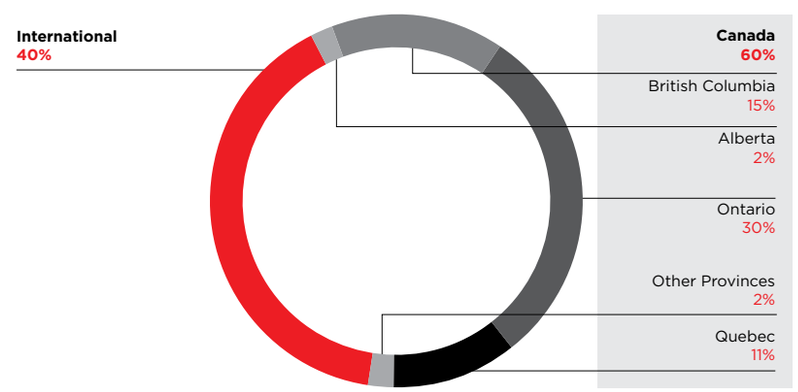
Expenses

for the year ending June 30, 2016



Research Program Funding by Region

for the year ending June 30, 2016



FINANCIAL OVERVIEW

Statement of Operations

for the fiscal years ending June 30
(in $ 000s)

	2016	2015
Revenue		
Government		
Federal	5,070	5,000
Provincial	6,492	4,324
	11,562	9,324
Private sector		
Partnerships	1,608	1,049
Individuals, foundations and corporations	5,750	4,145
Investment income and other	53	364
	7,411	5,558
Total revenue	18,973	14,882
Expenses		
Program		
Active programs, direct	10,760	9,103
Active programs, support	3,254	2,661
Communications and knowledge outreach	2,000	1,458
	16,014	13,222
Non-program	2,959	2,549
Total expenses	18,973	15,771
Deficiency of revenue over expenses before undernoted	–	(889)
Unrealized gain on investments	876	955
Surplus of revenue over expenses	876	66

For full audited financial statements, see **www.cifar.ca/about/accountability**

Condensed Balance Sheets

as at June 30
(in $ 000s)

	2016	2015
Cash and short-term deposits	2.3	1.8
Accounts receivable	2.2	1.0
Prepaid expenses	0.1	–
Equipment and leasehold improvements	0.3	0.4
Investments	23.4	19.7
	28.3	22.9
Payables and accrued liabilities	(4.2)	(3.2)
Deferred revenue	(6.5)	(2.9)
Net assets	17.6	16.8
Comprising:		
Equipment and leasehold improvements	0.3	0.4
Endowment funds	0.5	0.5
Internally restricted reserves	11.0	9.0
Unrestricted reserves	5.8	6.9
	17.6	16.8

APPENDICES

In recent field trips to the Caribbean island of Curaçao, fellows of the program in Integrated Microbial Biodiversity have studied the health of coral reefs, which play an important role in supporting a diversity of ocean life.

Appendix A

Major Awards and Honours Received

July 2015 to June 2016

In 2015/2016, CIFAR fellows and advisors received **67 major awards and honours**, including the **Nobel Prize in Physics**.

1. Awards

Award	CIFAR Fellow or Advisor	CIFAR Program
Alfred P. Sloan Research Fellowship (USA)	• Honglak Lee (University of Michigan)	• Learning in Machines & Brains
Balzan Prize for Economic History (International Balzan Foundation)	• Joel Mokyr (Northwestern University)	• Institutions, Organizations & Growth
Bank of Canada Fellowship Award (Canada)	• Francesco Trebbi (University of British Columbia) • Daniel Trefler (University of Toronto)	• Institutions, Organizations & Growth • Institutions, Organizations & Growth
Breakthrough Prize in Fundamental Physics (Milner Foundation — USA)	• Mark Chen (Queen's University) • Arthur McDonald (Queen's University)	• Cosmology & Gravity • Cosmology & Gravity
Brockhouse Canada Prize for Interdisciplinary Research in Science and Engineering (NSERC — Canada)	• Edward Sargent (University of Toronto)	• Bio-inspired Solar Energy
Centenary Prize (Royal Society of Chemistry)	• Michael Graetzel (École polytechnique fédérale de Lausanne) • R. J. Dwayne Miller (Max Planck Institute for the Structure & Dynamics of Matter)	• Bio-inspired Solar Energy • Molecular Architecture of Life
Crafoord Prize in Astronomy (Royal Swedish Academy of Sciences)	• Roger Blandford (Stanford University)	• Cosmology & Gravity
Dannie Heineman Prize for Astrophysics (American Institute of Physics and American Astronomical Society)	• Wendy Freedman (University of Chicago)	• Cosmology & Gravity
Davisson-Germer Prize in Atomic or Surface Physics (American Physical Society)	• Randall Hulet (Rice University)	• Quantum Materials
Double Helix Medal (USA)	• David Botstein (California Life Company)	• Genetic Networks
Engineering Emmy Award (USA)	• Eero Simoncelli (New York University)	• Learning in Machines & Brains
Ernest-John Solvay Prize for Human and Social Sciences (Fonds de la Recherche Scientifique — Belgium)	• Axel Cleeremans (Université libre de Bruxelles)	• Azrieli Program in Brain, Mind & Consciousness
E. W. R. Steacie Memorial Fellowship (NSERC — Canada)	• Curtis Berlinguette (University of British Columbia)	• Bio-inspired Solar Energy
Faculty Early Career Development (CAREER) Award (U.S. National Science Foundation)	• John McCutcheon (University of Montana)	• Integrated Microbial Biodiversity
Friedrich Wilhelm Bessel Research Award (Alexander von Humboldt Foundation, Germany)	• Harald Pfeiffer (University of Toronto) • Ludovic van Waerbeke (University of British Columbia)	• Cosmology & Gravity • Cosmology & Gravity

