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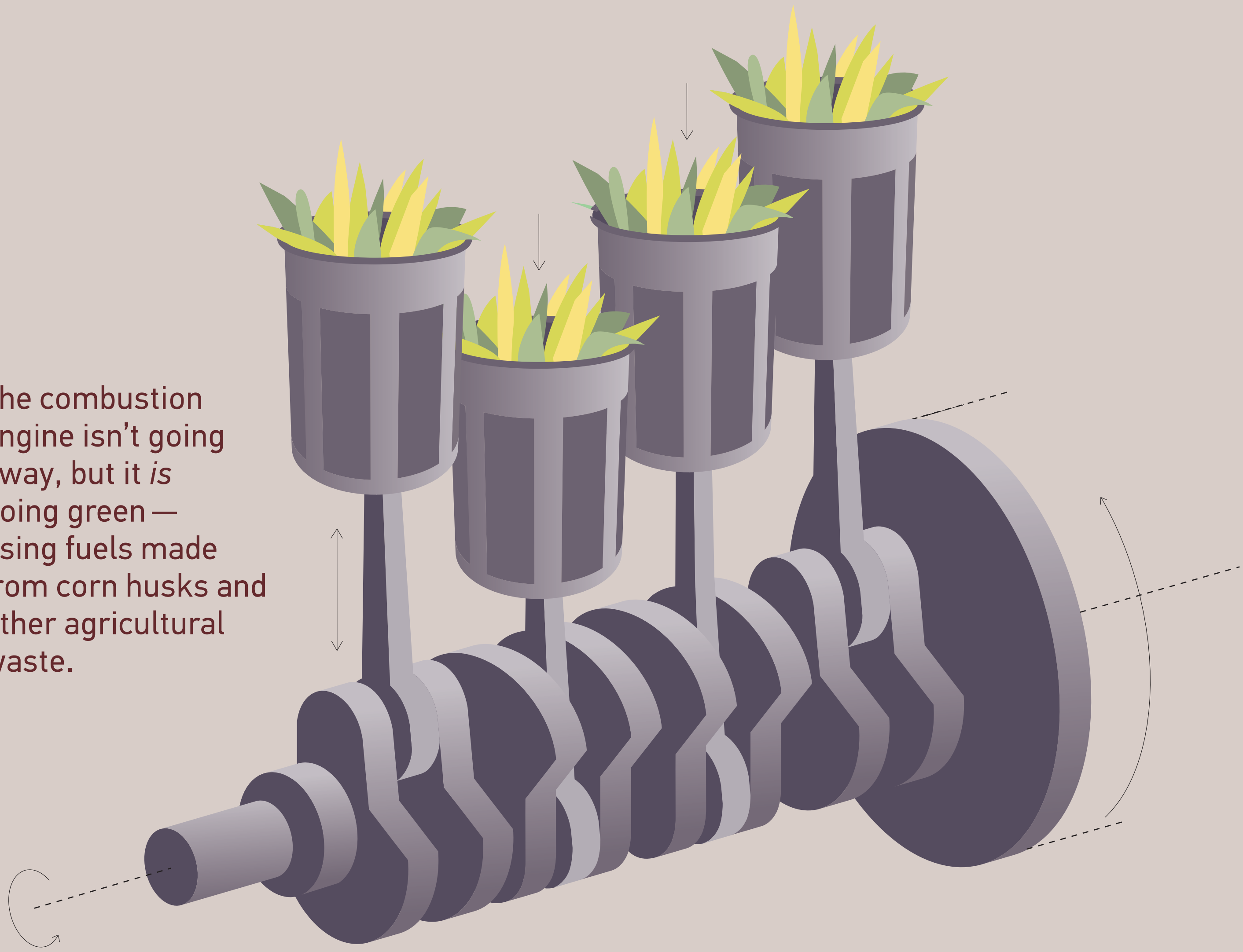
McGill

headway

RESEARCH, DISCOVERY AND INNOVATION AT McGILL UNIVERSITY



The combustion engine isn't going away, but it *is* going green — using fuels made from corn husks and other agricultural waste.

5 ways McGill researchers are BUILDING YOUR FUTURE

How we'll get around.
What we'll put in our bodies.
And even our bodies themselves.

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Research, discovery and innovation
at McGill University

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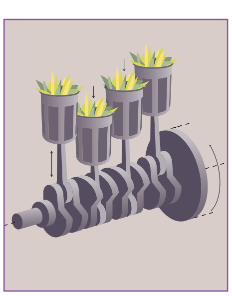


On the cover: Illustration by Matt Forsythe and Farah Khan

contents

Innovation

Research

Discovery

Message from the Vice-Principal (Research and International Relations)

One of the best parts about living in Montreal is that I am fortunate to live downtown and can walk to work. Every day I lace up my sneakers (or boots at this time of year), grab my backpack, and hit the pavement for 15 to 20 minutes to get to the office.

In the morning, my walk helps me focus on the day ahead. Heading home at night, I appreciate the chance to decompress. It may sound counterintuitive, but within the hustle and bustle of downtown Montreal I find time to reflect. Lately, inspired by the articles in this issue of *Headway,* I've been thinking about how research affects our lives in very tangible ways.

The idea of "building a better world" lies behind the articles that follow, and through my daily walks I've gained a new understanding about why this theme is so appropriate. It recently hit me that my routine could undergo changes, both big and small, in the coming years as the result of research being conducted at McGill today.

For example, if next month I suddenly have more time to cross a busy intersection, it could be because of one of the McGill-led transportation studies that are helping to make Montreal streets safer and more efficient. A few years from now, the cars zipping past may be propelled by Earth-friendly biofuels, thanks to our researchers' advancements in combustion engine designs. It's even possible that McGill research on pain-killing and cancer-preventing foods, and progress in the bio-engineering of bones and ligaments, will keep me trekking around my hometown longer than previous generations could have ever imagined.

And our discoveries will resonate far beyond my personal path to campus. With the help of our government and industry partners, we are moving many of these incredible new technologies from the lab to the market. That means our best practices for bike lanes may one day protect cyclists in distant cities. There is even the potential that transplant recipients on the other side of the planet could benefit from faster and easier recoveries after receiving treatments developed at McGill.

I recently marked my first anniversary as Vice-Principal (Research and International Relations), and seeing first-hand the impact of McGill research continues to be a great source of inspiration for me. I am regularly struck by the passion and perseverance of our researchers, how they dive in to tackle enormous problems, no matter how complex, and no matter how long it seems to take to actually create solutions. McGill researchers are up to the challenges!

When it comes to research, change usually happens through incremental progress. There are few "eureka" moments. But McGill researchers never seem to get frustrated. Instead, they quietly and purposefully go about making our world a little safer, smarter and more sustainable — one step at a time. I invite you to read about several such important steps taking place at McGill, presented in this issue of *Headway*. Some of the research described in these articles will be the basis of great progress — and some world-changing advances — in the not-too-distant future.

Dr. Rose Goldstein
Vice-Principal
(Research and International Relations)

Elena Bennett

Elena Bennett, an assistant professor in the Department of Natural Resource Sciences and the McGill School of Environment, studies how ecosystems provide humans with food production, recreation, flood control or habitat. Her work aims to create computer models that quantify these interactions and synergies. She's particularly interested in understanding how focusing on maximizing one service (e.g., agriculture) can cause a "regime shift," or unexpectedly sudden and large loss of another (e.g., water quality compromised by fertilizer run-off). "It's important to me to do research that's useful to the public, so we work with communities to understand the decisions that they're making."

One of Bennett's current projects focuses on 13 municipalities in Quebec's Richelieu Valley. (Other primary investigators on the project are Andy Gonzalez and Marty Lechowicz.) Valley land managers will soon be able to input information about proposed changes to land use—whether restoring a forest or expanding a suburb—and receive hard data about how the change would impact carbon storage, recreation potential, pollination and a wealth of other ecosystem services.

"It's doesn't tell them which decision is best, but it gives them the set of environmental outcomes," says Bennett. "Again and again, land managers tell me that they're often making reactive decisions out of necessity. They want to be more proactive, and the hope for this toolkit is to provide them with a way to do so."

For more information about the Richelieu Valley project, see www.monteregieconnection.com. The project is funded by the Natural Sciences and Engineering Research Council of Canada, Ouranos and the Max Bell Foundation.

Elena Bennett in her Macdonald Campus office, December 1, 2011. Photographed by Owen Egan.

In grad school, Bennett was upset over making "horrible miscalculations" on a research project. Her friend Chris Harvey, now a community ecologist at the Northwest Fisheries Science Center, cheered her up with a clay dinosaur—and has continued to make the beasts. "They're a good reminder for me when *my* grad students make some terrible mistake. Life goes on. Recalculate and figure it out." (And, no, each of the dozen-plus dinosaurs does *not* correspond to a research blunder.)

Bennett uses this *Historical Atlas of Canada* and other resources to understand how Canada's ecosystems have changed over the past century (a lot of streams have been straightened, for example) and how the ecosystem services have also changed.

Before joining McGill in 2005, Bennett held a post-doctoral fellowship with the Millennium Ecosystem Assessment, the largest-ever evaluation of the ecological state of the planet. Bennett co-led a subgroup of 60 scientists that looked at different potential future scenarios. The artist Pille Bunnell created these illustrations of how these possible futures could look.

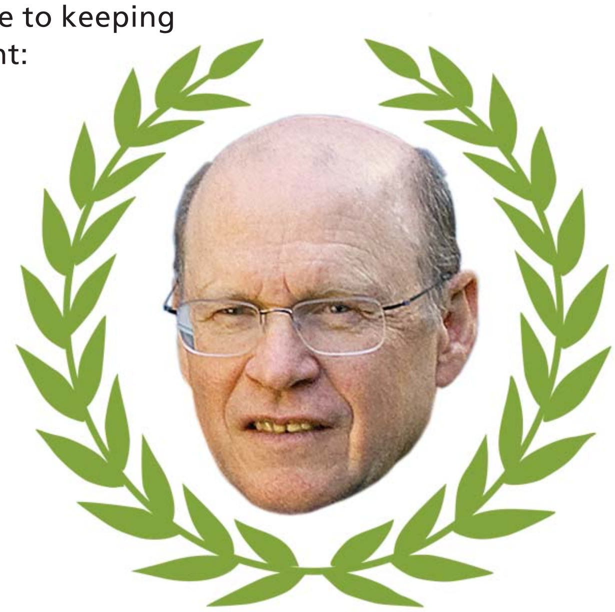
In addition to water, the researchers collect soil, insects and other samples. This ground-up leaf litter, for example, is used to determine the relationship between the size and isolation of forest patches and tent caterpillar deforestation—and how that affects maple syrup production, "because our work always relates back to some service that people get from the landscape."

