

Personal GENOMICS

HAS MOTHER'S BLUE EYES,
AQUILINE NOSE, AND
SUSCEPTIBILITY TO
ALZHEIMER'S DISEASE

SHOULD RECEIVE
PROSTATE EXAMS
FROM AN EARLY AGE

CURIOUS ABOUT
DATE'S GENETIC PROFILE

PRONE TO TOBACCO
ADDICTION

THE GENES OF AN
OLYMPIC ATHLETE

DOES NOT WANT
HIS EMPLOYER TO
HAVE ACCESS TO HIS
GENETIC SEQUENCE

ADOPTED AS A CHILD
WITH NO FAMILY MEDICAL
HISTORY OTHER
THAN GENOME

CARRIES THE GENE FOR
HUNTINGTON'S DISEASE:
ANY OFFSPRING WILL HAVE
50/50 CHANCE OF ALSO
CARRYING THE GENE

SHOULD HAVE KNOWN
ABOUT GENETIC SENSITIVITY
TO ALCOHOL BEFORE
GOING OUT TONIGHT

PLUS

MORPHING FROM MAGMA TO MAGNETISM • LIFE SATISFACTION A MATTER OF COMMUNITY • CIFAR INVESTS IN POSTDOCTORAL FELLOWS • CIFAR ASKED AND CANADIANS ANSWERED *WHAT IS THE NEXT BIG QUESTION?* • PIGEON LOVE

REACH

MAGAZINE

The Canadian Institute for Advanced Research supports the work of hundreds of researchers across Canada and around the world. Currently, CIFAR supports 12 major multidisciplinary programs. Those programs are:

Cosmology and Gravity
Earth System Evolution
Experience-based Brain and Biological Development
Genetic Networks
Institutions, Organizations and Growth
Integrated Microbial Biodiversity
Nanoelectronics
Neural Computation and Adaptive Perception
Quantum Information Processing
Quantum Materials
Social Interactions, Identity and Well-Being
Successful Societies

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PRESIDENT AND CEO, CIFAR

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NEW KNOWLEDGE DEMANDS NEW WISDOM

CHAVIVA M. HOŠEK
PRESIDENT AND CEO, CIFAR

One of CIFAR's guiding principles is to "strive to extend the impact of our research on the world to inform and improve the quality of human life."

As the main feature in this magazine outlines, the pursuit of knowledge for its own sake (another of CIFAR's guiding principles) is not necessarily a universally beneficial prospect.

We do not set off naively when we choose to explore areas such as genetics, microbial biodiversity, our changing planet, or the nature of the individuals, institutions and societies that populate it. There is something clearly idealistic about gathering together a team to explore some new frontier of human knowledge. We know that our research can and does lead to new cures, new beneficial technologies, and new ways for all of us to understand our universe and each other better.

But we also recognize that scientific revolutions can also lead us to grapple with issues of safety, privacy and uncertainty. Some CIFAR researchers are working to duplicate the power of human thought in

a computer. Others question whether the democratic institutions we hold dear are always the most effective tools for societal success. Still others are not far from being able to create life itself in a laboratory.

Some of the implications are beyond imagining. With each advance, humanity's power for both creation and destruction grow. And that means we have to be vigilant and wise in how we live up to our guiding principles – to increase the likelihood that our research enriches and improves our world.

One of the most important means to that end is to make sure Canadians are talking and thinking about these issues now, so that when the next scientific revolution is upon us, we are better prepared. If you enjoy this issue of *Reach* and want to continue the conversation, we would welcome your involvement through letters, e-mails, and on-line discussion. Please visit www.cifar.ca for more information. ■



RECENT DONORS SHARE CIFAR'S VISION

GEORGE FIERHELLER
CHAIR OF CIFAR
ADVANCEMENT COMMITTEE

Every *Reach* magazine contains a list of private and public donors who have supported CIFAR over the past year. I am pleased to see many, many new names on that list in this issue.

In particular, I am delighted that the Government of Quebec has come on board as a funder of CIFAR's research. Through their Ministry of Economic Development, Innovation and Export Trade, the Quebec Government has joined British Columbia, Ontario, Alberta and the Government of Canada as one of CIFAR's valued public funders. With so much of CIFAR's research activity involving Quebecers, this financial support makes a great deal of sense.

Equally exciting is the influx of new private donors. In the past year, we have increased our efforts to engage new audiences and seek out new prospective donors, and our expanded list of supporters suggests that this work is starting to pay off.

Of course, we still have our work cut out for us. CIFAR is an organization that is rapidly changing and growing. We continue to search for new research programs to answer new big questions. We are investing greater resources in younger researchers. We are looking further afield to ensure we are connected to research and researchers in India and China and elsewhere.

While we have much to do, the signs are very positive. I am very hopeful that we will be able to garner all the resources we need to continue supporting some of the most unusual and fascinating research in the world.