APPENDICES

Award	CIFAR Fellow or Advisor	CIFAR Program
Gerhard Herzberg Canada Gold Medal for Science and Engineering (NSERC — Canada)	• Victoria Kaspi (McGill University)	• Cosmology & Gravity
Global Award for Entrepreneurship Research (Sweden)	• Philippe Aghion (Collège de France)	• Institutions, Organizations & Growth
Henry G. Friesen International Prize in Health Research (Canada)	• Janet Rossant (Hospital for Sick Children)	• Humans & the Microbiome
Henry Marshall Tory Medal (Royal Society of Canada)	• Julio Navarro (University of Victoria)	• Cosmology & Gravity
Hughes Medal (Royal Society — UK)	• George Efstathiou (University of Cambridge)	• Cosmology & Gravity
James Clerk Maxwell Medal (IEEE/Royal Society of Edinburgh)	• Geoffrey Hinton (University of Toronto and Google)	• Learning in Machines & Brains
Jean-Jacques Laffont Prize (France)	• Elhanan Helpman (Harvard University)	• Institutions, Organizations & Growth
John Torrence Tate Award for International Leadership in Physics (American Institute of Physics)	• Neil Turok (Perimeter Institute for Theoretical Physics)	• Cosmology & Gravity
Killam Prize for the Social Sciences (Canada Council for the Arts)	• Daniel Trefler (University of Toronto)	• Institutions, Organizations & Growth
MacArthur Fellow (USA)	• Peidong Yang (University of California, Berkeley)	• Bio-inspired Solar Energy
Mike McCracken Award for Economic Statistics (Canadian Economics Association)	• Nicole Fortin (University of British Columbia)	• Social Interactions, Identity & Well-Being
Nobel Prize in Physics	• Arthur McDonald (Queen's University)	• Cosmology & Gravity
Rising Star Designation (Association for Psychological Science — USA)	• Lara Aknin (Simon Fraser University)	• Social Interactions, Identity & Well-Being
Sidney Fernback Award (IEEE Computer Society)	• Alexander Szalay (Johns Hopkins University)	• Cosmology & Gravity
Simons Fellow in Theoretical Physics (Simons Foundation, USA)	• Catherine Kallin (McMaster University)	• Quantum Materials
SSHRC Gold Medal	• Janet Werker (University of British Columbia)	• Brain, Mind & Consciousness; Child & Brain Development
Woodrow Wilson Foundation Award (American Political Science Association)	• Prerna Singh (Brown University)	• Successful Societies

