



THE GENERATIONS EDITION

Annual Report 09-10



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for ADVANCED RESEARCH

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2009-2010

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CIFAR

CANADIAN INSTITUTE
for ADVANCED RESEARCH

OUR MISSION:

To lead the world in framing and answering complex questions at the frontiers of human knowledge.

OUR VISION:

To create knowledge that enriches human life, improves understanding of the world, and advances the research community in Canada.



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GENERATION AFTER GENERATION, THE JOURNEY CONTINUES



On behalf of CIFAR's Board of Directors, I am pleased to present you with the Institute's 2009-2010 Annual Report. This is a special report for me, as it will be the last one I will present as Chair of CIFAR's Board of Directors. I am moving into a new role as chair of CIFAR's Capital Campaign.

That is why it is my exceptional pleasure to congratulate the researchers and to thank the volunteers and donors whose contributions have made the accomplishments of the past year possible. In fact, I would like to take this opportunity to recognize the contributions of all those who have contributed to CIFAR's 28 years of fascinating, groundbreaking research.

For nearly three decades, CIFAR has been convening elite members of the Canadian and global research community to push back the frontiers of human knowledge. It gives me pause when I consider that the youngest current members of CIFAR were conceived at about the same time as the Institute itself. Meanwhile, one of the Institute's founders, Fraser Mustard, is still involved with the organization as a member of the advisory committee for CIFAR's *Experience-based Brain and Biological Development* program.

In acknowledgement of the fact that the organization has been in operation for a generation, this report places the past year's work in the context of the Institute's history – CIFAR has had a lasting effect on many researchers' careers, on the broad research community, as well as on Canada and the world.

This proud history explains why CIFAR has been so fortunate in the loyalty and generosity of its donors. Although last year was tough economically for many people, CIFAR still managed to exceed its private-sector fundraising targets. This is of course reassuring from a financial perspective. It is also a powerful indicator that our supporters recognize the ongoing need for CIFAR's unique brand of research.

I would like to close by welcoming David Dodge as CIFAR's new Board Chair. David is an intellectual visionary, an inspiring leader and a long-time friend of CIFAR. As I take on my new role, I am delighted to know that the organization is in such good hands.

I hope that the readers of this report are looking forward to being a part of CIFAR's ongoing explorations as much as I am.

Richard W. Ivey

Chair of the Board of Directors



GENERATION OF IDEAS



I am delighted to begin my tenure as the Chair of CIFAR's Board of Directors. I have admired the organization since its inception in 1982, and feel deeply honoured to work with such an august group. This report gives me an opportunity to reflect on the successes of the past year, and to think ahead about where we might go next.

The Institute continues to place emphasis on investing in new generations of younger researchers (especially in Canada) and on seeking out collaborations with innovative thinkers at all stages of their careers in distant parts of the world.

History shows how effective it is to connect up-and-coming researchers with the world's established best. For instance, five Nobel laureates in physics subsequently produced 31 physicist laureates in their labs. CIFAR operates under the principle that excellence begets excellence. Its Nobel laureates and other equally prestigious researchers are helping to mentor new generations of young academics who will ensure that Canada maintains its position at the forefront of advanced research.

As you can see from this report, our recent investments are already paying off in the form of research that is more dynamic and innovative than ever.

I look forward to reporting on new discoveries and ideas in the years to come: ideas that enrich this country economically and intellectually; ideas that inspire us to rethink our limitations; and ideas that just make the world a more interesting place.

David Dodge

Incoming Chair of the Board of Directors

CIFAR BY THE NUMBERS

2009-2010

Year founded:

1982



Number of researchers as
of June 30, 2010:

386



Number of
current programs:

12

Percentage growth in
researchers over the
last five years:

25



Number of program
members recruited to
Canada since 1982:

66

Number of
programs supported
since 1982:

19



Percentage of senior
members ranked by
*Thomson Reuters Essential Science
Indicators* to be in the top
one per cent of their field:

14

Number of affiliated
Nobel laureates
since 1982:

Percentage of
members in the early
stages of their careers as
of June 30, 2010:

23

42



Percentage of
members who
received major
awards this year:

22

Number of countries
where researchers
are based:

16



Percentage of affiliated
researchers based in countries
other than Canada:

39



Percentage of
Advisory Committee
members based in countries
other than Canada:

77



Number of institutions
in Canada:

27



Number of program
meetings held:

27

Percentage of researchers
reporting ongoing projects
or new ideas resulting from
CIFAR interactions:

90

Number of publications
authored by members:

2,143

Number of
meeting attendees:

1,250



Number of publications
co-authored by
2 or more members:

297

Number of program members
involved in knowledge transfer
and public outreach:

114



Number of graduate
students and post-doctoral
fellows mentored
by members:

1,479

Number of CIFAR
Lunar Circle donors,
a group of donors with
lifetime giving of
\$100,000 or more:

95



Average private
donation to CIFAR:

\$11,172

Number of governments
(Federal and Provincial)
that supported CIFAR:

5



Number of institutions
where researchers
conduct their work:

107



Annual budget
(in thousands of dollars):

14,524



REPORT FROM THE PRESIDENT AND CEO

This year's Annual Report continues our tradition of telling unusual and thought-provoking stories about CIFAR research and CIFAR researchers. In addition to the research highlights section, I am pleased to present you with a brief report from the Office of the President and CEO, which outlines all of the Institute's activities over the past year, from exploring new research areas, to forging new relationships with institutes around the world.

CIFAR continues to grow and evolve, and to seek out new ways of expanding the frontiers of human knowledge. I hope this report communicates some of that spirit of intellectual adventure.

You are receiving this report because you are a part of CIFAR's growing community of scholars, business leaders, policy makers and other interested and influential individuals. I want to thank you for your interest in and support of CIFAR's research.

I sincerely hope you enjoy this report.

Chaviva M. Hošek

President and CEO and
Lawson Family Foundation Fellow

This year, significant progress has been made on all five of the Institute's strategic goals. Here are highlights:

Goal 1: Research

Expand and enhance CIFAR research: build programs, extend and expand global reach, develop the model

CIFAR's research portfolio consists of 12 research programs, each with a five-year mandate and an average of 25 to 30 researchers.

During the past year, 325 researchers from across Canada and around the world participated in CIFAR's programs, and 61 eminent scholars contributed as advisory committee members for a total of 386 affiliated researchers.

- **New and Departing Program Members:** CIFAR appointed 36 new members in diverse areas of expertise to nine research programs, including 15 Junior Fellows appointed to CIFAR's Junior Fellow Academy – an increase from nine the previous year. Of the new member appointments in 2009/2010, 56% were based in Canada, and 44% internationally.
- With funding contributions and offers of program membership, CIFAR helped Canadian universities recruit two new researchers from the United States, and to retain two others in Canada.
- CIFAR also lost 12 departing program members during the year.
- **New and Departing Program Advisors:** CIFAR appointed four distinguished researchers as new program advisory committee members. No existing advisors stepped down from their roles. These advisory bodies help to monitor and maintain the excellence of the intellectual directions and membership of each program.

- **Program Meetings and Co-sponsored Events:** CIFAR organized 27 program meetings, including two meetings of the Junior Fellow Academy; and co-sponsored 12 special topic workshops or events, each of which provided opportunities for researchers to interact in mainly interdisciplinary groups.
- **Program Student Schools:** CIFAR fully funded three student-organized summer schools in areas related to *Quantum Materials*, *Nanoelectronics*, and *Neural Computation and Adaptive Perception*. The Institute also co-sponsored three additional summer schools in *Quantum Information Processing* and *Neural Computation and Adaptive Perception*. The latter took place in India with the co-sponsorship of Microsoft Research India. The summer schools continue to be one of the mechanisms by which CIFAR provides direct support for early-career researchers.

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EXPLORING NEW RESEARCH QUESTIONS

CIFAR maintains an active search and exploration process for new research topics and “big questions.” The Institute hosted efforts in five areas during 2009/2010:

Oceans – the role of poorly understood chemical cycles that are critical to the health of oceans;

Cellular Decision-Making – the mechanisms used by cells to make decisions on how energies are directed toward specific functions;

Astrobiology – the understanding of how life may have evolved on other planets both in our solar system and around other stars;

Human-Environment Interactions – the role that environment and climate played in human migrations over the last 10,000 years (the Holocene); and

Humanities – the nature of advanced research in the humanities and CIFAR’s potential role.