Low-tech: a soil sampler.

High-tech: The ISCO 6712 portable automatic water sampler enables Bennett and her students to collect data without having to sit next to a stream all day (or night).

How to tell Brenda Milner and Nahum Sonenberg apart

These two McGill research superstars are always getting some prestigious recognition or other, so you'd be forgiven for confusing the two. Here's *Headway*'s guide to keeping them straight:



BRENDA MILNER

Birthplace: England
Joined McGill: 1950

Her big idea: The human brain contains multiple memory sytems. Her work in the field of cognitive neuroscience opened the way for a greater understanding of cognitive learning and language. She also identified the central role of the hippocampus in memory.

Does she hold the Order of Canada? Yes.

Has she won the Gairdner Award? Yes.

The Killam Prize? Yes.

Is she in the Royal Society of Canada? Yes.

What about the Royal Society of London? Yes.

The American Academy of Arts and Sciences? Yes.

What's she done lately? On November 3, 2011, Milner received the $100,000 Pearl Meister Greengard Prize, given by Rockefeller University. The prize recognizes female scientists who have made exceptional contributions to biomedical science, a group that historically has not received appropriate recognition and acclaim.

How's she feel about that? Pretty excited. "I am absolutely delighted and amazed to receive this special award and so proud and honoured to be representing women scientists in this context," says Milner. "I am very privileged for having been able to pursue my sense of curiosity within the culture of excellence at the Montreal Neurological Institute, as well as to train and encourage talented young students — driving forces throughout my career to which I attribute much of my success."

Brenda Milner is the Dorothy J. Killam Professor at the Montreal Neurological Institute and Hospital and a professor in the Department of Neurology and Neurosurgery.

NAHUM SONENBERG

Birthplace: Germany (but grew up in Israel)
Joined McGill: 1979

His big idea: He discovered how messenger RNAs (mRNAs) are selected for protein translation, how this translation is initiated and how a variety of regulatory factors control the efficiency of translation. Sonenberg's work has huge implications for understanding—and, ultimately, curing—cancer, memory loss and viral infections.

Does he hold the Order of Canada? Yes.

Has he won the Gairdner Award? Yes.

What about the Killam Prize? Yes.

Is he in the Royal Society of Canada? Yes.

The Royal Society of London? Yes.

The American Academy of Arts and Sciences? Yes.

What's he done lately? On March 29, 2012, Sonenberg will receive the Lewis S. Rosenstiel Award for Distinguished Work in Basic Medical Science, from Brandeis University. The award is given to scientists who have made discoveries of particular originality and importance to basic medical research.

How's he feel about that? Thrilled. "This is an award for basic science and this kind of research is struggling. In the last decade, or so, funding has focused on application, meaning research that has an immediate benefit to the economy or health, and the money to explore the biology behind basic questions is steadily dwindling. But basic research is the real source of new knowledge. Finding DNA—that is a prime example of basic research which revolutionized biology! This award shows that basic research is still appreciated, and I am excited to pursue it."

Nahum Sonenberg is James McGill Professor of Biochemistry and a senior researcher at the Rosalind and Morris Goodman Cancer Research Centre.

The neuroeconomics of choice

There may be more to the old adage "have your cake and eat it, too" than first thought. New research reveals that when we make decisions, the process to choose between stimulus (like kinds of cake) and actions (like how to eat the cake) are actually independent processes in the brain.

We've known for a long time that a person makes optimal choices by weighing costs and benefits and making a choice or taking an action based on the value comparison. But these functions were previously believed to be sequential parts of a single process. What's new about this study is its discovery that deciding *what* we want from among available options is handled separately from choosing *how* we get it.

"There are distinct processes in the brain by which value information guides decisions, depending on whether the choice is between objects or between actions." says the study's lead investigator **Dr. Lesley Fellows**, neurologist and researcher at the Montreal Neurological Institute. "This finding gives me more insight into what is happening in the brain of my patients, and may lead to new treatments and new ways to care for them and manage their symptoms."

The patients Fellows refers to are those with damage to the frontal lobe, where decision-making areas of the brain are located, caused by conditions ranging from stroke to traumatic brain injury to dementia. Such individuals have trouble making well-informed decisions, which can cause disastrous encounters with society and the legal system, and distress for patients and their families.

In the study, people with damage to the orbitofrontal cortex displayed an inability to sustain the correct choice of stimulus, but they chose normally between different actions. On the other hand, people with damage in a separate frontal lobe region known as the dorsal anterior cingulate cortex (dACC) had the opposite deficit; they weren't as good at choosing between two actions, but they could choose between objects normally.

The neuroeconomics findings were published in the Journal of Neuroscience. *The study was funded by the Canadian Institutes of Health Research.*

iStock

McGill's Banting Nine

In September, nine elite researchers from McGill were among the first-ever recipients of the new Banting Postdoctoral Fellowships. The fellowships recognize outstanding research in a broad range of areas in health, natural sciences and engineering, and social sciences. McGill's complement of Banting fellows is the largest among all Canadian universities. This year's honorees hail from Canada, France, the United States, Benin and Australia and they will each receive $70,000 per year for two years in support of their research:

Aurelie Cobat (Faculty of Medicine): Genetic resistance to tuberculosis bacterium

Cory Harris (School of Dietetics and Human Nutrition): An interdisciplinary approach to traditional medicine and Aboriginal health

Jim Geach (Department of Physics): A cosmic census of molecular hydrogen: the link between galaxy evolution and environment

Marion Van Horn (Department of Neurology and Neurosurgery): Studying tadpoles to show how glia are active players in brain development

Jessica Coon (Department of Linguistics): Understanding the nature of human language through the commonalties between the endangered languages of the Maya and Austronesia

Jean-Baptiste Jeangène-Vilmer (Faculty of Law, Centre for Human Rights and Legal Pluralism): The roles of privatization, robotization and ecologization in the future of war

Armel Brice Adanhounme (Faculty of Law): Juridical origins of exclusion at work

Melodee Mograss (McGill University Health Centre): Episodic memory and emotional processing in children with REM-related obstructive sleep apnea

Mark Lewis Shepheard (Faculty of Law): The stewardship debate and the role of virtue in regulating water management for agriculture

"The awarding of these Banting Fellowships to McGill researchers is an affirmation of the value of their cutting-edge research," says Heather Munroe-Blum, McGill's Principal and Vice-Chancellor. "It also highlights the resources and support available to these exceptional post-doctoral students from here and abroad who have made the decision to pursue their research in Canada and at McGill."

The Fellowship is named in memory of Sir Frederick Banting, the Canadian physician, researcher, Nobel laureate and war hero who, with his assistant Charles Best, is credited with the discovery of insulin. Funding for the awards is delivered through the Canadian Institutes of Health Research, the Natural Sciences and Engineering Research Council of Canada and the Social Sciences and Humanities Research Council of Canada.

AAAS welcomes two McGillians to its ranks

Congratulations to McGill researchers **Mark Wainberg** and **Daniel Levitin** for being elected to the American Association for the Advancement of Science. The AAAS is an international non-profit organization dedicated to "advancing science around the world by serving as an educator, leader, spokesperson and professional association." Accordingly, the two McGillians are both high-profile advocates for science. Wainberg is a tireless promoter of global access to HIV-fighting drugs; he himself helped develop one of the first anti-viral drugs. A musician and bestselling author, Levitin's research into the neuroscience of music attracts rock stars like Sting and Feist to his McGill lab.

Carmen Jensen

Unleashing the Supersolider Ant Within

In 2006, McGill biologist **Ehab Abouheif** was minding his business in Long Island (his business, of course, being poking around in the dirt next to a highway, looking for insects) when he discovered eight Pheidole ants of the "supersoldier" variety. Supersoldier ants are much larger than their civilian kin, and have really big heads and massive mandibles. They are strange looking creatures, no doubt, but here's the really weird part: Supersoldiers don't live in Long Island.

Now, after five years of research, Abouheif and his team have figured out this mystery: It turns out that any old Pheidole ant contains the dormant genetic potential to develop into a supersoldier — and, even more exciting, the researchers can induce a regular ant into unleashing its inner supersoldier by applying juvenile hormone to the ant larvae at critical stages in their development. The team, led by PhD student **Rajee Rajakumar**, and including collaborators at the University of Arizona, published a paper in January 2012 edition of the journal *Science*. The potentially revolutionary findings show that dormant genetic potential can be locked in place for a very long time.

"The kind of environmental stressors that evoke this dormant potential are there all the time — so when the need arises natural selection can take hold of the potential and actualize it," says Abouheif, who holds the Canada Research Chair in Evolutionary Development Biology. "So what we're showing is that environmental stress is important for evolution because it can facilitate the development of novel phenotypes. Anytime you have a mismatch between the normal environment of the organism and its genetic potential you can release them—and these things can be locked in place for 30 to 65 million years."

■ *The research was funded by Natural Sciences and Engineering Research Council of Canada, the National Sciences Foundation (U.S.) and the Konrad Lorenz Institute Fellowship.*

Diabetes drug has unexpected side effect: It fights cancer

In 2005, researchers at Scotland's University of Dundee reported that diabetics taking metformin, a drug commonly prescribed to patients with Type II diabetes, had unexpectedly low rates of cancer—perhaps as much as a 50 per cent reduction in risk. Follow-up studies supported this claim. But nobody could explain what was going on.