2. Honours

Honour	CIFAR Fellow or Advisor	CIFAR Program
Fellow of the American Academy of Arts and Sciences	• Paul Pierson (University of California, Berkeley)	• Successful Societies
Fellow of the American Academy of Microbiology	• Karen Guillemin (University of Oregon) • Thomas Richards (University of Exeter)	• Humans & the Microbiome • Integrated Microbial Biodiversity
Fellow of the American Association for the Advancement of Science	• Thom McDade (Northwestern University)	• Child & Brain Development
Fellow of the American Physical Society	• Immanuel Bloch (Max Planck Institute for Quantum Optics) • David Cory (University of Waterloo) • Scott Ransom (National Radio Astronomy Observatory)	• Quantum Materials • Quantum Information Science • Cosmology & Gravity
Fellow of the European Academy of Microbiology	• Julius Lukeš (Czech Academy of Sciences)	• Integrated Microbial Biodiversity
Fellow of the Royal Society of Canada	• David Cory (University of Waterloo) • Brendan Frey (University of Toronto) • Michèle Lamont (Harvard University)	• Quantum Information Science • Genetic Networks; Learning in Machines & Brains • Successful Societies
Foreign Associate of the Institut de France Académie des sciences	• Ian Affleck (University of British Columbia)	• Quantum Materials
Foreign Associate of the U.S. National Academy of Sciences	• Arthur McDonald (Queen's University)	• Cosmology & Gravity
Foreign Honorary Member of the American Economic Association	• Torsten Persson (Stockholm University) • Guido Tabellini (Bocconi University)	• Institutions, Organizations & Growth • Institutions, Organizations & Growth
Foreign Member of the Academia Europaea	• Vivian Yam (University of Hong Kong)	• Bio-inspired Solar Energy
Member of the College of New Scholars, Artists and Scientists of the Royal Society of Canada	• Matthew Dobbs (McGill University)	• Cosmology & Gravity
Member of the U.S. National Academy of Sciences	• Philip Hieter (University of British Columbia) • Peidong Yang (University of California, Berkeley) • Hazel Markus (Stanford University)	• Genetic Networks • Bio-inspired Solar Energy • Successful Societies
Order of Canada — Companion	• Brenda Andrews (University of Toronto) • Arthur McDonald (Queen's University) • Janet Rossant (Hospital for Sick Children, Toronto)	• Genetic Networks • Cosmology & Gravity • Humans & the Microbiome
Order of Canada — Officer	• Philippe Gros (McGill University)	• Humans & the Microbiome

APPENDICES

Honour	CIFAR Fellow or Advisor	CIFAR Program
Canada Research Chair	• Andrea Damascelli (University of British Columbia) • Patrick Keeling (University of British Columbia) • Sara Mostafavi (University of British Columbia) • Ruslan Salakhutdinov (University of Toronto) • Francesco Trebbi (University of British Columbia)	• Quantum Materials • Integrated Microbial Biodiversity • Child & Brain Development • Learning in Machines & Brains • Institutions, Organizations & Growth
Canada Research Chair — Renewal (In total, CIFAR researchers hold 32 Canada Research Chairs and 4 Canada Excellence Research Chairs)	• Jillian Buriak (University of Alberta) • Raymond Laflamme (University of Waterloo)	• Bio-inspired Solar Energy • Quantum Information Science

Appendix B

Board, Councils and Executive

as of June 30, 2016

Patron

His Excellency the Right Honourable David Johnston, C.C., Governor General of Canada

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Barbara Stymiest (Chair)	Corporate Director, Toronto
Alan Bernstein, O.C.	President and CEO, CIFAR, Toronto
Bruce H. Mitchell (Vice-Chair)	President and CEO, Permian Industries Limited, Toronto
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Peter J.G. Bentley, O.C.	Director and Chair Emeritus, Canfor Corporation, Vancouver
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William L. Young	Chairman, Magna International Inc., and Founder and Managing Partner, Monitor Clipper Partners, Boston

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Evan V Chrapko	CEO, The Crystal Cougar Group of Companies, Edmonton

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Claude Lamoureux, O.C.	Past President and CEO, Ontario Teachers' Pension Plan, Toronto
Peter C. Maurice	Corporate Director, London, Ontario
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C. William Stanley	Former CEO, Fundy Communications Inc., Rothesay, New Brunswick
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Antonia Maioni	Department of Political Science and Institute for Health and Social Policy, McGill University, Montreal
Anne Martin-Matthews	Department of Sociology, University of British Columbia, Vancouver
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APPENDICES

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Mohamed H.A. Hassan	Co-Chair, IAP, the global network of science academies; and Past President, African Academy of Sciences, Trieste, Italy
Linda A. Hill	Director, Leadership Initiative, and Professor, Harvard Business School, Cambridge, USA
Ming Lei	Director, National Center for Protein Science Shanghai, Chinese Academy of Sciences, Shanghai, China
Geraldine Richmond	Chair of the Board, American Association for the Advancement of Science, Eugene, Oregon, USA
Krishnaswamy VijayRaghavan	Secretary, Department of Biotechnology, Government of India, New Delhi

Executive Team

Alan Bernstein	President and CEO
Kevin Cash	Chief Financial Officer (Interim)
Rebecca Finlay	Vice-President, Knowledge Outreach
John W. Hepburn	Vice-President, Research
Kara Spence	Vice-President, Advancement
Denis Thérien	Vice-President, Research and Partnerships
Jessica Kamphorst	Senior Director, Advancement and Government Relations
Aimee C. Park	Senior Director, Research and Partnerships

Governance and Administration

At June 30, 2016, CIFAR's Board of Directors consisted of 20 members, including four women. Five members are from Western Canada, thirteen are from Central Canada, and two members are based in the United States.