INTERNATIONAL REACH AND KNOWLEDGE MOBILIZATION

During 2009/2010, the total portion of international researchers involved in CIFAR’s programs (both as program members and advisors) held steady at 45 per cent. The Institute also maintained or increased the representation of international researchers invited as guests to program meetings.

CIFAR collaborated with the Institute of Physics (IOP) of the Chinese Academy of Sciences on a three-day workshop in Beijing in March 2010. This brought together researchers from CIFAR’s *Nanoelectronics* and *Quantum Materials* programs with their counterparts at IOP. A number of IOP researchers have been invited to attend CIFAR program meetings, and plans are underway to provide students supervised by both IOP and CIFAR researchers with opportunities to collaborate in their hosts’ laboratories.



CIFAR organized a *Cellular-Decision-Making* workshop in May 2010 in collaboration with the U.S. National Science Foundation, the U.K. Engineering and Physical Sciences Research Council and the U.K. Biotechnology and Biological Sciences Research Council. This brought together 34 researchers from the three countries in a three-day workshop held in Arlington, Virginia.

CIFAR’s *Quantum Information Processing* program held its 2010 Spring meeting in Seefeld, Austria near Innsbruck. This location was chosen to facilitate stronger research collaborations with European researchers. There was a particular focus on establishing contact with investigators from the Austrian Institute for Quantum Optics and Quantum Information based at the universities of Innsbruck and Vienna, as well as investigators from other European Centres. A similar strategy was used to engage international researchers in the *Social Interactions, Identity and Well-Being* March 2010 program meeting in Paris, France.

CIFAR also hosted or co-hosted half a dozen Knowledge Mobilization events in 2009/2010. These events disseminated CIFAR research to a wide range of audiences, including government, business and industry, NGOs, and pan-governmental organizations.

Goal 2: Young Researchers

Support, celebrate and build capacity in gifted young researchers, particularly in Canada

THE JUNIOR FELLOW ACADEMY

The most significant activity has been the development of the CIFAR Junior Fellow Academy, a prestigious, two-year fellowship program attracting some of the world's best early-career researchers to CIFAR and the Canadian research community. The Institute identified funding for up to 24 such positions, two in each of the existing research programs. The Academy comprised 21 Fellows as of 30 June 2010. The inaugural meeting of the Academy was held in April 2009, and subsequent meetings were held in November 2009 and June 2010.

The Junior Fellow Academy identifies and mentors early-career researchers so as to contribute to Canada's long-term research leadership capacity.

Goal 3: Positioning

Position CIFAR to benefit Canada within the global research community

PUBLIC OUTREACH

In 2009/2010, CIFAR embarked on a national public events series called *Next Big Question*. This was the second time CIFAR held the series, each event of which involves three researchers from diverse fields engaging a public audience in a debate about which enigma from the world of advanced research deserves the title of *Next Big Question*. To achieve a low net cost, CIFAR secured corporate sponsorships from Great West Lifeco, Encana and Telus. They also forged partnerships with the *Globe and Mail*, CBC Radio and many universities.

Goal 4: Organization

Develop the 2012 CIFAR organization: capabilities, capacity, and international reach

PERFORMANCE AUDIT AND EVALUATION

This year, a Performance Audit and Evaluation assessed CIFAR's value within the Canadian research community, what it did to meet its commitments to the Government of Canada and how well it accomplished its mission. An external consultant was hired in August 2009, who collected data from document reviews, extensive interviews, and an analysis of the organization. The consultant also looked broadly at aspects of the organization such as governance and the effectiveness of strategic planning.

A key PAE finding was that CIFAR remains a unique, highly relevant institution for Canada with a track record of significant outcomes. "There is no other research program that is dedicated to supporting interactions among scientists for the purpose of addressing fundamental questions," the report says. "[CIFAR's] impact has not only been in terms of improved policies and governments, but also in the opportunities the programs have afforded universities to strengthen the quality and capacity of their research across the disciplines involved in CIFAR programs."

Goal 5: Financial

Establish stable and balanced funding capable of sustaining growth

Against a goal of \$2.5 million, CIFAR raised a total of \$2,670,239 from 239 private-sector donors in 2009/2010. This represents an increase of 2.3 per cent in revenue but a decrease of 2.4 per cent in the number of donors compared to the previous year. Public sector support from the Government of Canada and four provinces, including Ontario, Quebec, Alberta and British Columbia, totalled \$11,255,000.



GENERATIONS

Complex research subjects can take generations to fully explore. When this kind of research comes to fruition, the impact ripples out for generations more. Some of the people on the following pages have been with the Institute nearly since its inception, while others represent its future. All of them are united in collaborating through CIFAR to expand the frontiers of human knowledge.



Learning from experiences

Early Environmental factors leave marks on our biology that go last a lifetime



When psychologist Megan Gunnar, a professor in the University of Minnesota’s Institute of Child Development, talks about her research on early childhood behaviour and adopted children, she often talks about the importance of understanding how “experience gets under the skin.” Literally.

Gunnar has spent her career trying to understand the neurobiology of stress and social processes. During her post-doctoral work, Gunnar – a CIFAR researcher since 1998 in the *Experience-based Brain and Biological Development* program – began looking for ways to understand stress biology in children, based on strong findings in animal studies.

“There was clear evidence in animal models that suggests experiences early in life set the tone,” she says. “Adverse early life conditions can have long-lasting effects.”

The link becomes apparent in the levels of cortisol, a stress hormone secreted by the adrenal gland, produced by young children. Toddlers in emotionally nurturing environments tend not to produce high levels of cortisol in stressful circumstances, while children growing up in insecure settings do.

She wanted to explore the links and thus sort out the long-term impact of emotional stress (e.g., parental abuse) and environmental factors such as family poverty.

“It’s very difficult to understand what the effect of early adversity has been as compared to living a life of ongoing stresses,” says Gunnar. “We can’t experiment randomly.”

The fall of Communism presented an opportunity to test the hypothesis, as middle class American and Canadian families adopted thousands of profoundly deprived children raised in grim Eastern Europe orphanages. Gunnar, who had been studying post-institutionalized children in the U.S., learned about the plight of Romanian orphans from her friend Elinor Ames. A Simon Fraser University developmental psychologist, Ames published a major 1997 report that concluded that these adoptees must be considered to be special needs children because of the abuse and emotional neglect they endured.

That connection led to an opportunity for Gunnar to begin systematically studying cortisol-released stress levels in such kids, and that work has since expanded into a more broadly-based study on about 4,000 adopted children, comparing their development to American children in foster care and those growing up with their biological parents. The project, which Dr. Gunnar launched in 2002, is known as the Minnesota International Adoption Project (MnIAP), and its ultimate goal is to find ways to improve outcomes for children facing such transitions. >>

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While many of the orphans in the MnIAP come from Romania and Russia, she’s broadened her work to include children from Latin America and girls from China. There are many unknowns, because important family information – deprivation prior to life in the orphanage, fetal alcohol syndrome, genetics, etc. – is typically missing. “We’re collecting kids from everywhere. While that makes things noisier, I’m interested in what rises above that noise.”



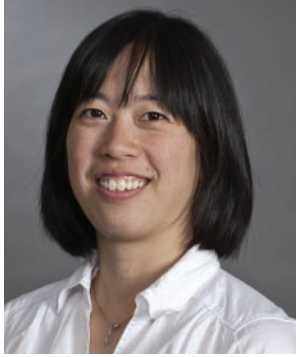
Some of the conclusions cut in unexpected directions – such as the impact of too much attention on small children. In a paper published in May 2010, in *Child Development*, Dr. Gunnar found that 40 per cent of three- and four-year-olds in 115 family daycare facilities displayed elevated cortisol levels in the presence of over-controlling or intrusive caregivers. Dr. Gunnar’s study found that girls with cortisol spikes behaved more anxiously, while boys tended to be angry and aggressive.

Gunnar’s relationship with CIFAR dates back to the early 1990s when CIFAR fellows Ron Barr and Thomas Boyce, who is now the *EBBD* co-director, invited her to participate in a network of researchers investigating the biological imprint of early childhood experiences. (This CIFAR program, which was called *Human Development*, wrapped up in 2003.) Dr. Boyce is a professor of pediatrics at the University of British Columbia, and a long-time collaborator. Dr. Gunnar says they share an interest in stress and temperament, and review one another’s research proposals.