As reported in the January 2012 edition of *Cancer Prevention Research*, researchers from McGill University and the Université de Montréal discovered actions of metformin that may provide the answer. The drug reduces the accumulation of DNA damage by reducing levels of reactive oxygen species (ROS), which are known DNA-damaging agents. This appears to take place in mitochondria, cellular organelles that produce required energy by "burning" nutrients, with ROS production as an undesired by-product. Metformin thus appears to reduce mutation rate. (Mutations have been long implicated in carcinogenesis, but lowering cancer risk by inhibiting mutation hadn't been considered feasible.)

"It is remarkable that metformin, an inexpensive, off-patent, safe and widely-used drug, has several biological actions that may result in reduced cancer risk," explains the study's director, **Dr. Michael Pollak**. Pollak is a professor in McGill's Departments of Medicine and Oncology and a researcher at the Lady Davis Institute for Medical Research at the Jewish General Hospital. He collaborated with Dr. Gerardo Ferbeyre's lab at Université de Montréal. "These latest findings suggest that metformin reduces mutation rate in somatic cells, providing an additional mechanism by which it could prevent cancer."

"This study opens an exciting new direction in cancer-prevention research," Pollak adds. "This doesn't imply, however, that metformin is now ready to be widely used for cancer prevention. We do not yet know if the drug accumulates to sufficient concentrations in human tissues at risk for cancer, such as breast or colon, when taken at the usual doses used for diabetes treatment, nor do we know if the findings from the original studies showing reduced cancer risk, which were carried out in diabetics, also apply to people without diabetes. But the possibility of protecting DNA from oxidative damage by the use of a well-tolerated drug was not expected, and this topic now needs further study at many levels."

■ *This research received funding from the Canadian Cancer Society Research Institute.*

Multi-tasking and the busy brain

Our brains can only process about one per cent of the information that our eyes throw at it—which makes the twin ideas of "paying attention to" and "ignoring" powerful coping mechanisms. But, until now, neuroscientists have puzzled over how, exactly, we're able to attend to multiple objects at the same time. Do our brains split the focus of attention into multiple, simultaneous "spotlights"? Or is there just one spotlight that quickly switches between objects? Or is there one really big spotlight taking in everything at once?

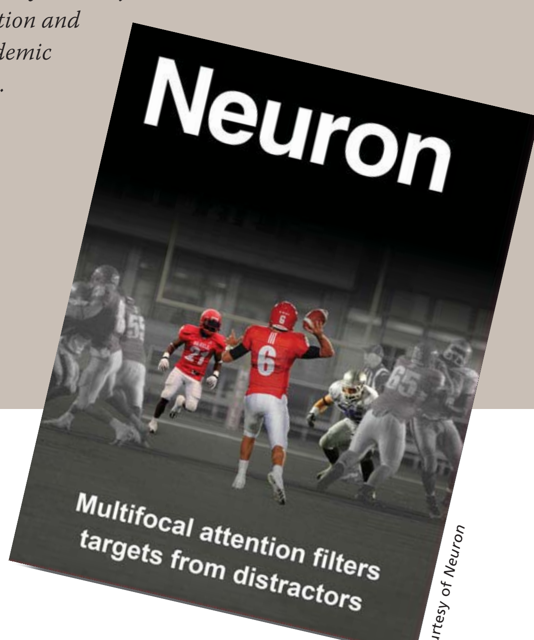
A new study, led by **Dr. Julio Martinez-Trujillo**, a cognitive neurophysiology specialist in the Faculty of Medicine's Department of Physiology, has found evidence of multiple spotlights.

The team published their findings in the December issue of *Neuron*. The journal included a cover photo of McGill's Redmen football team in action. Why? Because sports offers an excellent example of cognitive multi-tasking. Consider how a besieged quarterback keeps simultaneous tabs on his receiver and the opposing defense, while ignoring less immediately relevant players and the roaring crowd.

Martinez-Trujillo and his team recorded the activity of single neurons in the brains of two monkeys while the animals concentrated on two objects that circumvented a third "distracter" object. The neural recordings showed that attention can, in fact, be split into two "spotlights" corresponding to the relevant objects and excluding the in-between distracter.

"One implication of these findings is that our brain has evolved to attend to more than one object in parallel, and therefore to multi-task," says Martinez-Trujillo. "Though there are limits, our brains have this ability." It is the researchers' hopes that a better understanding of the brain mechanism underlying multifocal attention may, among various applications, help to understand and plan treatment strategies for ADHD and autism.

■ *This research was funded by the CIHR, the EJLB Foundation and the German Academic Exchange Service.*



Courtesy of Neuron

McGill's latest CRC Recipients

We are proud to welcome McGill's newest crop of Canada Research Chair (CRC) recipients, as announced in September 2011. The CRC program is a permanent, cross-country Government of Canada initiative, launched in 2000, which gives out $300 million per year to attract and retain 2000 of the world's most accomplished and promising minds. In total, 23 CRCs were awarded to McGill University, categorized into two tiers.

Tier 1 Chairs are "outstanding researchers acknowledged by their peers as world leaders in their fields." For each, the university receives $200,000 annually for seven years, which is renewable. New McGill recipients of Tier 1 chairs are:

Roger Azevedo (Metacognition and Advanced Learning Technologies)
Dr. John Breitner (Prevention of Dementia)
Isabelle Daunais (Esthetics and Art of the Novel)
Christian Genest (Stochastic Dependence Modeling)
Laurie Hendren (Compiler Tools and Techniques)
Susanne Lajoie (Advanced Technologies for Learning in Authentic Settings)
Mark Lathrop (Medical Genomics)

Tier 2 Chairs, tenable for five years and renewable once, are recognized as "exceptional emerging researchers, acknowledged by their peers as having the potential to lead in their field." The university receives $100,000 annually, for five years, for each Tier 2 chair. McGill's new Tier 2 CRCs are:

Antoine Adamantidis (Neural Circuits and Optogenetics)
Marta Cerutti (Biosynthetic Interfaces)
Sarah Kimmins (Epigenetics, Reproduction and Development)
Odile Liboiron-Ladouceur (Photonic Interconnects)
Arijit Nandi (Political Economy of Global Health)
Thomas Martin Schmeing (Macromolecular Machines)
Victoria Talwar (Developmental Psychology and Law)
Johannes Walcher (Mathematical String Theory)

Five Tier 1 CRCs were also renewed: **Robert Brandenberger** (Theoretical Cosmology), **Colin Chapman** (Primate Ecology and Conservation), **Stephen McAdams** (Music Perception and Cognition), **Andrea Tone** (Social History of Medicine) and **Silvia Vidal** (Host Response to Virus Infection). Three Tier 2 chairs were renewed: **David Juncker** (Micro- and Nano-bioengineering), **Grace Marquis** (Social and Environmental Aspects of Nutrition) and **Bradley Siwick** (Ultrafast Science). ■

Alzheimer's, acidification, abnormal brain activity and titanium foam: The year in Quebec science

As is its tradition, *Québec Science* magazine rang in the new year with its shortlist of the top 10 discoveries of the previous year. Scientists from McGill University and the McGill University Health Centre Research Institute are behind four of the selections:

- A new blood test to diagnose Alzheimer's disease. The study was authored by **Georges Rammouz**, **Laurent Lecanu** and **Vassilios Papadopoulos**, from the MUHC Research Institute and McGill University, and Paul Aisen (University of California at San Diego).
- How treating chronic low back pain can reverse abnormal brain activity and function. The study was authored by **Laura S. Stone** of the Alan Edwards Centre for Research on Pain, with McGill colleagues **David A. Seminowicz** (now at the University of Maryland), **Timothy H. Wideman**, **Lina Naso**, **Zeinab Hatami-Khoroushahi**, **Summaya Fallatah**, **Mark A. Ware**, **Peter Jarzem**, **M. Catherine Bushnell**, **Yoram Shir** and **Jean A. Ouellet**.
- A study of the acidification of Lower St. Lawrence estuary bottom waters. The study was authored by **Alfonso Mucci** of McGill's Department of Earth and Planetary Sciences, with Michel Starr and Denis Gilbert (of the Maurice Lamontagne Institute, Fisheries and Oceans Canada) and Bjorn Sundby (Institut des Sciences de la Mer de Rimouski).
- Helping broken bones heal faster. Orthopedic surgeons **Paul Martineau** and **Edward Harvey** (Faculty of Medicine and MUHC), in collaboration with Louis-Philippe Lefebvre of the National Research Council of Canada, have patented a screw made of titanium foam that could replace screws made of stainless steel.

One of the 10 will be crowned discovery of the year. Readers can vote for their favourite at:
www.quebecscience.qc.ca/decouverte2011 ■


Fotolia

High-tech storytime to help kids learn language

Much ado is made about how technology changes how we read — but how might it change how we learn the skills needed to read? A new collaboration between McGill's School of Communication Sciences and Disorders and Tribal Nova, a Montreal-based developer of online educational services, is exploring new approaches to young children's language acquisition processes.

When it comes to learning language skills, children between the ages of two and four get the most benefit from shared book reading. That's when their parent (or other readers) involves them in the reading process, whether by pausing a story to ask if they know the meaning of a word, or asking if they can relate something in the story to their own lives. This exchange can turn storytime into an extended affair, admits **Susan Rvachew**, associate professor in the School of Communication Sciences and Disorders, but it's worth the effort: "This is a method that's proven to greatly help children acquire important language skills. We're not talking about learning to read — that needs to be taught explicitly later — we're talking about acquiring the oral language skills that are the foundation of written language skills."

This "dialogic reading" method doesn't just take time to do, however — it also takes time to learn, and the better the parent is at it, the more the child benefits. Rvachew says it takes about six hours to learn, something not every parent has the time or resources to do. "Even for well-educated parents, it's quite the teaching process." But what if a smart book could teach parents how to read with their children, while they're doing it?

Rvachew's lab has the knowledge about how children learn language, and Tribal Nova has the technical savvy. Together, they're creating iREADwith, a new style of interactive storybook (for the iPad) that will guide parents with specific prompts—such as "Wait for a few seconds for your child to say something here" or "Ask your child if they know what this word means" — in order to help them learn the dialogic method. The e-book will also give children visual and audio prompts to encourage them to get involved in the story.