There is another heartening facet of this new support from the Quebec Government and so many others: in addition to improving our financial security, this support is also an indicator that we as an organization are on the right track – that governments, corporations, foundations and individuals find the work we do valuable. Naturally, we believe in the power of collaborative advanced research to improve the world. It is tremendously encouraging to know that more and more Canadians share that sentiment.

Finally, if you don't already support the organization financially, I invite you make a tax deductible donation to CIFAR, and join all those donors who share our vision of creating knowledge that enriches human life, improves our understanding of the world, and advances Canada's research community. ■

BRIEFS

MORPHING FROM MAGMA TO MAGNETISM

Four billion years ago, the Earth may not have had a magnetic field. A compass would have been useless, and the planet would have been unprotected from the brutal bombardment of high energy particles from the sun known as solar wind.

This is one of the likelihoods suggested by recent research in CIFAR's *Earth System Evolution* program.



Postdoctoral fellow and geophysicist John Hernlund studies the evolution of the deep Earth, 2,900 km beneath our feet. His mathematical models show how, 4.5 billion years ago, the Earth was much hotter, and thick oceans of molten rock swirled at the base of the planet's solid mantle. Dr. Hernlund and collaborators in Lyon, France conclude that these fiery oceans were as much as 1,000 km thick, and that radioactivity slowed their cooling over hundreds of millions of years.

This liquid magma ocean gradually crystallized to leave a mostly solid, rocky, mantle behind. It is likely that only as these oceans solidified did the Earth acquire the magnetic field that we now rely on to make our planet livable by protecting us from solar wind.

CIFAR INVESTS IN POSTDOCTORAL FELLOWS

CIFAR is launching a major program designed to identify and foster gifted young researchers, and to create new generations of thought leaders.

Targeted primarily at postdoctoral fellows, the aim is to build a community of young, broad-thinking researchers from many fields, who are open to interdisciplinary collaboration, and dedicated to the outstanding quality of their research. The fellows chosen for this group will fully integrate into CIFAR research programs and will also participate in special networking, mentorship and career development activities created just for them.

"This is about more than new funding for postdoctoral research," said Mel Silverman. Dr. Silverman is CIFAR's Vice-President, Research, and one of the initiative's architects. "This is also about helping to create a community of researchers who will carry on CIFAR's tradition of breaking down boundaries to think broadly as well as deeply about big questions."

As successive waves of researchers move through this new program, CIFAR hopes the community will grow in size and influence.



LIFE SATISFACTION A MATTER OF COMMUNITY

Recently, many media have reported that research from CIFAR's *Social Interactions, Identity and Well-Being* program suggests Canada's happiest cities are in the Atlantic provinces.

While data do suggest that our country's happiest urban dwellers tend to live in smaller cities and provinces, this does not tell the whole story.

Program Co-Director John Helliwell and CIFAR postdoctoral fellow Christopher Barrington-Leigh base their province and city rankings on three surveys: two from Statistics Canada and another financed by the Social Sciences and Humanities Research Council. They acknowledge that differences in average life satisfaction can be partially explained by economic factors, which tend to favour the larger central and western provinces. A variety of other crucial factors, though – such as the extent to which people think their neighbours can be trusted – tend to favour smaller and more connected communities.

Dr. Helliwell and Dr. Barrington-Leigh have also found life satisfaction varies more among neighbourhoods and even among individuals, in the same city, than from one Canadian city or province to another.

Ultimately, the strongest predictors of happiness are neither geography nor income.

"Research from economics, psychology and sociology combines to show that life satisfaction is not about where you live, it's about how you relate to the people around you," says Dr. Helliwell. "By examining the structure of communities with high life satisfaction, it is possible to pick up tips that might help to improve the quality of life elsewhere."



VERY LIKELY TO DEVELOP
LACTOSE INTOLERANCE

HAS A MALARIA-RESISTANT
GENETIC PROFILE

AT RISK FOR BREAST
CANCER: CAUTIOUS ABOUT
TAKING THE PILL

MIGHT SUFFER SAME FATE
AS PARENT WITH HEMOPHILIA

PARTICIPATES IN A CLINICAL
TRIAL TO ADVANCE RESEARCH
INTO GENETIC DISEASE

Personal GENOMICS

By Alison Palmer

We are all about to become part of a massive, life-changing experiment.

Much like any major scientific or technological achievement – identifying the sun as the centre of our solar system, sending a man to the moon, discovering the structure of DNA – personal genomics is poised to significantly boost our understanding of the world.

Personal genomics tells us about more than nucleic acids and proteins. "We are actually revolutionizing our understanding of ourselves through understanding our genomes," says Steve Scherer, a member of CIFAR's *Genetic Networks* program, which strives to identify the genetic interactions that keep cells healthy and those that cause disease.

Personal genomics involves decoding the 3 billion base pairs that compose an individual's genome. By uncovering the genes that define who we are and how we uniquely function, personal genomics will diffuse into our lives and dramatically influence how we live, work and play.