To maintain sound governance practices, the Board meets five times per year, and its four standing committees also meet on a regular schedule:

Standing Committee	Responsibilities Include...	Meetings Held
Governance Committee	Renewal of the Board and review of the effectiveness of its chair, members and CEO	Semi-annually
Audit & Finance Committee	Review of quarterly financial statements and expenditures; meetings with external auditors; reporting to Board on CIFAR's financial status	Five times per year
Advancement & Communications Committee	Oversight of fundraising, cultivation and stewardship activities and communications policies	Semi-annually
Investment Committee	Development of investment policies and oversight of investment management	Semi-annually

As of June 30, 2016, the staff count was 45 (44.2 FTEs). Full staff listings are available at **www.cifar.ca/directory**.

Appendix C

Partners and Donors

CIFAR Knowledge Circle

CIFAR is grateful to its partners and donors for helping to connect the best minds for a better world. This list recognizes annual contributions to CIFAR between July 1, 2015, and June 30, 2016, and current multi-year commitments of $10,000 or more.

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* indicates donors who have given consecutively for five or more fiscal years

If you have any questions about this listing, or if your recognition wishes have changed, please contact (416) 971-4453 or donations@cifar.ca.

Government

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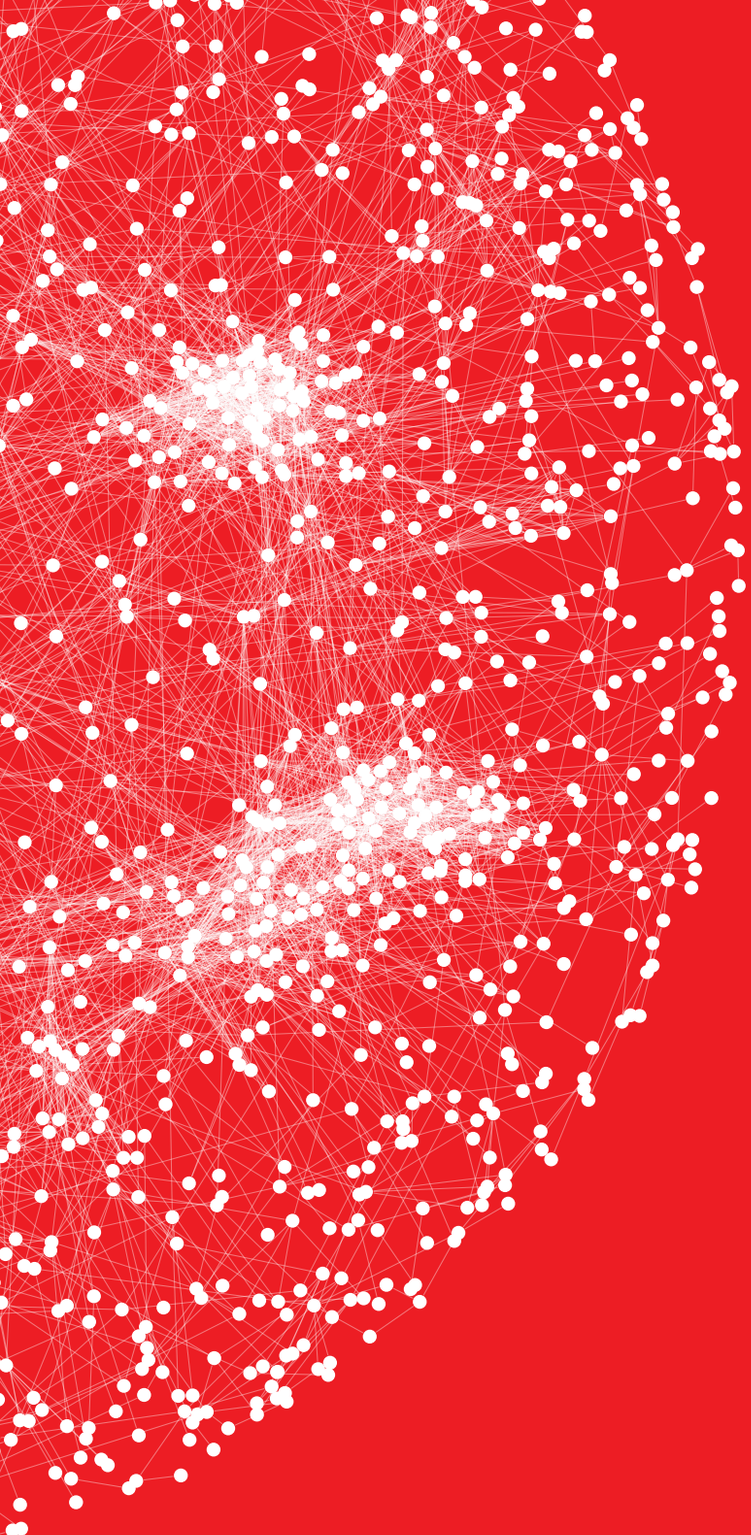

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