Tribal Nova has secured the rights to a HarperCollins children's picture book called *Frank and Tank: The Big Storm*, which Rvachew and her team are rewriting to optimize its effectiveness as a learning text. They are currently testing prototype versions with volunteer parents and children, and hope to launch the iREADwith series at the end of 2012.

"Language learning happens when you follow the child's lead," says Rvachew. "By using the iPad as a reading support, the parent will have a high-performance tool to encourage their child to interact with the story, which could substantially boost their language skills."

■ *This project received financial support from the Canada Media Fund.*

The Sound of Research

As a vibrant site of traditional artistic practice, you might think the Schulich School of Music is the odd man out in McGill's research-intensive environment. The school's composers want to change your tune.

By James Martin

Ludwig van Beethoven loved red wine, long walks and jotting down ideas. His famous sketchbooks — actually collections of some 8,000 loose pages — show how the composer worked out complex musical ideas. But all those semi-legible scribbles weren't composing, says Sean Ferguson. They were research.

"When you're actually writing a piece, that's artistic practice," says Ferguson, who was appointed dean of McGill's Schulich School of Music in May 2011. "But the work leading up to writing — developing new strategies and techniques, like the sketches where Beethoven takes a motive and figures out all the ways he can transform it — that's artistic research."

The music school is home to eight composers, including Ferguson. Just like their colleagues in the sciences, they often approach musical composition by asking a question. It could be a question about harmony: How can music be written so the audience hears exactly what the composer intends? Or ways to use new technologies: How can sounds be spatially projected over loudspeakers so that concertgoers experience a new immersive virtual environment?

"Compositional research can be contributing to new technology," says Ferguson. "It can involve psychology and perception. It can be cultural studies. It can be artistic research in the sense of developing new ways of thinking about harmony or form or melody."

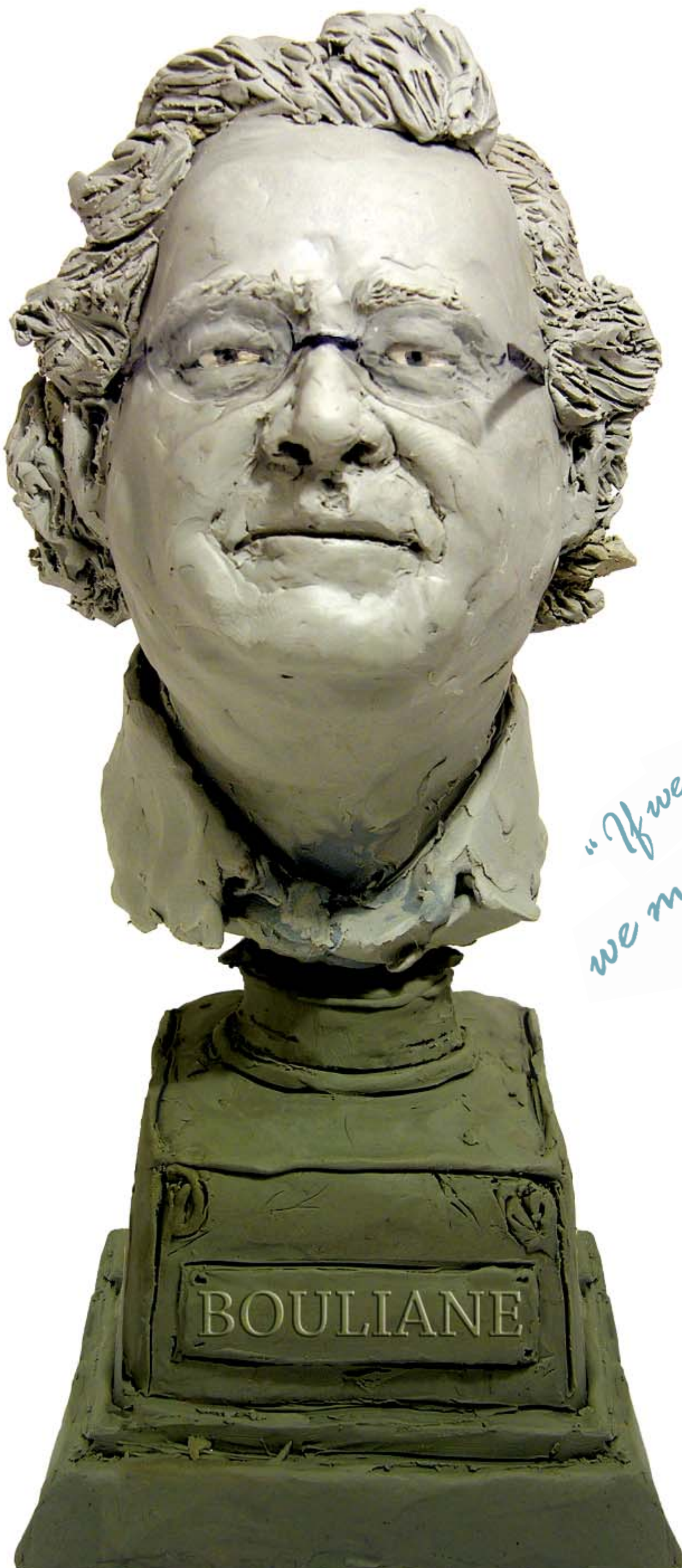
As the former director of McGill's Centre for Interdisciplinary Research in Music Media and Technology (CIRMMT), Ferguson has extensively collaborated with scientists and engineers on projects like the real-time manipulation of instrumental sound in concert or creating new digital instruments that transcend physical limitations. Those high-tech collaborations have given him valuable insights into how other people see composition within the University.

"It's not always easy for people to understand artistic research," he says. "One of the things that's been good for me is collaborating with people outside music. I've learned how they see their own work, and the confusions they have in seeing my work. It's a valid question: 'You don't publish your results in *Nature*, so how do I know what it is?' Even composers themselves don't necessarily agree on what constitutes research in their domain. Artistic researchers can look peculiar from the outside, until you put yourself in their position. Sometimes their work looks like science, sometimes like engineering, sometimes the humanities. And sometimes it is completely unique."

Ferguson's own research marries musical creation with new technology, and his compositions have been performed by the Philharmonic Orchestra of Radio France, the Montreal Symphony Orchestra, the Société de musique contemporaine du Québec and Les Temps modernes de Lyon, among others. A big part of his work involves computer-assisted composition. Ferguson named his software Apprentice because he likens his interaction with it to that between baroque painters and their skilled helpers. "The painter would train the apprentice so they wouldn't have to spend hours painting fabric folds or some other time-intensive detail," he says. "In the same way, I could play 200 chords on a piano to judge which ones are the most consonant *or* I could train an apprentice to do it for me who would then give me a selection of the most suitable ones — but I still have to listen to those chords myself and make the artistic decisions. It does not compose for me. It's not a shortcut. You can do things compositionally that you couldn't do otherwise, but it doesn't make composing faster. It allows me to expand my harmonic language beyond a small repertoire of chords that I return to all the time. It allows for more diversity.

"I *could* listen to hundreds and hundreds of chords, but it would be exhausting," he adds, "and after a while they would all start to sound the same!"

Portrait busts by Karen Caldicott



"If we want to prepare for the future, we must give meaning to music."

"Artistic research can look like science, engineering, the humanities or something completely unique."

Philippe Leroux, who joined the faculty as associate professor of composition in the Department of Music Research in September 2011, is also interested in new technologies. The French composer is world-renowned for his works using live electronics and multi-channel audio. His music has been performed at festivals around the world and he's received commissions from the French Ministère de la Culture, the Orchestre Philharmonique de Radio France and Südwestrundfunk Baden-Baden, among others.

One of Leroux's research interests is in the activity of composition itself. In France, he collaborated with anthropologist Jacques Theureau and musicologist Nicolas Donin on a Centre National de la Recherche Scientifique and Institut de Recherche et Coordination Acoustique/ Musique project. Theureau and Donin studied Leroux's every artistic move — for 18 months — while he composed *Voi(rex)*, a piece for a soprano, six instrumentalists and live electronics.

The study broke down Leroux's creative practice into cognitive ergonomics, from his initial idea to write a voice-centered piece to preparation (making sketches, compiling lists of material, organization), to writing the score, to, finally, tweaking the composition during rehearsals. Leroux is fascinated not only by the insights into his creative process, but by the surprising, non-musical applications of this knowledge. Jacques Theureau had previously studied nuclear plant security systems, professional ping-pong players and fishermen in Brittany — seemingly strange bedfellows that find common ground in basic processes of human activity — and his work with Leroux was later used to create, of all things, a production protocol for the Renault auto factory.

"It was amazing," says the composer of this unexpected throughline. "A lot of people don't think contemporary music is very useful to society — but beyond the artistic benefits it brings it can even be used to make cars!"

Of course, it can be used to make music, too: Leroux used the project's data to create a new piece, *Extended Apocalypsis*, which was premiered in autumn of 2011 by the Athelas Sinfonietta in Copenhagen, during the Integra Festival that brought together research centres, ensembles and composers from around the world.

"The first thing for me, always, is to try to compose good music," says Leroux. "And, at the beginning of the 21st century, to compose good music requires new tools." To that end, he's keen to collaborate with researchers in McGill's Music Technology Area.

"Electronics have changed how we listen to music, and also our composition concepts. Now, for example, we can repeat sounds infinitely. Or we can play much faster than a human could. Or we can change a sound little by little, a slow and imperceptible continual transformation. Those are completely new things. Before, we couldn't ask a violinist to repeat the same notes for two days. When a sound is infinite, it changes our relationship between music and memory; that has to change our points of reference. It's interesting to examine that path, to show the possibilities of electronics to extend the instrument's possibilities — and the instrumentalist's possibilities."