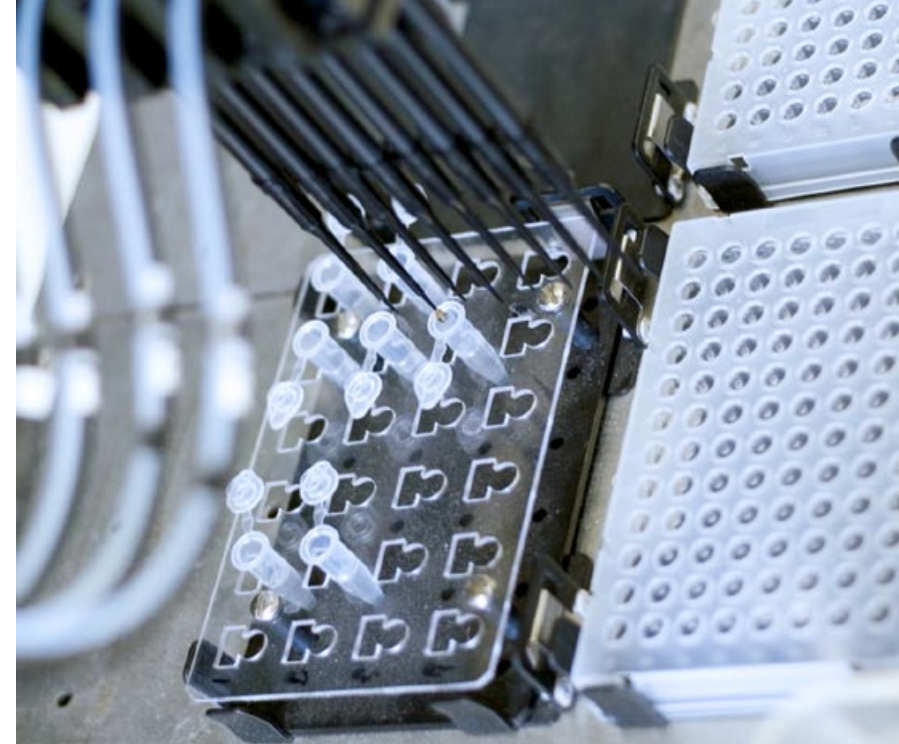
Personal genomics researchers envision individuals storing their entire genome sequence in a Blackberry or on a data stick, and using it to evaluate predisposition to diseases, explore family history, or even engage in genome-based matchmaking. Although this vision might seem light years away, sequencing technology is actually advancing so rapidly that scientists predict it will be reality in as little as five years.

"The sequencing technology has allowed us to view the genome in a totally different way. It's driving the science," Dr. Scherer says.

Dr. Scherer made headlines many times this year, most notably for his research collaboration with entrepreneur and biologist Craig Venter. They published the results of Dr. Venter's sequenced genome, the first entire DNA makeup of an individual. The total project cost approximately \$70 million. Just one year later, with new advances in technology, an identical project only cost \$300,000.

An organization called the X Prize Foundation wants to lower this price tag even further. The foundation is currently offering \$10 million to the first team to sequence 100 human genomes in ten days for less than \$10,000 each. A company called Pacific Biosciences already has its eye on that prize, certain that their technology will enable 15-minute complete, high-quality genome sequencing by 2013.

These advances hint that we should soon be able to buy our entire genetic sequence for \$1,000 or even less.

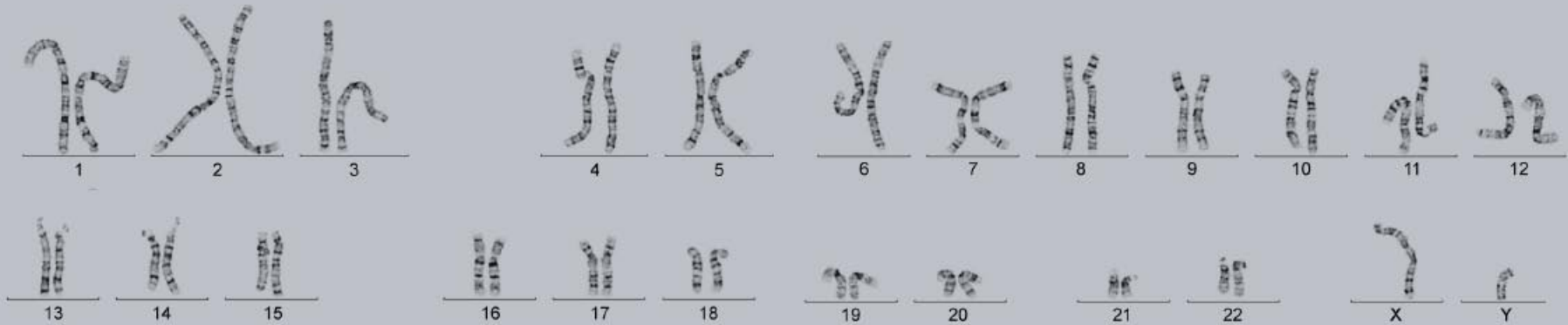


DNA testing machine

Some companies already offer partial genome scans for \$1,000. In only two to three weeks, companies such as 23andme scan DNA from saliva to identify 500,000 single nucleotide polymorphisms (SNPs), assemble the results, and send them to your inbox.