The connection has also provided mentoring opportunities for up-and-coming researchers: One of Dr. Gunnar’s doctoral students, Jelena Obradovic, ended up doing post-doctoral work for Dr. Boyce and subsequently became the *EBBD* Great West Life Junior Fellow of CIFAR. Dr. Obradovic, now an assistant professor at Stanford University’s School of Education, studies how stress reactivity allows some disadvantaged children to demonstrate resilience while placing others at risk.

Where the diversity is

An entire new world opens up to young researcher thanks to CIFAR mentorship



AS an undergraduate studying biology at the University of New Brunswick, CIFAR Junior Fellow Vera Tai, like many other students, was intrigued by the possibility of studying “exotic” animals such as pandas – “charismatic mega-fauna,” as microbiologists jokingly refer to such species.

But as she learned more, Tai discovered that the real biological frontiers lay elsewhere, and generally out of sight. The unanswered questions, Tai observes, are at the microbial level.

“It’s exciting because microbes are really diverse and exist in all these different environments,” says Tai, who has a masters in botany from the University of British Columbia and obtained her doctorate from San Diego’s Scripps Institute of Oceanography in December 2009 after working for several years as a technician in a cell biology lab. She joined CIFAR’s *Integrated Microbial Biodiversity* program as a Junior Fellow in spring 2010.

Tai has become part of an interdisciplinary CIFAR group that includes scientists who study both insects and microbes. UBC botanist Patrick Keeling, who is the director of the *IMB* program and supervises Tai’s research, has focused his team’s research on microbial predators. “They are notoriously difficult to work on because they’re rare and difficult to grow,” says Keeling, who has been involved with CIFAR programs since 1999 and specializes in malaria.

Keeling’s fascination with this microscopic frontier dates back to a second year undergraduate cell biology course, during which the instructor shared “a hair-brained theory” that bacteria may live inside a cell’s mitochondria in a symbiotic relationship. “That idea blew me away.”

He completed a PhD with CIFAR veteran Ford Doolittle, of Dalhousie University. During his post-doctoral work in Melbourne and then at Indiana University, Keeling began to explore further the subtleties of symbiotic pairings, such as the transfer of genes between two organisms.

“

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In his search for answers, Keeling and researchers like Vera Tai have turned to other disciplines for strategies and insights into tackling tough problems. Keeling has taken to consulting with environmental microbiologists in the *IMB* program, who study ecological systems, not just individual organisms.

“By hanging around with people who are doing things that are so different from you, their outlook starts to rub off on you,” he says, describing the professional relationship as symbiotic. “If someone’s own research gives you ideas on changing your research program, that can be permanent. It can completely change the direction you’re going in.”

Origins of Creativity

Giving young scholars disruptive opportunities



Ray Laflamme, the director of CIFAR’s *Quantum Information Processing* program, knows all about the intellectual disruption that up-and-coming researchers inflict on their academic elders. As a Cambridge University doctoral student working for Stephen Hawking, Laflamme and his colleague, Don Page, managed to persuade the acclaimed astrophysicist that time does not run backwards in a shrinking universe, as he had long argued. Hawking even cited the story in his best-seller, *A Brief History of Time*.

An internationally acclaimed researcher who held posts at the University of British Columbia and Los Alamos before joining the newly formed Perimeter Institute of Theoretical Physics in 2001, Laflamme has never forgotten why science depends on young people who are like the sand in the oyster of scientific progress.

“They come and challenge,” he says. “The really interesting result is when you see things that are totally unexpected.” Recruiting the right people is more of an art than a science. “It’s important when we hire the young people not to come in with a strong prejudice that they fit in a particular mold,” Laflamme remarks. “We don’t know what is the origin of their creativity. We can try to make the oyster healthy by feeding it, but you cannot know which grain of sand will change into the pearl.”

“

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Context is also vitally important. In 2010, for example, Laflamme and his colleagues decided to broaden the cross-section of participants in one of the program’s regular meetings. They held the session in Innsbruck in May, with an eye to asking Austrian colleagues to invite young local researchers who might not have had the means to travel to Canada. “That was a new strategy and it really worked very well,” he says.

One of the local attendees has since begun to collaborate with one of Dr. Laflamme own graduate students as a result of a chance encounter in Innsbruck in May.

“You have more time,” Laflamme says of such events. “Conference calls or Skype work well for solving particular problems. But at a meeting, you encounter someone you weren’t expecting.”

Success story

Harvard researcher maintains her Canadian connections



Growing up in Hull, Quebec, in the late 1960s, Michele Lamont, a CIFAR Fellow in the *Successful Societies* program, developed an early fascination with borders – political, social, cultural, even racial. At the time, separatism was on the rise while bulky federal buildings were sprouting pointedly across from her high school. The stark lines dividing people and communities were difficult to ignore.

After focusing on political theory and sociology at the University of Ottawa, the Sorbonne and Stanford, Lamont built a career analyzing racial stigmatization and social resilience at Princeton and Harvard, where she is the Robert I. Goldman Professor of European Studies and Professor of Sociology and African and African American Studies. Her research on discrimination has been recognized internationally.

Until 2003, however, Lamont says she was an example of brain drain for Canada. That changed when CIFAR asked her to participate in its *Successful Societies* program. “For me, it’s really allowed me to renew my contacts with Canada.” Through the program, Lamont has built collaborative projects with CIFAR Fellow Peter Hall, a Harvard European studies expert and fellow Canadian, and McMaster University’s James Dunn, who has emerged as one of Canada’s leading authorities on housing and health.

Lamont and Hall have published two books on successful societies; a forthcoming volume, to be released in January, 2011, will focus on the ways in which racial minorities buffer themselves using social networks, institutional supports and cultural self-definition. At a conference on racism at Harvard in April 2010, she brought together CIFAR researchers and other experts to compare responses to stigmatization in racialized groups in the U.S., Brazil and Israel. The meeting also produced important mentoring opportunities for young academics, as several of Lamont’s doctoral students presented findings and received feedback from CIFAR Fellows and program directors.



“These are the kinds of things that would not happen if it were not for CIFAR’s ability to bring people together,” says Lamont, who is currently on sabbatical in Paris. “They’re not breathing down our necks [for results], which allows us to follow our scientific instincts on how research projects should develop.”

But her work isn’t just an exercise in observation. With her focus on the ways culture and institutions can affect health outcomes in certain societies, Lamont has found a receptive audience at the World Bank, whose officials are interested in transferring these insights to other countries. She has also found an audience among federal Human Resources officials in Ottawa, just across the river from her old high school. “It’s an effort to make the knowledge we’ve produced in the past make an impact on the future.”

The next small thing

Building circuits according to the laws of quantum physics



“Walking on the edge.” That’s how University of Sherbrooke physicist Alexandre Blais characterizes the way his nanoelectronic research focuses on the unexpectedly blurry boundary between classical and quantum mechanics.

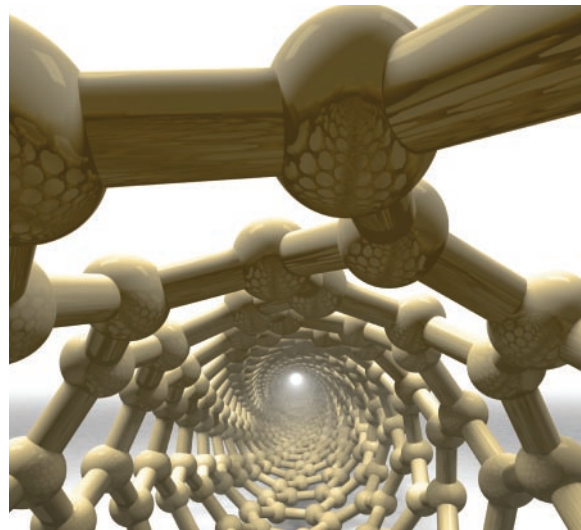
As a Scholar in the *Nanoelectronics, Quantum Information Processing* and *Quantum Materials* programs, Blais is part of CIFAR’s broad and ongoing effort to explore the new frontiers of computing at the scale of atoms, photons and electrons. Collaborating with CIFAR Junior Fellow Jay Gambetta and others, Blais is studying how to control the quantum states of mesoscopic devices fabricated using superconductive materials created by researchers in the *Quantum Materials* program.

Blais became intrigued by quantum computing during his undergraduate years in the late 1990s, a time when the field was still in its infancy. He completed his doctorate at Sherbrooke in 2002, spent two years at Yale University, and ended up doing qubit research with Loughborough University physicist Alexandre Zagoskin.