Denys Bouliane is also looking to take composition into the future, but not necessarily through technological innovation — or even by looking forward. The associate professor of composition in the Department of Music Research is concerned about what he terms the "symbolic value" (as opposed to market-driven, monetary value) of music. "If we want to prepare for the future, we must give meaning to music," he insists. "With all the greatest respect to Mahler or Mozart, who I teach very happily, I ask, 'Why are they great masters?' How did the form of Mozart's music represent the political and social ideas of his time? How did Mahler transform the formal structure in his 10 symphonies to reflect the dissolving social order of Vienna?

"Then, for my own work, how can I reformat the musical language to express things in a fresh way — but still communicate with listeners? Universities are one of the few places left where you can think about music in these not necessarily commercial terms."

Bouliane is preoccupied with questions of cultural identity. As a Québécois who spent half his life in Europe — he was based in Germany for almost 20 years before returning to Quebec — he's been asking himself difficult questions. "Where do I come from? What do I stand for? Do I have roots anywhere?" Music, naturally, is his main tool of inquiry. But, whereas his German colleagues could draw upon centuries of tradition, Canada's musical history is short. So he's inventing his own.

He's five years into an ambitious project: a nine-opera cycle that tells an alternative history of Canada and North America by speculating on what 500 years of a real cross-pollination between First Nations and European culture and music might sound like. In Bouliane's version, Jacques Cartier and his band of 16th-century explorers landed on the shores of Anticosti Island, located in the Gulf of St. Lawrence, "with an attitude, not to conquer, but to learn." (In reality, Cartier sailed along Anticosti's shores in 1534, but doesn't seem to have ever set foot on it.) The explorers and the island's Mi'kmaq residents go on to make beautiful music together, figuratively and literally, "while learning to share a fabulous transcendental secret."

"Of course, in my story everyone's favourite mode of expression is music," chuckles Bouliane. He has immersed himself in studying authentic First Nations musical traditions, as well as the Portuguese sailing songs favoured by Cartier's crew and other European music of the time. Now he's combining that meticulous research with a deep understanding of how real-life musical evolutions work, to create a "syntactical functioning musical language" that can change as he recounts key moments in the history of his mirror-world. In early 2011, Bouliane achieved an impressive hat trick when the first three instalments of his Anticosti cycle were each given major world premieres. The Montreal Symphony Orchestra, under Kent Nagano, performed *Vols et vertiges du Gamache* for orchestra with Schulich colleague Matt Haimovitz as cello soloist; the Orchestre Métropolitain, with Yannick Nézet-Séguin, performed *Kahseta's Tekeni-Ahsen*; and *Tekeni-Ahsen*, for quintet and real-time electronics, was presented during the live@CIRMMT concert series under Bouliane's baton.

"This hybrid music I'm creating is not about being right," he says. "It's my reinterpretation from two different perspectives. The point is to re-evaluate what musical culture is, but without just quoting First Nations music — that wouldn't be respectful or imaginative." Instead, he's thoughtfully intertwining distinct strands of cultural and musical DNA, then growing them in never-heard directions.

"It's a touchy thing," he admits. "I don't like cultural tourism or cafeteria-style picking of elements: 'Let's take an Indian drummer, a South African singer and a Montreal jazz player and improvise for an hour.' That's not what this is about. I'm trying to take the spirit of rhythms and forms and make them inhabit the work from the inside." On top of that, he's extrapolating historical events into a rich fiction that includes an imagined pen-pal correspondence between Jacques Cartier and the French satirist François Rabelais, and a Freemason-worthy conspiracy theory that recasts key historical figures as secret Anticostians. There's an epic love story, too.

"It's a crazy, crazy thing," he admits with a laugh.

"Composers aren't just the lunatics who dream of a better world," he adds. "Scientific research is about discovering new things and pushing the boundaries. That's exactly what we're trying to do, too: to go where nobody has gone before musically. If everyone in the world did music the same way, by god it would be boring!"

■ *Funding sources for this research include the Canada Foundation for Innovation, the Fonds de recherche du Québec - Société et culture, the Social Sciences and Humanities Research Council of Canada, the Natural Sciences and Engineering Research Council of Canada and the Canada Council for the Arts.*

"At the beginning of the 21st century, to compose good music requires new tools."

Shining a Light on Food Poisoning

As the Department of Food Science and Agricultural Chemistry celebrates 25 years of studying the good and the bad in food, one of its hallmark innovations — a specialized infrared technology that identifies food-borne pathogens — is getting ready to leave the nest.

By Philip Trum

Food-borne illnesses affect more than 12 million Canadians each year. Always unpleasant, sometimes fatal, bad food takes a huge toll: By some estimates, salmonella, E. coli and other bacteria are responsible for $1.3 billion annually in lost productivity and medical bills. And that's just in Canada.

For the past 25 years, researchers in the Department of Food Science and Agricultural Chemistry have been exploring the molecular underpinnings of what we eat. Some of their projects look at how we can prevent unwelcome microbial reactions from ever starting. One of the department's marquee projects, however, takes a different approach to the problem: Identify spoiled food as fast as possible so nobody eats it.

"Every organism has an infrared signature that is as unique as a human fingerprint," explains Ashraf Ismail, associate professor in the department. A technology called Fourier transform infrared (FTIR) spectroscopy is the metaphorical magnifying glass for detecting this fingerprint — and an efficient way to identify food-borne pathogens in a fraction of the traditional time.

When the McGill Infrared (IR) Group started its research with FTIR spectroscopy, the technology's food application was limited to analyzing the nutritional composition of milk. But Ismail and professor Frederick R. van de Voort thought FTIR technology had potential for even broader applications in food science and food analysis. Today, the McGill IR Group has one of the world's best-equipped research facilities for FTIR spectroscopy.

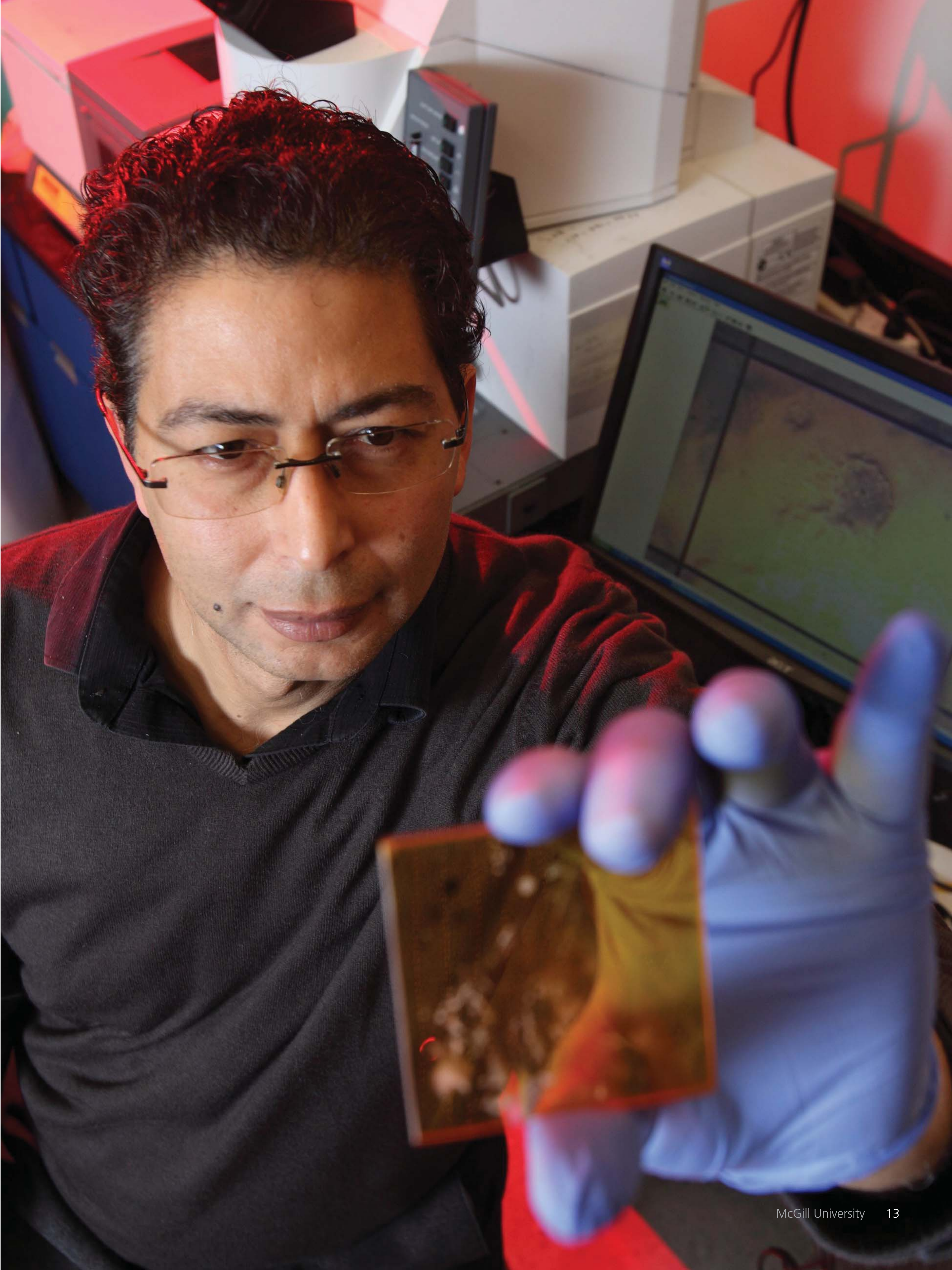
The process starts by growing a bacterial culture from the food in question (Health Canada regulations for bacteria analysis require a lab culture), which takes eight to 48 hours. After smearing a tiny amount of the culture on an infrared-transparent slide, an analyst then uses an FTIR spectrometer to measure the absorption of infrared light by the bacteria. The resulting spectrum is matched to a database of spectra from hundreds of bacteria. Identifying the mystery bacteria takes less than two minutes. Traditional lab analysis, which is done using a variety of biochemical tests, takes 24 hours — or more — on top of the culturing time.