How it works: SNPs (pronounced "snips") are tiny genetic discrepancies that differentiate one person from another. The company uses SNP scan results to calculate risk for diseases such as prostate cancer, Crohn's disease and Alzheimer's disease. (Other conditions such as Huntington's disease and breast cancer have genetic underpinnings, but are not characterized by SNPs, and therefore require other genetic tests.)

While these companies can't yet offer complete personal genome sequences, these kinds of tests bring them much closer to reality. It raises an important question: Would you want your genome sequenced?



Images of a complete human chromosome set. Researchers can use these images to identify abnormalities that characterize diseases such as Turner syndrome and Down's syndrome.

The benefits would be considerable. Personal genomics holds the promise to personalized medical treatment. For example, two people who have the same type of cancer may take different drugs to treat their cancer depending on what is more compatible with their individual genetic sequence. Or, what appears to be a single genetic disease can turn out to have more variations, requiring different treatments. This is already a reality for diseases such as lymphoma, which is now categorized and treated differentially as Hodgkin's and non-Hodgkin's lymphoma.

This might seem like an exciting opportunity to get to know and take care of ourselves at the genetic level. But there is still much to learn before we can use this information to make people healthier.

"We just don't know enough to move forward with this," says Clyde Hertzman, a member of CIFAR's *Experience-based Brain and Biological Development* program. Members of this program are investigating how a child's early experiences get "under the skin" to affect their biology and set a trajectory for their development and health.

"It is overly optimistic to think that having our genome sequence in hand will positively impact our health," he says.

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 GIVING PEOPLE ACCESS TO THE BEST INFORMATION AVAILABLE
 MIGHT ALLOW THEM TO TAKE PREVENTIVE MEASURES OR TO
 ENROLL THEMSELVES IN A CLINICAL TRIAL AND ADVANCE
 THE GENETIC RESEARCH INTO THEIR DISEASE.
 ”

Still, newspapers report on new genetic links to diseases each day, and as genome sequencing becomes more accessible, more data will reach researchers' fingertips. This will enable the creation of more knowledge about the genetic underpinnings of disease.

"At present, correlating genetic information to disease states is only slightly more effective than using family history to predict disease. But as our databases develop, the predictive value of sequencing will become apparent," says Dr. Scherer.

Establishing a genetic link, though, is only part of the equation – having a hereditary predisposition to a disease is by no means the same as having the disease. Turning all this genetic knowledge into a formula to assess and predict disease susceptibility is complicated. For example, 23andme's risk calculation is completely experimental. There are many complex factors that influence the onset of a disease that their analysis cannot take into account. What's more, different genes can cause the same disease, and a massive 95% of the time, one disease is actually the result of interplay among several genes. For example, a disease like Type II diabetes involves eight SNPs, each of which causes a different effect.

The company makes the ambiguity of its risk calculation very clear and does not claim to be in the diagnosis business. But this ambiguity sheds light on the challenges that lie ahead for interpreting our complete, massive genome sequences.

Challenges will range from analytical to moral to psychological.

Imagine that your genome sequence reveals that you are susceptible to a disease for which there is no cure. How does this change your approach to life? Should the government, your insurance company and your employer have access to your sequence and be aware of your predisposition?

The privacy implications alone induce nervousness about personal genomics. The *New York Times* recently reported on several cases in the United States where people refused important genetic tests, and suffered serious medical consequences, out of fear that their insurance company might gain access to the test results and begin charging them a higher insurance premium.

Insurance companies also have reason to be worried about not having access to personal genomic information. William Falk, a health and life sciences consultant and member of CIFAR's Advancement Committee, sees pros and cons to the issue.

"Healthy people who are tested and find out they are susceptible to a devastating disease will probably want to buy more insurance. This will undermine the economics of insurance companies, potentially leading to higher insurance rates for everyone," he says. "Giving people access to the best information available might allow them to take preventive measures or to enroll themselves in a clinical trial and advance the genetic research into their disease." Enrolling in such a trial, though, could make their sequence, and potentially their disease susceptibility, public.

“
IMAGINE THAT YOUR
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”

Geneticist Steve Scherer studies the genome sequence of his research collaborator, Craig Venter.



“

IT'S A COMPLICATED SUBJECT AND WE NEED TO ADDRESS THE PRIVACY, HEALTH, AND ECONOMIC ISSUES SURROUNDING IT.

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"It's a complicated subject and we need to address the privacy, health, and economic issues surrounding it," he says.