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The immediate goal is to figure out how to build circuits made of superconductors that behave according to the laws of quantum mechanics.

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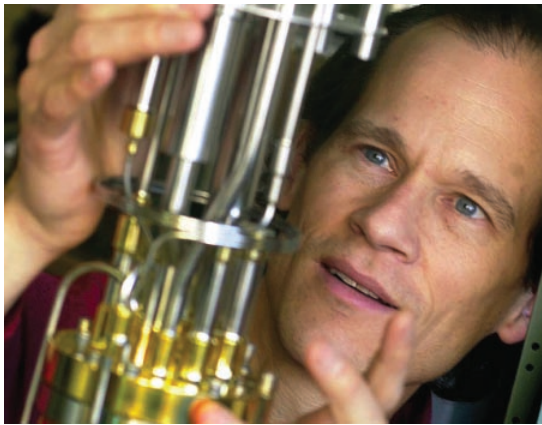


“My goal is basic science,” says Blais, “but the practical goal is better computers, which take advantage of the weirdness of quantum mechanics.” The immediate goal is to figure out how to build circuits made of superconductors that behave according to the laws of quantum mechanics. “The big motivation is building a quantum computer,” he adds. “In the end, we expect huge speed-ups. Problems that would take a billions of years to solve could be solved in weeks or more.”

Two decades on, researchers get closer than ever to unlocking one of the most intractable enigmas in the world of physics

The June 2010 issue of *Scientific American* featured what could be considered a global scientific “bucket list” – twelve events that could “change everything.” The roster featured various apocalyptic scenarios (an asteroid collision, a massive pandemic), but it also included the advent of room temperature superconductivity, considered to be the “holy grail” of CIFAR’s *Quantum Materials* program.

The reason superconductors made the list, says Louis Taillefer, a University of Sherbrooke physicist and the director of CIFAR’s program, “is that you would have a qualitatively new kind of technology,” one that would forever transform electricity transmission because such materials allow electrons to flow with virtually no resistance.



Born in Montreal, Dr. Taillefer excelled at math and physics, but grew tired of high school, and dropped out to work with Claude Côté, an entrepreneurial farmer whose knack for solving daunting technical problems made a deep impression on his bright 16-year-old apprentice.

“For Claude, everything was possible,” Taillefer told Science.ca. “He showed me that a person can do anything.” After a year, the young man returned to school, thinking he’d pursue a career in theatre. Instead, Taillefer enrolled in a metallurgical engineering program at McGill.

He became intrigued by superconductors while doing his doctoral work at Cambridge University in England. “It’s like perpetual motion,” he says. “It’s always been a fascinating property, but it had only been seen at very low temperatures.”

Until the early 1980s, scientists knew how to make superconductive materials that only functioned at temperatures near absolute zero. Then, in 1986, two U.S. researchers discovered a copper oxide superconductor that performed at significantly higher (though still very low) temperatures – a game-changing breakthrough that not only generated international headlines but sparked Taillefer’s imagination.

Cambridge was home to the Cavendish Physics Laboratory, which was fitted out with new equipment geared to conducting experiments at ultra-low temperatures. Dr. Taillefer began to experiment with an “unlikely” superconductive magnetic material, and succeeded in growing specialized uranium platinide crystals that functioned as high temperature superconductors.

After completing his PhD, Taillefer spent five years at the CNRS Lab in Grenoble, France, before returning to Canada in 1992 to take a tenured faculty position at McGill University. Well known by then for his work in fabricating these materials, he received an invitation to his first CIFAR meeting on superconductivity research shortly after returning. Dr. Taillefer, who was named to the Order of Canada last June, was soon hooked into a CIFAR network of Canadian scientists working on superconductivity.

“I would say CIFAR has been my real home [in Canada],” he says. “It’s been my most steady home.” >>

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Through CIFAR’s inter-disciplinary approach, says Taillefer, experts in three overlapping fields collaborate in what he calls “a rapid feedback loop.” These people are: materials researchers, whom he describes as “modern day alchemists;” explorers and experimentalists who probe the properties of new superconductive substances, and theorists, who build the mathematical models that describe the observations in a coherent way.

“The best way is to join this triad in a tight, collaborative loop.”

He says this collaborative model has contributed as much to the advancement in the field as any individual investment in lab equipment or any solo research project.

The most recent result of this approach was a major finding about cuprate superconductors, published in the January 2010 issue of *Nature*. Dr. Taillefer and his Sherbrooke team paired up with another group of CIFAR program members at the University of British Columbia – QM fellows Doug Bonn, Walter Hardy and Ruixing Liang – on a project that revealed that the electrons in these materials have a spontaneous tendency to align – a phenomenon known as “quantum oscillation.” This aligning tendency strongly suggests that some form of order, hitherto hidden and probably magnetic, coexists with superconductivity. The discovery brings them an important step closer to understanding the superconductivity mechanisms in these materials, which are considered to have great promise in future applications.

This research relationship goes back to the early days of CIFAR. Dr. Taillefer says he has been working through CIFAR with the UBC team for 17 years to produce very high quality crystals with superconductivity properties. All the work led to a string of discoveries in the past three years. Dr. Taillefer appreciates the long-term nature of CIFAR funding for research as much as the collaborative efforts.

“There’s been a real change in the landscape of high temperature superconductors,” he says. “Since 2007, we’ve been running down this new trail that has been opened.”

Today, these superconductive copper wires create the possibility of building vast wind farms in the middle of the Sahara or other remote areas by tethering such facilities to populous areas thousands of kilometres away with transmission lines that don’t lose electricity due to resistance, and are therefore capable of carrying far more power.

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When Dr. Taillefer joined CIFAR, he was a young but already respected pioneer in the field. Today, he is one of the world’s preeminent experts on high temperature superconductors, thanks in great part to the exchange of ideas and the inspiration he found through CIFAR. The major advances of the past year have only whetted his appetite for where the *Quantum Materials* program goes next.

Perhaps recalling the problem-solving skills of the farmer who once gave him a job, Dr. Taillefer told a reporter last February that he likes the field because it’s a bit of a jungle.

“Superconductivity is easy to see. It’s not easy to understand.” He is also captivated by its potential, and compares the latest discoveries to a moment in 1947 when the transistor was invented.

“No one would have anticipated Google then,” he says. But the information revolution was unleashed with the single innovation of the transistor.

Today, these superconductive copper wires create the possibility of building vast wind farms in the middle of the Sahara or other remote areas by tethering such facilities to populous areas thousands of kilometres away with transmission lines that don’t lose electricity due to resistance, and are therefore capable of carrying far more power.

“You don’t need high-voltage, high-frequency lines,” he says. “It would be a very big revolution.”

What can a social scientist learn from a biologist?

With the right collaboration, a lot

Athabasca University urban geographer Joshua Evans, a Junior Fellow in the *Successful Societies* program, thinks a lot about how social networks can improve policy. His specific concern is the challenge of disseminating knowledge about improved therapeutic facilities and supportive housing for the chronically homeless. But as his research evolves, he is finding inspiration from an unlikely source: the biological and physical scientists who come to CIFAR Junior Fellow Academy meetings.

“You’d be surprised,” he says. “There’s some really interesting cross-fertilization that happens.”

At one session, a biologist presented some observations about mapping genes using certain types of network analysis software, ideas that Evans found helpful in his efforts to map social networks.

Evans completed his undergraduate degree at the University of Alberta and did his PhD at McMaster. His recent work has focused on how homeless people experience different types of interventions. He published some of the findings, focusing on the “caring and controlling dimensions of a low-barrier shelter,” in the journal *Health & Place*.

The goal, he says, is developing “place-based” solutions to addressing homelessness at the community level – for example, the way the City of Toronto in recent years has targeted resources to 13 priority neighbourhoods with high levels of poverty, crime and unemployment.



To that end, Evans has become involved in efforts to promote “learning networks” linking poverty-reduction efforts taking place in a growing roster of Ontario cities. These networks, he says, “have been instrumental in spreading place-based policies across Canada, in cities such as Hamilton and Victoria.” Indeed, the way these networks function – i.e., how ideas are generated, spread and adopted – offers insights into the public policy formation process.