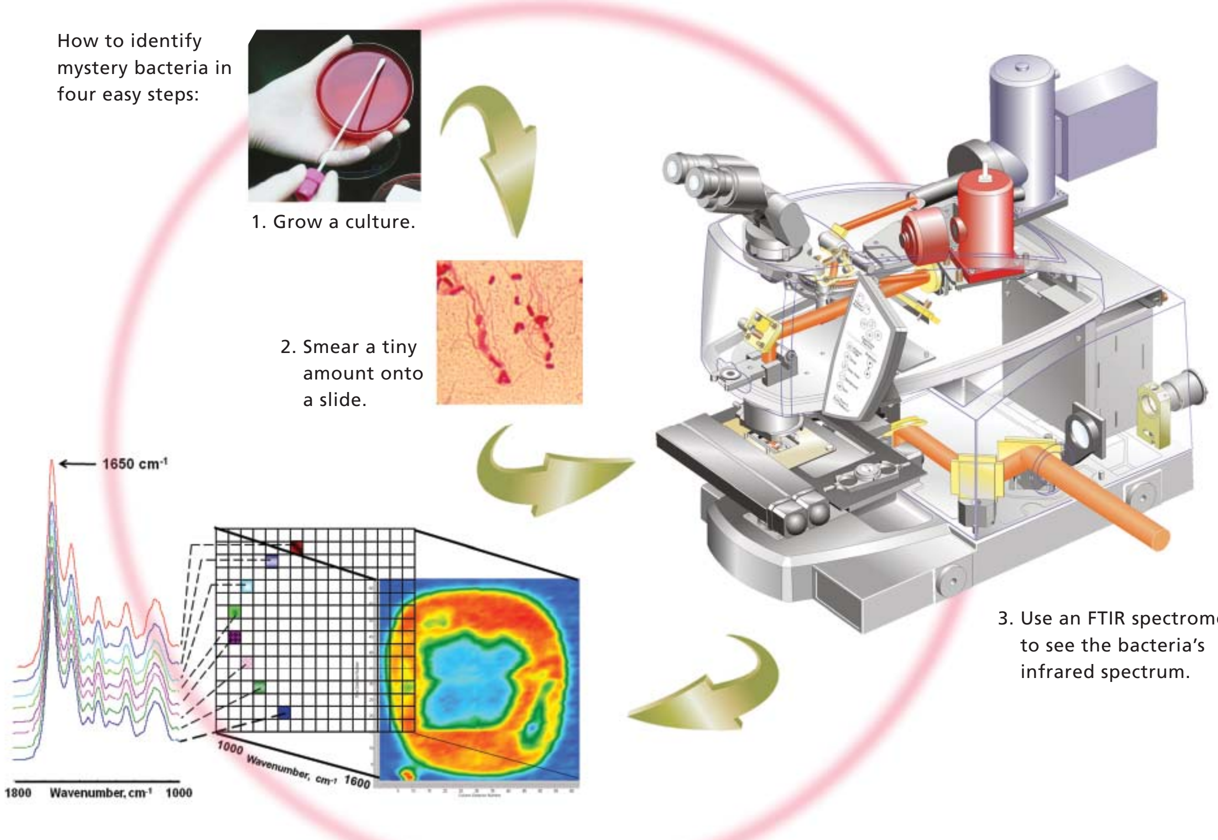
"Smear a sample on a slide, shine infrared light on it, and you're done," says Ismail. "It doesn't get much easier to use — and there's basically zero overhead."

In August, the McGill IR Group finished a series of Health Canada challenge studies. They began by placing known bacteria into five different types of foods. They

Owen Egan

Professor Ashraf Ismail prepares a slide of unknown bacterial culture. He'll identify the sample by comparing its infrared spectrum to a database of spectra from hundreds of bacteria.





4. Compare the spectrum to a database of known spectra. A spectrum is like a fingerprint: Find a match and you've found your bacteria.

then extracted the organism, cultured it, and identified it using both the two-minute FTIR analysis and the standard 24-hour method. The FTIR identification hit the mark 100 per cent of the time.

"We're at the level where the confidence one can have in the results of the technique is comparable to that for the other techniques," says an obviously proud Ismail. "The next step will be to repeat those tests using unknown pathogens."

The time advantage provided by the FTIR technology has major implications. There's a great advantage to knowing as early as possible which bacteria has compromised the food supply. A full, speedy recall of contaminated products mitigates the potential adverse health effects of food-borne pathogens — the proverbial ounce of prevention.

Ismail and his department have a long history of industry collaborations. Some of these are research collaborations, such as when van de Voort and Ismail helped Frito-Lay determine "best before" dates for their potato chips based on the specific oil oxidation profile for each batch of frying oil. (There isn't a one-size-fits-all expiry date; the profile dictates how long each batch will retain its fresh taste after leaving the factory). Now, with FTIR bacteria identification technology having proved itself to Health Canada, Ismail says it's time for the private sector to pick up the ball and run with it. The McGill IR Group has been working with McGill's Office of Sponsored Research to get this technology out of the lab and into the world. The ultimate extension would be scaling down the FTIR technology into a hand-held device that could be used by regulatory agencies doing supermarket spot checks, or safety managers inspecting their production lines. Ismail would love to see it. But he's not the man to do it.

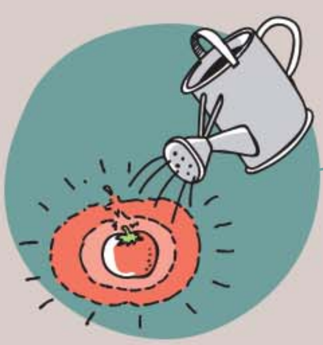
"I'm a biochemistry researcher," he says. "The systems I love studying happen to be proteins, micro-organisms and food products, but we're a research laboratory — not a product development centre. We've shown feasibility. We developed the software and the system for analysis. We trained the students who know how to use this technology— students who, in many cases, helped create the technology in the first place. Now it's time for industry to translate all this into a product for whatever market segments. I've been working on this for 20 years. Maybe it's time for a change."

He breaks into a little grin. "But it's so fun I almost can't believe I get paid to do it."

The McGill IR Group is funded through a Natural Sciences and Engineering Research Council Collaborative Research and Development grant, which sees the federal government match industry funding two-to-one. The project's industry partner is Agilent Technologies (Canada) Inc. The McGill IR Group has also collaborated with Health Canada and the U.S. Food and Drug Administration on the development of the FTIR bacteria identification technology.

Illustrations by Matt Forsythe and Farah Khan

The world of tomorrow probably won't look like a science-fiction utopia of personal jet-packs and silver jumpsuits. You'll just have to settle for a future that's healthier, safer and greener.



5 ways McGill researchers are

Building Your Future

Healing

It's no secret that eating well plays a big role in health. But the past 15 years has seen a dramatic increase in the research field of nutraceuticals, which looks at exactly what it is about certain foods that makes them able to stave off, or even reverse, disease. Here are four wonder foods that McGill nutraceutical researchers are currently exploring.

By Philip Trum

A Certain isoflavone compounds, such as genistein, are linked to preventing breast cancer. **Soybeans** are loaded with them — except when they're not. "A farmer might grow soy-beans one year and get a certain concentration of iso-flavones," says Philippe Seguin, chair of the Department of Plant Science. "The next year, he might grow the same beans but get a much lower concentration. It's a big issue." Vendors, of course, want to be guaranteed a certain concentration of isoflavones, whether they're selling soy supplements (widely marketed as menopause symptom relief) or soy-based foods like tofu. To that end, Seguin is studying the relationship between environmental conditions (such as air temperature or soil moisture) and agricultural practices (such as use of fertilizer) and the resulting isoflavone concentration in crops. "Our ultimate goal is to be able to model, in advance, what the concentration will be based on, say, the air temperature being at a certain level when the crops are in the flowering stage." All the better for the health-conscious eater who wants to load up on isoflavones — and not get stuck with, well, just a handful of beans.

B **Kefir** isn't all the rage in Canada — not yet, at least — but the fermented beverage has been popular in Eastern Europe and parts of Asia for a long time: Marco Polo encountered the drink during his 13th-century travels, calling it "wonderfully tonic and nutritious, and it is said that it has cured many persons threatened with consumption." Professor Stan Kubow, associate professor in McGill's School of Dietetics and Human Nutrition, says that the fermentation of soy using kefir is a particularly potent health-promoting combination. The Kubow lab's open-label studies (that's when the subject knows what they're taking) show, over and over, that soya kefir is quite the pain reliever for people suffering from fibromyalgia, a long-term condition that produces body-wide pain and tenderness, and chronic fatigue syndrome. Soy already contains opioid peptides derived from soy proteins, and Kubow thinks fermentation "creates a super-soy product, in which a lot of the bioactive components become more bioavailable and are absorbed to greater effect." (Soy kefir is also showing significant mood- and energy-enhancing effects.)

The researchers suspect kefir's particular form of fermentation — driven not by a single bacteria but by a symbiotic matrix of several bacteria — may be at the root of its remarkable health benefits. They've completed studies, published in the *Journal of Medicinal Food* and in *Breast Cancer – Current and Alternative Therapeutic Modalities*, that compared kefir-fermented milk to that fermented by the lone

Meal

Daniel Cooper

bacteria commonly used to make yogurt. "The studies showed much more potent anti-cancer properties in the kefir," reports Kubow. "What we think is happening is that the various bacteria act together to create a synergy of bioactive compounds." And when it comes to pain-beating bacteria, there seems to be strength in numbers.

C **Whey**: not just for nursery rhyme breakfasts any more. Stan Kubow and various collaborators have been running liquid whey through an industrial-strength hyperbaric pressure processor that packs more punch than the bottom of the Pacific Ocean. The result is a product that corrects a stressed body's ability to utilize proteins to combat illness.

Kubow has conducted studies with Dr. Larry Lands (Montreal Children's Hospital), Dr. Franco Carli (Montreal General Hospital) and Linda Wykes (School of Dietetics and Human Nutrition), which found the pressurized whey seems to be particularly effective in helping people recover from diseases involving excessive inflammation. The researchers suspect that, because the process changes the structures of whey proteins, their peptides can be more readily absorbed — which helps diminish free radicals. (Free radicals are implicated as a risk factor for developing disease.) Pressurized whey still isn't available commercially. "That's something we're looking into," says Kubow.