Genome sequencing might seem no less private than the detailed family history of disease that insurance companies already demand. But as we get more and more information, it becomes a much more powerful means to assess someone's health. In addition, a person who maps their genome gives up information not only about themselves, but about their parents, children, siblings and other close relatives.

But consider the flipside. What if you don't have a family medical history for one of your loved ones, say for an adopted child. Individual genomic information would shed light on what conditions and diseases to look out for, and could have a huge impact on the life of your child.

The scenarios are complex. Your genes might predispose you to lung cancer. This would be a strong impetus not to smoke. But of course, addictive personality is also a part of that equation, and some research suggests this is also genetically linked.

The great hope of personal genomics is that it will enable us to lead healthier lives. Our personal sequences could become powerful tools, exploited to determine our own personal strengths and weaknesses, and maximize our productivity and success.

Dr. Scherer has written about his desire to sequence the genomes of exceptional human beings like Albert Einstein and Ted Williams: "For me, such data would provide a wondrous glimpse into those things that most intrigue me: my current research focus, the minimal code for a brilliant mind, and the indices for the perfect swing," he wrote in *Nature Genetics*.

But personal genomics also has the potential to turn our lives into a game of Stratego. We might become so wrapped up in what our genes seem to tell us about our future, that we might ignore other factors that contribute as much to our quality of life.

Richard W. Ivey, the Chair of CIFAR's Board of Directors, is an extremely curious individual who is intrigued by personal genomics. "My instinct tells me to have my genome sequenced for sure," he says. "I'd have to discuss the pros and cons with the experts to make a really informed decision, but it's unlikely that I would learn anything that would turn me off."

But he is also concerned about the impact on his loved ones. "I'm not so sure my family would want me to have it done," he says.

For many people, even more important than any health implications, is the simple excitement of discovery. Eric Shoubridge, another researcher in CIFAR's *Genetic Networks* program sees inherent merit in the new scientific frontiers opened up by personal genomics.

He would try the 23andme SNP scan as a personal science experiment. "It would be interesting to see whether the companies offering this service and our health care system have enough resources available to make any sense of the output," he says.

Making sense of the output is the real issue. There are fewer than 50 physicians in Canada who specialize in medical genetics, and only a smattering of other genetic counselors. These issues are so new that regulation and a code of ethics do not yet exist to govern their work.

CIFAR has been hosting a discussion about personal genomics on the social networking website Facebook. Here is a sampling of some of the group members' opinions about getting a glimpse of their individual genetic blueprints:

I'd be happy to have my genome sequenced. I see way more upsides than downsides in knowing medical risks. I wonder when they'll cover it under the Ontario Health Insurance Plan.

David Creelman

Imagine you just started going out with someone. Most people nowadays Google the person to find out about them. But imagine if you found that the person has a predisposed risk, however small, to a devastating disease. This might make a good relationship turn sour.

Information is powerful, though. It may help people try to live healthier lives when they know they could have heart disease at age 50. The information can also be used to support orphan drug trials and tailor certain disease groups for specific drugs. But science is still catching up to understand the risk factors, and a perfectly tailored treatment program is probably years away. Currently, I am still skeptical about having my genome sequenced.

Christian Code

I worry deeply about the ethical implications related to privacy...particularly, banks, insurance companies and employers getting their hands on my personal DNA information. The potential for penalizing people for their genetics has staggering ethical implications.

Pam Davis-Ross

Do you have an opinion about personal genomics?

Let us know what you think. Visit the CIFAR group at www.facebook.com, or send us a message at letterstoreach@cifar.ca

“
PERSONAL GENOMICS PROMISES TO BE AN EVERYDAY REALITY
BEFORE WE KNOW IT. WE NEED TO THINK ABOUT THE
IMPLICATIONS NOW SO THAT WE'RE READY ONCE IT'S HERE.
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Researchers in many advanced fields, though, are thinking about the issues. Patrick Keeling, Director of CIFAR's *Integrated Microbial Biodiversity* program, benefits enormously from the advances in gene sequencing technology – there is more genetic diversity in the microbial world than anywhere else. New sequencing technologies create a flood of information, and he hopes that this will also lead to new understanding.

“Perhaps we need a prize for developing a low-cost, high efficiency genome analysis system,” he suggests.

Skeptics like Dr. Clyde Hertzman think that genome sequencing, taken in isolation, could do more harm than good for human health and well-being. He fears that people will be labeled “at risk” unnecessarily, based upon information from their genomes, and that this will negatively affect their well-being. In fact, his research shows that we are not prisoners to that which is written in our DNA – social experiences, for instance, can turn harmful genes off, so that potential predispositions never materialize.

Also, many diseases will be diagnosed before cures exist for them. Huntington's disease, for example, is well understood at the genetic level, but we still don't know how to cure it. It is a single gene disorder that causes neurons to break down in certain parts of the brain.

Conversely, many other diseases, from Alzheimer's to autism, are understood only at the clinical level, while more research is needed to understand the genetics. As researchers make giant leaps forward in the precision of genomic understanding, huge pragmatic challenges occur. One of the most pressing has to do with what are called orphan diseases.