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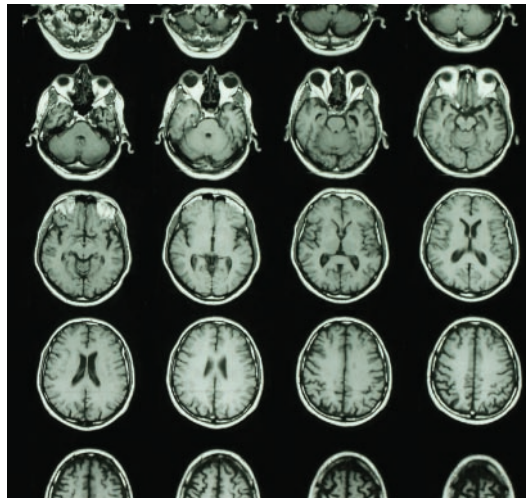
The “Splicing Codebook” reveals hidden complexity in human DNA

The numbers seem highly counterintuitive. While humans are the most complicated of all organisms, we possess a relatively small array of genes – 22,000, compared to 45,000 for a balsam poplar tree. Why that should be is “a big puzzle that’s arisen in the last decade,” says University of Toronto computer scientist Brendan Frey, who is jointly appointed to the engineering and medical faculties.

But in May 2010, Frey’s lab at U of T published a headline-grabbing study in *Nature* that laid out a computer algorithm designed to decipher the hidden code in the DNA that instructs our genes to produce various types of cells. “The code shows how genes will be reassembled in different ways,” says Frey, who is a CIFAR Fellow in two programs: *Genetic Networks* and *Neural Computation and Adaptive Perception (NCAP)*.

He likens the discovery to the moment in World War Two when Allied cryptographers cracked the Germans’ Enigma coding machine. “We are the first people to actually make predictions about which genetic message will be produced in different tissues,” he told the *Toronto Star*. “Prior to this, there was no way to predict that actually.”

Frey’s next projects are equally ambitious. His lab is trying to further refine the genetic decoding algorithm with a technique that “allows us to peer inside the cell and figure out how proteins are saddling up beside these genetic messages.” Frey’s team, in effect, is looking at combinations of genes and trying to understand how they’re working together. “We’re very hopeful this will give us a completely new understanding of how this process works in human beings.”



Over in the NCAP program, Frey and program director Geoffery Hinton are supervising CIFAR Junior Fellow Ryan Adams, who completed his PhD in physics at Cambridge University last year, on a project that seeks to devise “a new computational paradigm to understand how vision works.” Adams, Frey says, has developed a device that can track the position, velocity and orientation of a small video camera that is attached to a moving object. The riddle is to invent a neural network that can predict what’s going on based on an analysis of the images recorded by the camera.

The problem is much more complex than it might appear. The natural vision systems in animals will make corrections for changes in perspective if the head or the perspective shifts. In other words, an artificial vision system must be able to factor out that kind of visual background noise while retaining the ability to recognize objects within the viewfinder. Adams ultimately wants to develop intelligent machines that can begin to emulate the built-in computational capabilities of the human brain.

No lack of security about quantum communication

Bill Coish, a Junior Fellow in the *Quantum Information Processing* program, is a theoretical physicist who can talk about teleportation without reaching for Star Trek references. An assistant professor at McGill, Coish is a talented young researcher who wants to invent radically new approaches to creating secure communication technologies. The teleportation technique he works with involves destroying a quantum state in one location while creating an identical one elsewhere.

By studying the properties of these “entangled pairs,” Coish hopes to gain a better understanding of how quantum mechanics can help to overcome the shortcomings of conventional fibre optic technologies, in which photon streams may dissipate over long distances, thus damaging the data being transmitted. As Coish says, “You lose the ability to tell if they were lost to an observer or in a random way.” Coish, who worked for three years at the University of Waterloo’s Institute for Quantum Computing and received his CIFAR Junior Fellowship in March 2009, became intrigued by quantum information processing while completing his Master’s in superconductivity at McMaster University.

“If we really use the full power of quantum mechanics and forget about what we know about classic computing,” he says, “then it turns out there are certain tasks we can do much better. This is a fundamentally new way of doing things, not just squeezing more out of conventional technology.”

Last June, Coish was heavily involved in organizing a CIFAR-supported workshop at IQC to bring together experts to share insights about new advances, and especially links between superconductivity research and quantum information processing.

His co-organizer was Junior Fellow Jay Gambetta, whose area of expertise is the production of qubits. Gambetta, now with CIFAR doing post-doctoral work at IQC with CIFAR Fellow Joseph Emerson, studied quantum optics at Yale for three years before coming to Waterloo to focus on the mathematics of quantum information and superconductivity. “I found out I had a real liking for theory that can be realized,” he says, joking that his career path has been “stochastic.”

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Coish is a talented young researcher who wants to invent radically new approaches to creating secure communication technologies.

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The latest findings from his work in superconductivity were published last year in *Nature*, and the journal published a second paper on qubits in the fall of 2010. “What we’ve done,” he says, “is try to build the building blocks, the proofs of principles, and develop techniques and protocols to get the errors down to less than a percent.”

Coish and Gambetta are, in effect, coming at the same set of problems from different trajectories. As Coish says, “It’s not clear which one will win in the end.”

Long-time CIFAR friend breaks new ground in researching childhood health



IN recent months, University of British Columbia early childhood expert Clyde Hertzman, one of the leaders in CIFAR’s efforts to fundamentally alter our understanding of population health, has been pondering some troubling statistics.

Canada, in the mid-1990s, had one of the world’s lowest rates of infant mortality. But after years of steady declines, he notes, progress has stalled, with a rate of 5.7 per 1,000 live births. Sweden’s infant mortality rate, meanwhile, is at 2.3, the United Kingdom’s is below 5, and the gap between Canada and the U.S. has closed. And this despite Canada’s apparent prosperity and programs such as expanded parental leave.

“Relatively speaking,” Dr. Hertzman says, “we’ve done poorly.”

Nor are the problems limited to maternal health. In September 2010, UBC’s Human Early Learning Partnership (HELP), which Dr. Hertzman directs, released a province-wide study showing that the proportion of B.C. kindergarten students living in poverty or troubled homes has risen steadily. “Since we started tracking the progress of B.C. children 10 years ago, we can clearly demonstrate that child vulnerability is trending upwards,” he told the *Vancouver Sun*.

For more than 20 years, Dr. Hertzman has been trying to understand why, in wealthy societies like Canada, there are lingering social inequalities in health outcomes. But when he entered the field in the 1980s, few people understood the connection between public policy and population health. Many decision-makers at the time felt that increased health spending led to a healthier population. That view was so entrenched, he recalls, that it was difficult to find research funding to study measures meant to promote healthy lifestyles rather than cure illness.

“Among the wealthy countries,” as he observes, “there’s little correlation between health spending and health.”

At the time, Dr. Hertzman had a medical degree from McMaster University and was working in the field of occupational and environmental health. After joining the University of British Columbia as an assistant professor, he met two established members of Canada’s research community: CIFAR *Population Health* program director Robert Evans, known internationally for his work in health economics, and CIFAR’s first president Fraser Mustard.

Thanks to those intergenerational research connections, Dr. Hertzman joined the *Population Health* program and began exploring precisely how it is that societies invest in ways that produce health, and not just by policy. It was *terra incognita*.

“What CIFAR did by paying my salary was to reorient me to a field that was totally emerging,” he recalls. “It didn’t fit any of the existing research programs we had.”

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Almost all diseases have a social gradient beyond behavioural and lifestyle [factors]. That’s why where you are in a social hierarchy must signal something that will influence resilience and vulnerability, independently of the specific disease processes. CIFAR is willing to take a chance on this thinking.

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“Gradually,” he adds, “population health research became respectable. CIFAR created the beacon.”

Over the years, Dr. Hertzman, now an *EBBD* Fellow, has worked extensively in the field of early childhood development, and played a pioneering role in advancing theories about how early experiences are “embedded” in biological development. He has also participated in landmark studies on health gradients in the United Kingdom, and worked with the World Health Organization to study the determinants of health among children.

Researchers and policy makers now have a clearer understanding of the ways in which socio-economic status can affect health and even disease trajectories. “Almost all diseases have a social gradient beyond behavioural and lifestyle [factors],” he says. “That’s why where you are in a social hierarchy must signal something that will influence resilience and vulnerability, independently of the specific disease processes. CIFAR is willing to take a chance on this thinking.”