"My colleagues and I have shown there is great potential for considerable benefits for cystic fibrosis, chronic obstructive pulmonary disease, irritable bowel syndrome and post-surgery recovery. There's a real range of diseases that we think would benefit from pressurized whey."

D "Do you want fries with that?" That's a discussion best kept between you and your bathroom scale. But if you *do* indulge in that crispy, golden deliciousness, you might as well get as many nutrients out of it as you can. Vijaya Raghavan, professor in the Department of Bioresource Engineering, is exploring new processes for extracting good nutrients from food-processing waste products, like vegetable and fruit skins. Those skins — particularly **potato skins** — are loaded with nutrients that fight microbes, carcinogens and cholesterol — yet the Canadian food industry rejects more than two million tonnes of skin each year. Working with Stan Kubow and Danielle Donnelly (Department of Plant Science), Raghavan has been experimenting with microwave-assisted extraction techniques that quickly and selectively dislodge the useful nutrients, minerals and vitamins from the bio-matrix. The nutrient-loaded extract could then be sold as a stand-alone supplement (Valérie Orsat, also in Bioresource Engineering, is working on a spray-drying technique to encapsulate sensitive bioactive compounds such as vitamins and phytonutrients to maintain their viability), or added back into foods — even the same French fries or potato chips that lost their skins in the first place. ■

They've studied some of the world's most congested cities. Now researchers in McGill's Faculty of Engineering are using that experience to make traffic of all kinds move more smoothly through Montreal's streets.

Streets

Future Streets

By Katherine Gombay

Until there's teleportation, we'll have to deal with traffic. City planners around the world are increasingly under pressure to set in place transportation policies that will directly reduce greenhouse gas emissions. Now McGill researchers in the Department of Civil Engineering and the School of Urban Planning, both part of the Faculty of Engineering, are using that wealth of experience to bring sustainable transportation planning and engineering to Montreal's streets.

Effective transportation planning begins by understanding the people actually being transported. City planners would certainly have an easier time if they could simply force people to use certain routes and certain kinds of transportation — but, of course, that's not feasible. Instead, in order to make long-term decisions about transportation and traffic, they first need to gather information about the elements that play into an individual's choice about what kind of transportation to use. And this is where Naveen Eluru can help. A recent addition to the Department of Civil Engineering, the assistant professor became interested in transportation modelling because it allows him to use his love of math to solve real human problems.

Eluru collects data on individual travel information (such as where people are going and how they're getting there). By collecting such detailed data from just five per cent of the population within an urban region, he is then able to use complex models to make predictions about travel choices for the population as a whole. This information can then be manipulated to help city planners understand how individual travel choices might change if policies were set in place to encourage certain kinds of transportation choices and discourage others.

"We can look at what will happen if there is emissions taxing, for instance, where you charge a certain price for every kilometre people travel in their cars to see whether that will work in reducing the number of kilometres people drive," Eluru explains. "Or what if we improve public transportation so that people only have to walk half a kilometre to the bus and we have more frequent service — will this increase the number of people using public transportation? If you want to understand how much money to invest in transportation you need to look at policies where increasing transportation affects actual ridership numbers and reduces automobile usage."

Ahmed El-Geneidy, an assistant professor in the School of Urban Planning, has had the chance to work on these issues directly while helping to reshape one of Montreal's busiest bus routes. Working with the Société de Transport de Montréal (STM), El-Geneidy and his students used GPS systems and passenger counters along with rider surveys to redesign the No. 67/467 route which transports nearly 40,000 passengers each day. Both buses follow the same route, but whereas the regular bus (No. 67) has 40 stops that are spaced about 400 metres apart, there are only 15 stops on the express bus route (No. 467), and the distances between them stretch to over a kilometre in some cases. "We estimate time savings in the order of 10 per cent," says Paul Tétreault, a graduate student who worked with El-Geneidy on redesigning the route. "The methodology we developed could be used to put in place other limited-stop routes on heavily used bus lines and improve transit service." Thanks to the reduced number of stops, the express bus also has lower carbon dioxide emissions — a change that helps all of us breathe a little easier.

In addition to studying Montreal's mass transit, El-Geneidy is also interested in the city's two-wheeled commuters. Bicycling is no small thing in Montreal, which was recently named the eighth-most bike-friendly city in the world by Copenhagenize, a Danish urban-planning group that specializes in cycling culture. (The top two cities, not surprisingly, were Amsterdam and Copenhagen. Montreal was the only North American city in the top ten.) Montreal has a bike-sharing program, named Bixi, that now boasts 40,000 members, and more than 500 kilometres of urban bike paths that the city plans to double by 2020. But El-Geneidy wants to know exactly how all these cyclists are using the city — so he talked to almost 3,000 of them.

El-Geneidy and co-author Jacob Larsen, a PhD student, used an extensive survey to create a detailed analysis of how Montreal riders use the city's cycling facilities, be they on-street or off-street paths. The researchers gathered detailed origin-destination information, as well as data about specific routes used by cyclists, to under-

Smart

stand the relationship between travel patterns and the availability of cycling facilities. Among their conclusions, the researchers found that recreational cyclists are more likely to use physically separated paths than their hardcore brethren — yet it's the latter who are riding much greater distances in the city. With the city of Montreal wanting to double its existing cycling facilities by 2020, the study warns of a tough choice: Attract more occasional cyclists by building expensive separate paths, or cater to the higher-mileage needs of the city's serious cycle-commuters by building more on-street bike lanes?

Luis Miranda-Moreno may not have the answer to that particular question, but he's certain of one thing: Cycle tracks greatly improve cyclist safety — and safety is very much on Montrealers' minds after two cyclists were killed by cars within a 48-hour period last summer. Miranda-Moreno is a professor in the Department of Civil Engineering at McGill. He has been working with Montreal city officials, as well as with representatives from Quebec's Département de la santé publique, to try to make Montreal safer for cyclists.

Miranda-Moreno and his students have created a mobile safety lab to monitor non-motorized transportation. Using a range of sensors and a GPS traffic-tracking system, they collect data about the way that pedestrians and cyclists are currently using the city streets. What they've discovered is that bicycle paths are overflowing, and that, despite the large numbers of cyclists on many streets, traffic lights are still mainly synchronized to car speeds. He thinks that should change.

Miranda-Moreno suggests that on streets where there is more bike traffic than car traffic, lights should be adjusted because cyclists are more likely to stop at red lights when green lights are lit for adequate stretches of time. "Synchronization is critical," he says. "In Europe, they're trying to accommodate pedestrians and cyclists, to reduce traffic delays not only for vehicles, but for everybody."

Of course, traffic light timing isn't only of interest to cyclists. In order to understand how changes in the timing of lights might affect traffic flow, Montreal city planners have called on the expertise of Marianne Hatzopoulou, another recent addition to McGill's Department of Civil Engineering. Using a tool that looks a bit like a 3D Etch-a-Sketch in action, with lines and icons of different colours moving across the computer screen, Hatzopoulou and her students are able to create very complex traffic simulations.

Using satellite imagery, the team builds a grid of the existing streets in a borough. They then add a second layer to the grid, showing all the intersections, with details about each traffic light, right down to how much time each light is green, amber and red. The third layer, which is based on hard data such as traffic counts, adds the pedestrians, the cyclists and the cars to the model. "We're simulating the entire Montreal Plateau neighbourhood and you can see every single car stopping at intersections, then moving and turning," says Hatzopoulou.

Using the grid, Hatzopoulou can then simulate how traffic flow will be affected if a stop sign is added in one place, a bike lane is added somewhere else, or if the cycle times of certain traffic lights are changed. On the screen, the multicoloured lines and icons representing streets, cars, pedestrians and bicycles re-etch themselves as the researchers make changes to the data. "It's the work of a lifetime building this kind of tool," explains Hatzopoulou. "We keep adding to it and making it more realistic."