Many Canadians' introduction to orphan diseases came last fall, when journalist Ian Brown published a series of moving features in the *Globe and Mail* about his son, Walker. Walker Brown has a disease called cardio-facio-cutaneous syndrome, or CFC. CFC is an orphan disease, an umbrella term to describe extremely rare illnesses. There is no universal definition, but any disease that affects fewer than one in 2,000 people can reasonably be considered an orphan disease. Walker Brown's condition, for instance, is caused by genetic mutation and is shared by only a few hundred people the world over.

There are already thousands of known orphan diseases, but as we understand more and more about the functions of our genes, thousands more will likely be identified.

Orphan diseases pose a severe challenge to drug development: If a drug company invests billions of dollars to find a cure for an orphan disease, the market for the cure is so small that the price tag for the drug would have to be inaccessibly high in order for the company not to lose money.

The United States and the European Union have begun to create policies to deal with the lack of an economic model to support orphan drug research, but Canada is not there yet.

Researchers who know how quickly these advances are happening also know that Canadians should be talking about these issues sooner rather than later.

“Personal genomics promises to be an everyday reality before we know it. We need to think about the implications now so that we're ready once it's here,” says Dr. Scherer. ■

TIMELINE

February 1865

Gregor Mendel, considered the father of modern genetics, uses experiments with pea plants to establish the principles of genetic inheritance.

April 1953

Based on the X-ray diffraction images of DNA taken by Rosalind Franklin, James Watson and Francis Crick solve DNA's three-dimensional structure.

May 1975 and February 1977

Frederick Sanger, Allan Maxam and Walter Gilbert develop the first methods to determine the sequence of DNA.

February 1977

The phi X bacteriophage, a virus with 11 genes that infects bacteria, becomes the first organism to have its full genome sequenced.

April 2003

The Human Genome Project – a full map of the approximately 25,000 genes in our genetic code – is completed for \$2.7 billion after 13 years of research.

The first phase of the International HapMap Project, a catalog of genetic variations, is published.

October 2005

James Watson's whole genome is sequenced at a cost of less than \$1 million.

May 2007

Craig Venter publishes the results of his own sequenced genome, in collaboration with CIFAR program member Steve Scherer.

September 2007

23andme opens for business with retail SNP testing for \$1,000.

November 2007

Deadline for the X Prize Foundation challenge to sequence 100 human genomes for less than \$10,000 each in 10 days.

October 2013

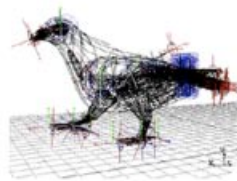
Pigeon Love

By Sofia Ramirez

"Bird-brain." "Feather-head." "Flighty." When it comes to intelligence, birds have a less than sterling reputation. Pigeons – "flying rats" to their detractors – bear the brunt of that negative image. But it turns out birds in general, and pigeons in particular, are advancing our understanding of the nature of thought and the basis of social interactions.

In fact, pigeons have an exceptional ability to process complex visual information, and also to recognize mating behaviour when they see it.





CIFAR member Nikolaus Troje has created animations of pigeons that mimic their natural mannerisms. These animations imitate courting behaviours so well that real pigeons fall in love with the cartoons.

Dr. Troje set up an animated pigeon and monitored the effects of various elements, such as head-bobbing and frequency of movement of the cartoon on real pigeons. He ultimately refined the animations to the point that live pigeons took the video as real and displayed full-blown pigeon courtship.

While it may seem unkind to meddle in the ways of pigeon love, these experiments illustrate some fascinating facts about the biology and psychology of social recognition.

Pigeons, in fact, do things effortlessly that even the most sophisticated computers cannot reproduce. No computer on Earth can 'look' at a picture and describe what is in it. And efforts to teach computers to find meaning in behaviour or motion are only in the early stages.

Dr. Troje, a Fellow in CIFAR's *Neural Computation and Adaptive Perception* program, investigates visual discrimination mechanisms that were first proved at the Harvard Pigeon Laboratory in the 1970's.

Dr. Troje's research program looks at the systems involved in 'higher-order' perception and social learning. These are the processes used to communicate and learn through observation. This knowledge provides answers to questions such as how we recognize familiar faces, how we attribute sex, age and other properties to strangers and, more complex, how we retrieve information about emotions and intentions from visual cues.

Such insights provide strategies that could be used in the production of computer models that simulate key aspects of what the pigeon's brain does naturally.

The pigeon provides the perfect subject for Dr. Troje since pigeons are monogamous and their courtship behaviour is highly sophisticated. Successful breeding depends on picking the right partner. The pigeon's astonishing ability to sort out visual information may result from natural selection that has equipped them with these tools.