He is also a Fellow in the Institute’s *Successful Societies* program. He and his team has been developing a monitoring program for the United Nations Convention on the Rights of the Child. Enacted in 1989, the convention laid out rights for adolescents. But in 2005, Hertzman says, a UN monitoring committee created a supplement to the Convention describing early-years rights, “so kids have the chance to evolve their capacities.”

During the past year, Dr. Hertzman’s team has been running an inter-agency secretariat to monitor compliance with the protocol. The project was piloted in Tanzania last year and will soon be tested in Chile. The monitoring looks at 16 indicators, such as the existence of birth registries, access of quality early childhood programs, and policies for children with special needs. Countries should be collecting data, Hertzman says, because wide gaps in gradients within one country should be seen as “rights violations.”



“There is no reason for 17-fold differences,” he says.

Here in Canada, he notes, there’s been “a great deal of interest” at the federal and provincial levels in CIFAR’s work on successful societies. But, he adds, the federal government’s 1996 deficit-elimination campaign remains “a watershed.... That was the point where Canadians’ health status stopped improving.”

RESEARCH HIGHLIGHTS

Each CIFAR’s research program involves an exploration that takes many years to complete. With more than 350 affiliated researchers, each doing their own work as well as collaborating with others, there emerge many fascinating stories along the way. Here are some of the highlights from these intellectual journeys – the new discoveries and ideas from the past year that are enriching Canada intellectually and economically.



Experience-based Brain and Biological Development

Fellows Moshe Szyf and Michael Meaney have shown that child abuse results in chemical changes to the DNA in a victim’s brain that persist into adulthood. This finding could help explain how and why experiences in early life have a lifelong impact on health and behaviour. It may be possible to use chemical marks laid down in DNA by adversity early in life, to identify vulnerable subjects and help them at an early stage. These changes might even be able to be reversed either pharmacologically or by behavioural interventions. This work was published in *Nature Neuroscience* in 2009.

Genetic Networks

A major five-year collaborative effort led by Fellow and Program Director Brenda Andrews and Fellow Charlie Boone culminated in a landmark paper published this year in *Science*. Co-authors of the study included Fellows Fritz Roth, Olga Troyanskaya, Howard Bussey and Junior Fellow Matt Weirauch. The paper describes the construction of the largest genetic interaction network ever reported for a eukaryotic cell – i.e., a cell that contains a nucleus. The group mapped genetic interactions in yeast cells, which researchers commonly use as a model system for human cells. The network consisted of about 170,000 genetic interactions representing more than 30 per cent of the yeast genome. Analysis of the yeast genetic network indicated that the number of interactions for a given gene is predictable, based on a specific set of properties associated with that gene. This observation has significant implications: it suggests that the yeast genetic network can be used to guide the study of genetic interactions in more complex organisms. For instance, identifying so-called “hub genes” is particularly important because they are sensitive to many different mutations, and thus may represent the “Achilles heel” of tumor cells and potential targets for anti-cancer drugs. The Boone and Andrews groups have already constructed a predictive model based on the yeast genetic network, and together with Scholar Jason Moffat, they are now testing genetic interaction predictions in mammalian cells.

Integrated Microbial Biodiversity

We often think of microbes in relation to disease, but *IMB* researchers are gaining a new appreciation of the diversity and importance of the non-harmful microbes that are intimately associated with animals and plants. One major question concerns the role these symbionts play in immunity: how do our resident microbes protect us against other microbes that could make us sick? Scholar Steve Perlman contributed a new puzzle piece this year by studying a *Drosophila* fruit fly species that is commonly infected with a nematode worm parasite. Although typically infections result in the fruit flies becoming sterile, Dr. Perlman and his team discovered that the flies have evolved a new resistance to sterility, thanks to a bacterial symbiont that they inherit from their parents. Fruit flies carrying the symbiont are no longer sterilized by the worms, placing them at a clear advantage over flies without it. This result, recently published in *Science*, has potential practical applications: many flies transmit worms that cause diseases in humans. If it can be determined exactly how the symbiont affects the worms in *Drosophila*, this knowledge could be used to treat related human diseases.



Earth System Evolution

Fellows Alessandro Forte, David Rowley, Jerry Mitrovica, Kelin Whipple, Scholar Peter Reiners, Junior Fellow Xavier Robert and CIFAR-supported post-doctoral fellow Robert Moucha have been working together to develop a fully integrated physical model of how the vast heat engine in our planet's interior functions and how it affects the surface evolution of the Earth. As part of this collaboration, a subset of these members (Drs. Moucha, Forte, Rowley, and Mitrovica) published a paper in *Geophysical Research Letters* that appears to have resolved one of the most hotly debated topics in continental geology – namely, when did the Colorado Plateau uplift? Their model of the uplift also makes clear predictions on another long-standing debate in the geological community – the timing of the appearance of the Grand Canyon. Their analysis indicates that warm upwelling material in the Earth's mantle caused the uplift of the Colorado Plateau only in the last 5 million years, and that this uplift in turn led to the formation of the Grand Canyon, due to incision of the Colorado River by the uplifting Plateau. The conclusion that the Grand Canyon is a relatively young geological feature is a transformative idea that has sparked much debate within the geological community.

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Researchers hope that once the mechanism behind superconductivity in the cuprates is revealed, they will be able to further manipulate the properties of these materials to produce superconductivity at room temperature, making possible a host of new technological innovations.

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Quantum Materials

A recent discovery by program members may hold the key to finally explaining how copper oxide materials, or cuprates, become superconductors when cooled to a certain critical temperature. Despite more than two decades of enormous effort by researchers around the world, this question has yet to be resolved. Part of the problem has been that cuprate materials are very difficult to study experimentally: to uncover their fundamental properties, one has to control or suppress the effects of their defects and impurities. Fellows Doug Bonn, Walter Hardy and Ruixing Liang have produced some of the purest crystals of yttrium barium copper oxide. In the past year, they provided some of their best samples yet to Fellow and Program Director Louis Taillefer. He and his team conducted new experiments that led them to discover a new property that may reveal the fundamental mechanism responsible for superconductivity in the cuprates. Researchers hope that once the mechanism behind superconductivity in the cuprates is revealed, they will be able to further manipulate the properties of these materials to produce superconductivity at room temperature, making possible a host of new technological innovations. The June 2010 issue of *Scientific American* identified room-temperature superconductivity as one of “twelve events that will change everything.” The findings of the CIFAR team were published in *Nature* in 2010.

Quantum Information Processing

Quantum mechanics and general relativity are two pillars of modern physics; quantum mechanics describes physical phenomena that happen at the subatomic level, while general relativity describes how gravitation works. Each theory has been highly successful in its relevant context, and yet the two are incompatible with each other. Physicists have long struggled over how to modify them to fit together. One adjustment scientists have debated is the possibility of violating a quantum axiom called Born’s rule. This rule posits that patterns of quantum interference always occur in pairs. In 1908, a now-famous experiment showed that a single photon, or particle of light, fired at a light-blocking material containing two slits, passed through both slits at the same time, creating pair-based interference patterns on the other side. Fellow and Program Director Raymond Laflamme, Associate Thomas Jennewein, and CIFAR Scholar Gregor Weihs conducted new experiments with three slits to see if they could disprove the rule by producing other interference patterns. After firing 30 million photons at their system, they were able to show conclusively that the interference still took place in complex pair-oriented patterns, thus confirming the rule. The result, published in *Science* in 2010, confirms the integrity of this key quantum mechanical principle.

Nanoelectronics

Fellow Mark Reed and collaborators made headlines by creating the first functional transistor made from a single molecule. They were able to show that a benzene molecule attached to gold contacts could behave just like a silicon transistor. The researchers' technique involves manipulating the molecule's energy states by varying the voltage applied to it. They were able to control the current passing through it. Building such a device has been a long-sought goal in nanoelectronics research, and of Dr. Reed's in particular. The achievement builds on work that he and his former post-doctoral fellow, Takhee Lee, began in the 1990s. Over the years, they developed the knowledge and technology that enabled them to make the electrical contacts on such a small scale, to identify the ideal molecules to use, and to determine where to place them and how to connect them to the contacts. Although their breakthrough will take many years – perhaps decades – to translate into practical applications, it is already teaching researchers new insights about the fundamental limits of electronics. The results were published in *Nature* in December 2009.

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Neural Computation and Adaptive Perception

NCAP researchers are working to improve deep-learning algorithms by continually making adjustments that increase the resemblance to the way the human brain works. Fellow Nando de Freitas and his students are working on a deep-learning system geared to recognizing features in video images. They are developing their model to behave more like the human visual system, which can only focus on a small region of high resolution at a time.

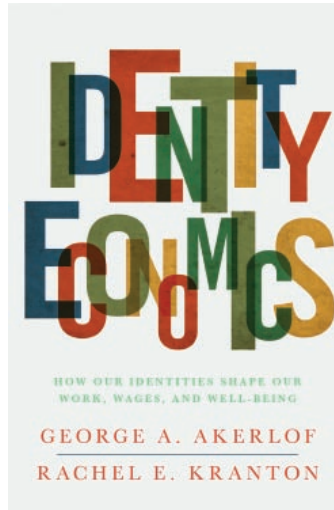
In 2010, Geoffrey Hinton's group applied deep-learning algorithms to the problem of speech recognition, and in particular the recognition of “phonemes,” the smallest units of meaningful speech sounds. Their algorithms achieved results significantly better than any previous speaker-independent method for recognizing phonemes. In fact, the deep-learning algorithms easily outperformed a highly-tuned system developed by a major speech research group, even when they were given only 2 per cent of the “training” data that the specialized system required. Speech recognition groups at IBM and Microsoft are now collaborating with *NCAP* researchers to make better speech recognizers by using deep learning.

Successful Societies

Fellow James Dunn studies how housing and neighbourhoods influence the health and well-being of individuals and communities. During the past year, Dr. Dunn, and Junior Fellow Joshua Evans and Neil Bradford co-authored a large report on “Place-Based Policy” for Human Resources and Social Development Canada. Dr. Dunn is also leading a major study of the effects of a major redevelopment in Toronto, known as Regent Park, on adult mental health and child development. Regent Park is one of Canada’s oldest and largest public housing developments. Over the next ten years, it is being completely demolished and rebuilt into a mixed income community. This year, Dr. Dunn was awarded a major grant for the project from the John D. and Catherine T. MacArthur Foundation in Chicago. It is the first urban housing study outside the United States to be funded by the Foundation, which invests heavily in housing policy development, housing research and affordable housing construction.



Social Interactions, Identity and Well-Being



In 2010, Nobel Laureate, Fellow and Program Co-Director George Akerlof and Fellow Rachel Kranton published the book, *Identity Economics: How Our Identities Shape Our Work, Wages, and Well-Being*. This joint work, which represents the culmination of years of research on how social identity impacts

economic outcomes, presents a new paradigm of how to approach economic problems. Traditionally, economists have assumed that people experience well-being from the physical act of consumption, and that this in turn is what motivates them. Drs. Akerlof and Kranton show how people’s beliefs about what they should or should not do and people’s conception of who they are, and of who they choose to be, also play an important role in economics. Much of psychology and sociology supports the concept that people feel good about themselves when they are living up to how and who they think they should be. This in turn can be an important indicator of well-being. In their book, Drs. Akerlof and Kranton apply this type of motivation to a wide range of issues including minority poverty, the economics of education, the economics of institutions, the economics of gender discrimination at work, and the economics of gender in the household. In each case they show that this motivation, which has not been represented in standard economics, has important economic and social implications. The authors report that *Identity Economics* was greatly shaped by the insights and feedback they received from their colleagues at CIFAR.



Institutions, Organizations and Growth

Fellows Siwan Anderson and Patrick Francois have completed a paper based on data they collected on 9,000 households in 300 randomly selected villages in the state of Maharashtra, India. They aim to understand the performance of rural institutions such as village-level governments, after reforms in the 1990s increased the flow of resources and power to poor, rural villages. Their analysis has revealed how, in spite of free and fair elections and universal franchise, a dominant minority of high-caste landowners has managed to manipulate village governments to further its own ends even while creating social harmony in the villages. Drs. Anderson and Francois have designed a model that shows how this is possible. Landowners provide private benefits to the peasants in return for political support. This practice generates good inter-caste relations in the villages, while at the same time preserving traditional power structures and repressing the poor economically. In other words, the mere existence of formal structures that are democratic and stable has not been sufficient to shift the balance of political power.

Cosmology and Gravity

Fellow Ue-Li Pen and collaborators at Carnegie Mellon University and the Academia Sinica in Taiwan have made pioneering observations using a new tool that they developed for mapping large cosmic structures. Their technique holds the potential to shed light on the mysterious nature of “dark energy.” The research team’s method, called “intensity mapping,” maps and measures the radio frequency radiation emitted by hydrogen, the most plentiful element in the universe. This radiation encodes information about the early structure and origin of the universe. A successful test of their technique this year enabled the team to create three-dimensional maps of hydrogen radio emissions over vast sections of the universe, to greater cosmic distances than ever before. The precise measurements made possible by this mapping will provide a new way of testing competing theories about dark energy. The group’s results were published in *Nature* in 2010, and their efforts have led to a new collaboration to map a large fraction of the universe. The initiative will involve researchers from across Canada, including *Cosmology and Gravity* Program Director and Fellow J. Richard Bond and Scholar Matt Dobbs, in addition to Dr. Pen.

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The research team’s method, called “intensity mapping,” maps and measures the radio frequency radiation emitted by hydrogen, the most plentiful element in the universe. This radiation encodes information about the early structure and origin of the universe.

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MANAGEMENT'S DISCUSSION AND ANALYSIS OF FINANCIAL RESULTS

As at June 30, 2010

RESULTS OF OPERATIONS

The 2010 fiscal year represented the midway point of CIFAR's 5-year strategic plan. The Institute continues to make good progress on all of its initiatives. Despite the ongoing challenge of external economic circumstances, CIFAR increased its investment in research by 8%.

Income for the year ended June 30, 2010 totalling \$13.6 million, and comprising \$2.7 million from the private sector (20%), \$11.6 million from five governments (85%) and \$0.8 million in investment loss (-6%). The government income was generated as a result of three previously negotiated funding agreements, as well as funding agreements with the Provinces of Ontario and Alberta which were renewed during the year on similar terms to those of previous arrangements.

Income dropped from \$15.4 million in 2009 due mainly to the realization of a loss on long-term investments of \$1.6 million during the year. Private sector support increased \$0.06 million, or 2.3%, from the previous year, notwithstanding a modest decrease in the number of donors.

Expenses were \$15.7 million for the year, up from \$14.5 million. The change relates to increased activity in CIFAR's research programs, including significant growth of the Junior Fellow Academy, as well as non-program activities including the *Next Big Question* series and costs related to an independent evaluation.

Program expenses were \$12.5 million for the fiscal year 2009-10, which is \$0.8 million, or 7%, higher than the prior year of \$11.7 million. Program expenses are divided as follows:

Active Programs – Direct expenditures of \$9.9 million for researchers' compensation and interaction costs were \$0.3 million higher than last year's \$9.6 million. Increased expenditures related to a higher number of program members. Program members, including Junior Fellow Academy, at June 30 totalled 336, up from 301 the previous year.

Active Programs – Support expenditures of \$2.5 million were \$0.4 million higher than the prior year. The increase was related to a greater level of activity in exploring new research questions as well as the associated infrastructure costs required to support the research programs.

Non-program expenses, consisting of Advancement and Communications and Governance and Administration, were consistent with prior years.

Special events costs of \$258 thousand related to the *Next Big Question* series. Other expenses of \$158 thousand represent the cost of the performance audit and evaluation, performed every five years in order to comply with certain government funding agreements.

BALANCE SHEET, LIQUIDITY AND CAPITAL RESOURCES

The Institute concluded the year with a strong balance sheet. The working capital of the Institute was \$10.3 million at year end, due to high cash and short-term deposit balances, and a high current portion of investments balance.

Long-term investments of \$29.3 million declined by \$2.4 million due to the maturing of bonds in various portfolios. During the year, CIFAR realized a loss of \$1.6 million on the divestiture of the long-term investments held in the See Far Fund.

The **See Far Fund**, established for the purpose of setting aside funds for the future needs of the Institute, held assets of \$19.3 million, consisting of cash (\$11.5 million) and a bond portfolio (\$7.8 million). The cash balance includes \$8.1 million of proceeds from the sale of long-term investments. The See Far Fund includes the endowment funds of \$0.47 million.