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PIGEONS, IN FACT, DO THINGS EFFORTLESSLY THAT EVEN THE MOST SOPHISTICATED COMPUTERS CANNOT REPRODUCE. NO COMPUTER ON EARTH CAN 'LOOK' AT A PICTURE AND DESCRIBE WHAT IT IS IN IT. AND EFFORTS TO TEACH COMPUTERS TO FIND MEANING IN BEHAVIOUR OR MOTION ARE ONLY IN THE EARLY STAGES.

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Equally valuable to his research, though less complimentary, is the ease with which pigeons can be fooled.

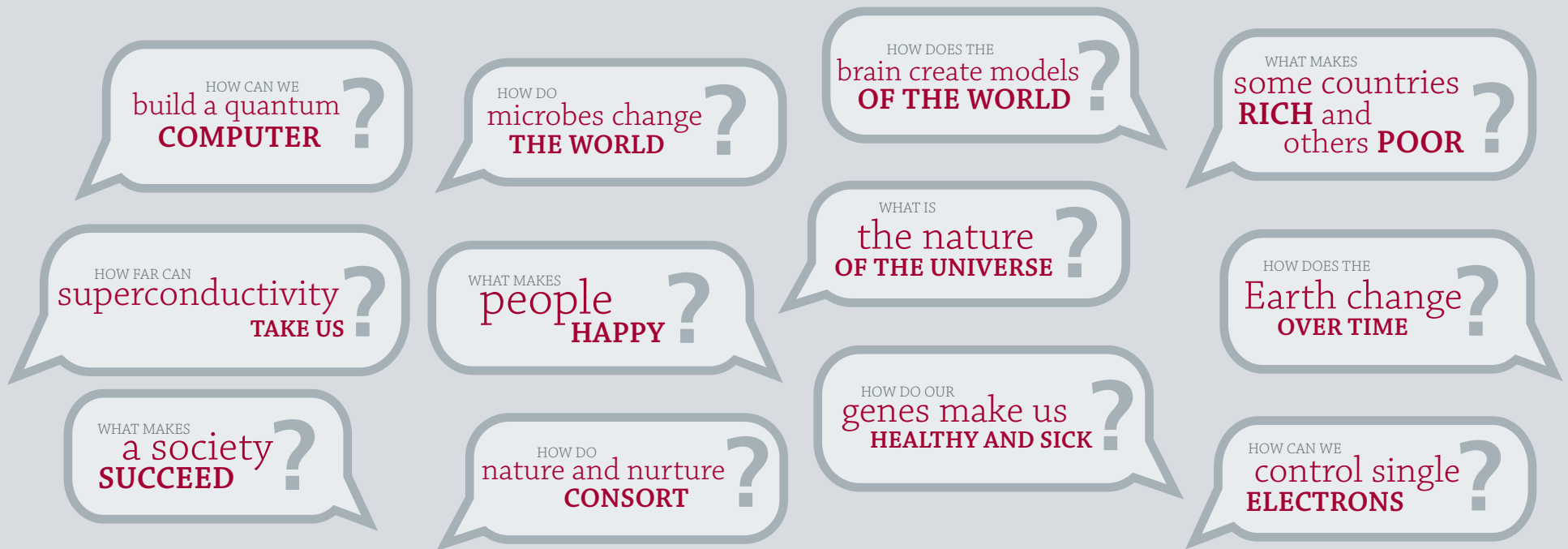
These experiments demonstrate how intention and emotion are communicated and the possible mechanisms that could be used in artificial neural circuits. Artificial brains might one day be able to discriminate and categorize visual information as well as Dr. Troje's lovesick pigeons. ■

View the animation online:

www.cifar.ca/cartoon-pigeon

www.cifar.ca/real-pigeon-in-love





CIFAR asked and Canadians answered: *What is The Next Big Question?*

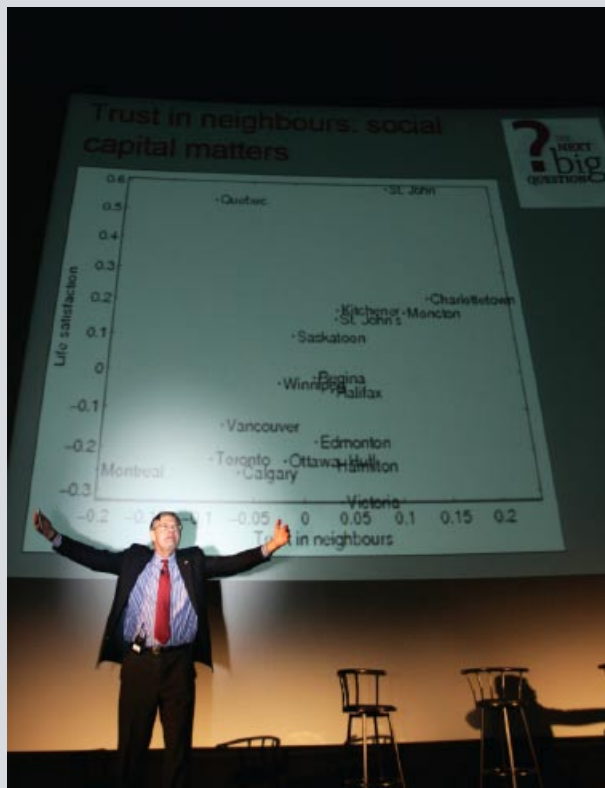
By Kathleen Garrett

LAST FALL, HUNDREDS OF INTELLECTUALLY CURIOUS PEOPLE ACROSS CANADA CROWDED INTO CINEMAS, SCIENCE CENTRES, MUSEUMS, ART GALLERIES, AQUARIA, AND LECTURE HALLS TO HEAR CIFAR RESEARCHERS DISCUSS SOME OF THE BIGGEST AND MOST PRESSING QUESTIONS OUR WORLD FACES. THIS 11-EVENT, SEVEN-CITY TOUR WAS IN CELEBRATION OF CIFAR'S 25TH ANNIVERSARY. THE TOUR'S THEME WAS *THE NEXT BIG QUESTION*, AND IT WAS DESIGNED TO GET CANADIANS TALKING ABOUT THE MANY WAYS IN WHICH ADVANCED RESEARCH CONTRIBUTES TO OUR LIVES.

Left: Chaviva M. Hošek moderates a discussion with (left to right) sociologist Michèle Lamont, quantum physicist Daniel Gottesman, and microbiologist Curtis Suttle at The Next Big Question inaugural event in Halifax, N.S.



Above: The marquee tour touched down at cinemas, art galleries and other unusual venues across the country. Below: Board Chair Richard W. Ivey addresses the crowd at a Toronto event.



Economist John Helliwell presents results from his research into life satisfaction.



Above: Neuroscientist Bryan Kolb (left), earth sciences researcher Shawn Marshall (centre), and computer scientist Sam Roweis debate The Next Big Question in Edmonton. Below: Physicist Louis Taillefer demystifies high-temperature superconductivity for an audience in Montreal.

AT each event, three CIFAR researchers discussed and debated the importance of three very big questions. Presenters pulled out all the stops to convince the audience that their question was biggest.

Presentations overflowed with compelling statistics. *Genetic Networks* member Steve Scherer, for example, championed the question, "How do our genes make us healthy and sick?" He said that there are more than one million deaths every year in North America due to toxic side effects of drugs, many of which had a genetic aspect. Mark Freeman, of *Nanoelectronics*, championed the question, "How can we control single electrons?" He said that today's silicon chips use electrons like a "rocket nozzle," and that by controlling the particles individually, we could build vastly more powerful, and more efficient computing machines.

Some researchers used the event theme to support their case literally. *Cosmology and Gravity's* Victoria Kaspi, ("What is the nature of the Universe?") argued that nothing is bigger than the Universe. Daniel Gottesman, of *Quantum Information Processing*, took the opposite approach. He argued that his question, "How can we build a quantum computer?" was the biggest because it was the smallest. "In information technology, we're not about the next big thing," he said, "because you don't want your next cell phone to be twice as big as your old one."

One presenter gave part of his argument in song. Economist John Helliwell, co-Director of *Social Interactions, Identity and Well-Being*, got the crowd singing, "The more we get together, the happier we'll be." This children's ditty is also known as "the social capital song" because it so effectively illustrates the power of social interaction to contribute to people's sense of well-being.

Curtis Suttle, a member of *Integrated Microbial Biodiversity* who advocated the question, "How do microbes change the world?" countered Dr. Helliwell by pointing out that "if there if there weren't any microbes, there wouldn't be any economists."



Cosmologist Vicky Kaspi gives Calgarians a sense of the immensity of our Universe.



Above: Microbiologist Curtis Suttle tells a Vancouver crowd, "without microbes, there would be no us." Below: Science advocate Preston Manning delivers the keynote speech at the final event in Toronto.

As big as CIFAR's 12 questions were, though, audience members came back with many others that were just as interesting. "What would a successful Afghan society look like?" "How can we separate the oil from the tar sands and generate less waste in doing so?" "How did the war experience of World War II soldiers affect the DNA of baby boomers?" At one event, someone asked the three presenters to review popular movies related to their fields: For a climatologist: "An Inconvenient Truth," a physicist: "A.I.," and a cosmologist: "Contact."

At the end of the events, audiences voted on which question they thought was the biggest. It was a difficult choice every time: Imagine having to choose whether it was more important to stop global warming, care for our children, or cure complex diseases. The results were interesting and exciting, and varied greatly across the country. What is most important to CIFAR, however, is not the results, but the fact that Canadians are discussing big questions.

CIFAR will continue asking and answering big questions throughout its next 25 years and beyond. The Institute will also continue hosting public events. Check your mailbox and the CIFAR website regularly for future talks. ■

CIFAR is grateful to its sponsors, who made its national *The Next Big Question* conversation possible.



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