The **net asset position** of \$27.7 million was consistent with the prior year-end. Although there was an operating loss of \$2.1 million, most of that amount related to the investment loss of \$1.6 million. The balance sheet previously reflected the unrealized losses in the long-term portfolio. The level of Unrestricted Net Assets, combined with the current portion of deferred income, (\$10.6 million), represents the equivalent of approximately 7 months of 2010-2011 budgeted expenditures.

RISKS AND UNCERTAINTIES

The activities of the Institute are funded entirely by **public sector grants and private sector donations**.

CIFAR has agreements or has received commitments for \$15.2 million from two provincial governments and the federal government to fund CIFAR's research over the next two years. Although these agreements and commitments remove some of the uncertainty from CIFAR's public sector grants, CIFAR will seek renewed support from two additional provincial governments in 2011, as well as from the private sector. While the Institute has met its private sector funding requirements in the past, there is no guarantee that it will continue to do so in the future.

The ability to budget **program expenditures** to discrete periods is affected by many factors, including the timing of appointments to various programs. This is especially the case when new programs are being established.

The **market value** of investments varies over time. The Institute may realize losses if it is required to liquidate investments prematurely or if the decline in value of the underlying securities is permanent.

AUDITORS' REPORT

2010 SUMMARIZED FINANCIAL STATEMENTS

To the Board of Directors of
The Canadian Institute for Advanced Research -
L'Institut Canadien de Recherches Avancées

The accompanying summarized statement of financial position and summarized statements of operations, changes in net assets and cash flows are derived from the complete financial statements of The Canadian Institute for Advanced Research - L'Institut Canadien de Recherches Avancées as at June 30, 2010 and for the year then ended on which we expressed an opinion without reservation in our report dated August 12, 2010. The fair summarization of the complete financial statements is the responsibility of management. Our responsibility, in accordance with the applicable Assurance Guideline of The Canadian Institute of Chartered Accountants, is to report on the summarized financial statements.

In our opinion, the accompanying financial statements fairly summarize, in all material respects, the related complete financial statements in accordance with the criteria described in the Guideline referred to above.

These summarized financial statements do not contain all the disclosures required by Canadian generally accepted accounting principles. Readers are cautioned that these statements may not be appropriate for their purposes. For more information on the entity's financial position, results of operations and cash flows, reference should be made to the related complete financial statements.

PKF Hill LLP

Chartered Accountants, Licensed Public Accountants
August 12, 2010



SUMMARIZED STATEMENT OF FINANCIAL POSITION

As at June 30, 2010

	2010	2009
ASSETS		
Cash and short-term deposits	\$ 3,623,429	\$ 4,193,948
Accounts receivable and prepaid expenses	1,537,478	1,445,668
	5,160,907	5,639,616
Investments, including current portion	29,306,080	31,695,859
Equipment and leasehold improvements, at net book value	198,351	277,964
Total assets	\$ 34,665,338	\$ 37,613,439
LIABILITIES AND NET ASSETS		
Accounts payable and accrued liabilities	\$ 3,220,349	\$ 2,913,940
Deferred income, including current portion	3,744,392	7,012,593
Total liabilities	6,964,741	9,926,533
Net assets		
Invested in equipment and leasehold improvements	198,351	277,964
See Far Fund		
Externally restricted for endowment	474,000	500,000
Internally restricted	18,781,094	20,348,700
Cumulative unrealized loss on available-for-sale investments	-	(2,332,600)
Unrestricted	8,247,152	8,892,842
Total net assets	27,700,597	27,686,906
Total liabilities and net assets	\$ 34,665,338	\$ 37,613,439

See accompanying note

SUMMARIZED STATEMENT OF OPERATIONS

Year ended June 30, 2010

	2010	2009
INCOME		
Program contributions		
Private sector	\$ 2,670,238	\$ 2,609,653
Federal government	5,000,000	5,000,000
Provincial governments	6,555,000	6,700,000
Other contributions	206,000	22,000
Investment income	(781,866)	1,048,984
Total income	13,649,372	15,380,637
EXPENSES		
Program expenses		
Active programs, direct		
Cosmology and Gravity	1,152,714	1,022,065
Earth System Evolution	618,203	786,377
Experience-based Brain and Biological Development	640,583	608,970
Genetic Networks	528,230	525,110
Institutions, Organizations and Growth	691,590	847,626
Integrated Microbial Biodiversity	585,143	551,338
Nanoelectronics	1,012,768	1,051,893
Neural Computation and Adaptive Perception	509,745	497,445
Quantum Information Processing	833,608	732,636
Quantum Materials	989,613	1,151,781
Social Interactions, Identity & Well-Being	604,084	684,579
Successful Societies	821,253	836,768
Junior Fellow Academy	950,453	304,525
	9,937,987	9,601,113
Active programs, support		
Program Development and Assessment	2,041,054	1,666,781
Program Reviews and Research Council	4,303	85,635
Knowledge Transfer	46,612	69,165
International Reach	38,816	47,709
Interdisciplinary Study	55,033	123,000
New Program Development	359,281	117,481
	2,545,099	2,109,771
Other		
Special events	58,775	-
Total program expenses	12,541,861	11,710,884
Advancement and communications	1,976,552	2,098,153
Governance and administration	804,038	690,365
Special events	257,657	14,431
Other	157,832	10,194
Total expenses	15,737,940	14,524,027
Excess (deficiency) of income over expenses	\$ (2,088,568)	\$ 856,610
Allocated to:		
Invested in equipment and leasehold improvements	\$ (102,543)	\$ (115,108)
See Far Fund		
Externally restricted for endowment	(101,400)	-
Internally restricted	(1,490,500)	-
Unrestricted	(394,125)	971,718
	\$ (2,088,568)	\$ 856,610

See accompanying note

SUMMARIZED STATEMENT OF CHANGES IN NET ASSETS

Year ended June 30, 2010

	2010	2009
Balance, beginning of year	\$ 27,686,906	\$ 29,080,123
Excess (deficiency) of income over expenses	(2,088,568)	856,610
Allocation of prior year unrealized loss recognized on available for sale investments sold during the year	2,332,600	-
Endowment bequests	75,000	-
Unrealized gain (loss) on foreign currency	(323,169)	343,425
Unrealized gain (loss) on investments	17,828	(2,593,252)
Balance, end of year	<u>\$ 27,700,597</u>	<u>\$ 27,686,906</u>

See accompanying note

SUMMARIZED STATEMENT OF CASH FLOWS

Year ended June 30, 2010

	2010	2009
Operating activities		
Excess (deficiency) of income over expenses	\$ (2,088,568)	\$ 856,610
Amortization of equipment and leasehold improvements	102,543	115,108
Realized loss on investments	1,591,900	-
Amortization of deferred income	(3,670,206)	221,111
Changes in non-cash working capital	616,604	(3,257,952)
Cash flows from operating activities	(3,447,727)	(2,065,123)
Financing activities		
Endowment contribution and cash flow from financing activity	75,000	-
Investing activities		
Investments	2,825,138	(2,130,498)
Investment in equipment and leasehold improvements	(22,930)	(117,868)
Cash flows from investing activities	2,802,208	(2,248,366)
Net change in cash during the year	(570,519)	(4,313,489)
Cash and short-term deposits, beginning of year	4,193,948	8,507,437
Cash and short-term deposits, end of year	\$ 3,623,429	\$ 4,193,948

See accompanying note

NOTES TO SUMMARIZED FINANCIAL STATEMENTS

Year ended June 30, 2010

1. Nature of Operations and Basis of Financial Statements

The Canadian Institute for Advanced Research - L'Institut Canadien de Recherches Avancées (the "Institute") is incorporated under the Canada Corporations Act as a not-for-profit organization and is a registered charity under the Income Tax Act (Canada). The primary objective of the Institute is to bring leading researchers together to work on major collaborative advanced-research projects that address scientific, economic and social questions that are of importance to the future of Canada and the world. The Institute funds multi-year projects that bridge institutional, regional, cultural and national boundaries. The funding provided by the Institute contributes to research support and salaries of program members.

In common with other not-for-profit organizations, the Institute is economically dependent on the continued financial support of federal and provincial governments and the private sector to meet its ongoing commitments.

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The Lunar Circle comprises an elite group of individuals and organizations with lifetime giving of \$100,000 or more to CIFAR. It was inspired by the 1760s *Lunar Society* – a group of philosophers, business leaders, scientists, and amateur experimenters who met on the nights of the full moon to share and debate ideas over long dinners. Through their collaborations, these individuals together became the catalyst for the industrial revolution.

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