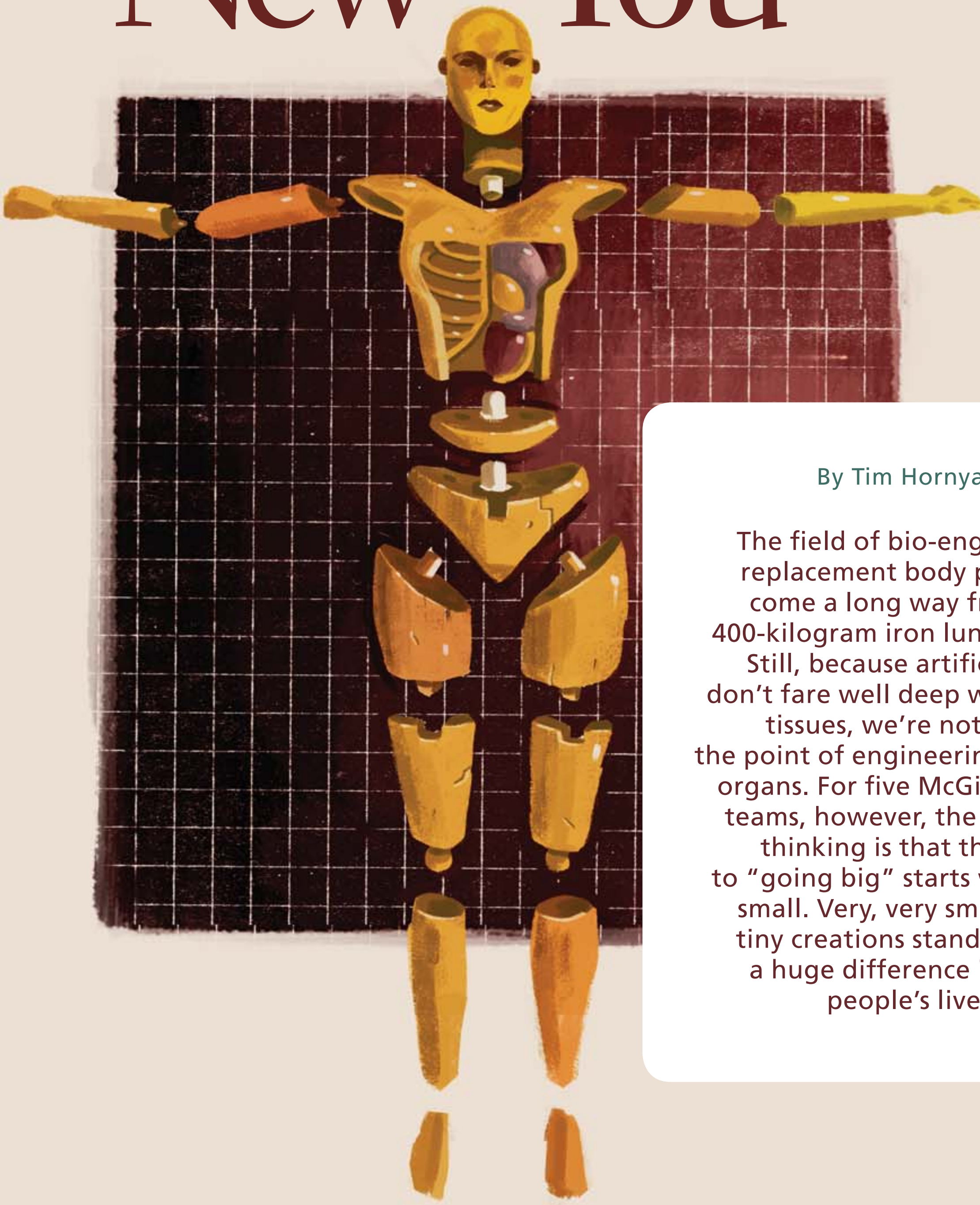
But this isn't just about helping people get from Point A to Point B in a more timely fashion. Traffic flow has a direct effect on the quality of our air. "One significant variable in air pollution is the way that you're driving your car," says Hatzopoulou. "Idling, stop-and-go driving and aggressive driving all result in higher emissions of air pollutants. We will be looking at both the traffic and the generation of car emissions to see how we can optimize the system and reduce emissions. The Plateau is a good case study because these are dense neighbourhoods with lots of people living and moving around on the streets."

But it's this very density of housing, businesses and population that is partly responsible for the problems with the urban air quality. "Because you have tall buildings on both sides of a street, you limit the dilution of air pollution caused by traffic," says Hatzopoulou. She is also quick to point out that this means, ironically, that the people who are helping to reduce air pollution — pedestrians and cyclists — are also the ones sucking most of it into their lungs. So Hatzopoulou and her students are also doing some monitoring of pollution levels around the city in order to characterize the air quality at street level.

Hatzopoulou and her team will continue to add to the model, and she hopes that other Montreal boroughs may eventually want to use it to help them make changes to their respective traffic patterns. But she cautions that the model is not about predicting the future. Instead it's about testing the effects of different traffic scenarios. "The model is not going to tell the policy-maker what to do. It's just another voice around the table," she says. But it's a voice that Montreal Plateau policy-makers believe will help reduce traffic problems and air pollution, and they're listening hard to what it has to say.

■ *This research receives funding from the Natural Sciences and Engineering Research Council of Canada and the Canada Foundation for Innovation.*

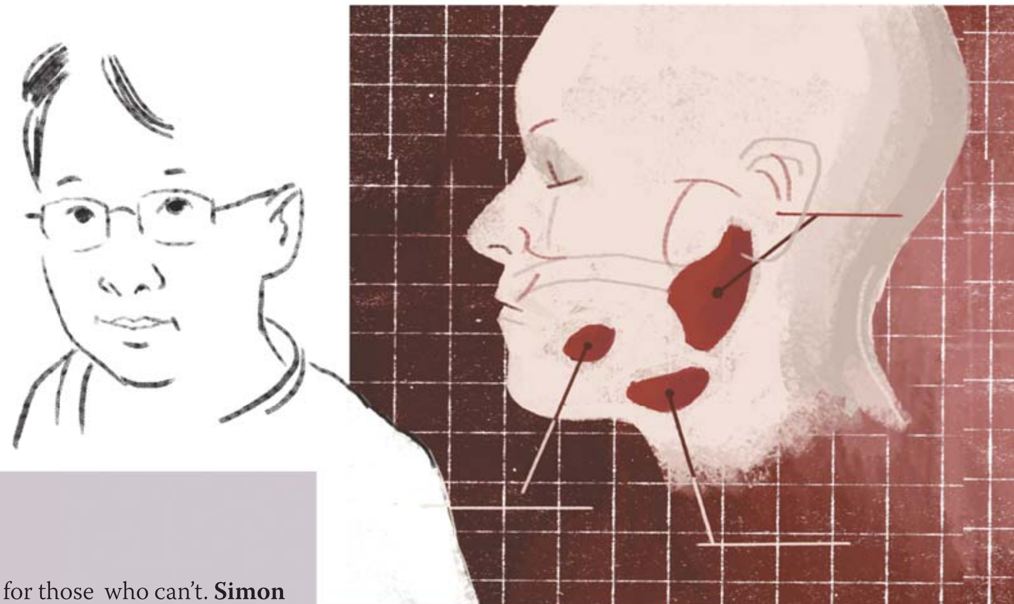
Making a New You



Illustrations by Matt Forsythe

By Tim Hornyak

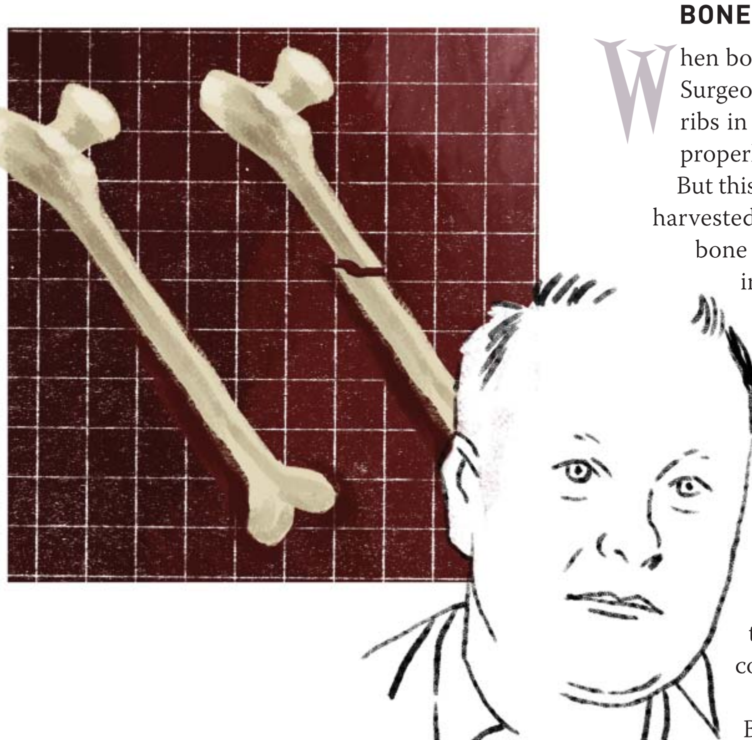
The field of bio-engineering replacement body parts has come a long way from the 400-kilogram iron lungs of yore. Still, because artificial cells don't fare well deep within large tissues, we're not yet at the point of engineering big-ticket organs. For five McGill research teams, however, the collective thinking is that the path to "going big" starts with going small. Very, very small. Their tiny creations stand to make a huge difference in many people's lives.



SALIVARY GLANDS

The next time you spit, spare a thought for those who can't. **Simon Tran** of the Faculty of Dentistry has spent years thinking about how to help thousands of people suffering from severe dry mouth, loss of taste or mouth ulcers. There are several possible reasons behind these conditions (the most common are head and neck cancer, and their attendant radiation treatments, and the autoimmune disease Sjogren's syndrome) and one common reality: There is no effective treatment. Tran is researching how to fix salivary glands with a two-pronged approach — by using bone marrow stem cells, and by bio-engineering new salivary glands. In the first approach, Tran has tested bone marrow cells for their ability to restore saliva flow in mouse models. He has also confirmed that human stem cells can repopulate salivary glands in leukemia patients. The mechanism, however, remains unclear.

"The next step is to understand how the bone marrow stem cells provide this therapeutic effect of restoring saliva flow," says Tran, who successfully cultured functional human salivary cells in 2005. Meanwhile, he and colleagues have built a prototype artificial salivary gland, and have managed to coat it with human salivary cells. Formed from a biodegradable substrate, the device is like a tube containing salivary cells, and would rest in a surgically created pouch in the mouth. They are now undergoing the tricky business of testing how well the seeded cells move water — a crucial step in saliva production. ■ *Simon Tran is the Canada Research Chair (CRC) in Craniofacial Stem Cells and Tissue Engineering.*



BONES

When bones become fractured or diseased, a graft may be in order. Surgeons often use "autograft" bone from a patient's own hips or ribs in the hope that the transplanted bone will reform and heal properly.

But this procedure isn't a panacea. The amount of bone that can be harvested is limited and numerous complications can arise; when bone from cadavers is used, it carries the risk of generating an immune response. The Faculty of Dentistry's **Jake Barralet** is developing materials to replace bone auto-graft. He's concentrating on 3D graft printing using equipment similar to an inkjet printer. Materials such as calcium phosphate are deposited in layers, forming a 3D shape. The process includes the use of ions such as copper to stimulate tissue repair.

"Biomaterials is like cooking—there is a finite number of ingredients and one becomes very skilled in squeezing new flavours and textures from them," says Barralet. "We also have the skills and experience to take our discoveries through to practice and have an excellent technology conversion rate."

McGill has licensed the technology to biotech firm Bonegrafix, which aims to make solid bone blocks based on patient CT scans, to fill in holes in bones or to bind parts during healing. The commercial application may be an early step on the road to widespread clinical use. "One day in the near future, just as custom crowns and bridges are made for your dentist, so custom bone grafts will be available too."

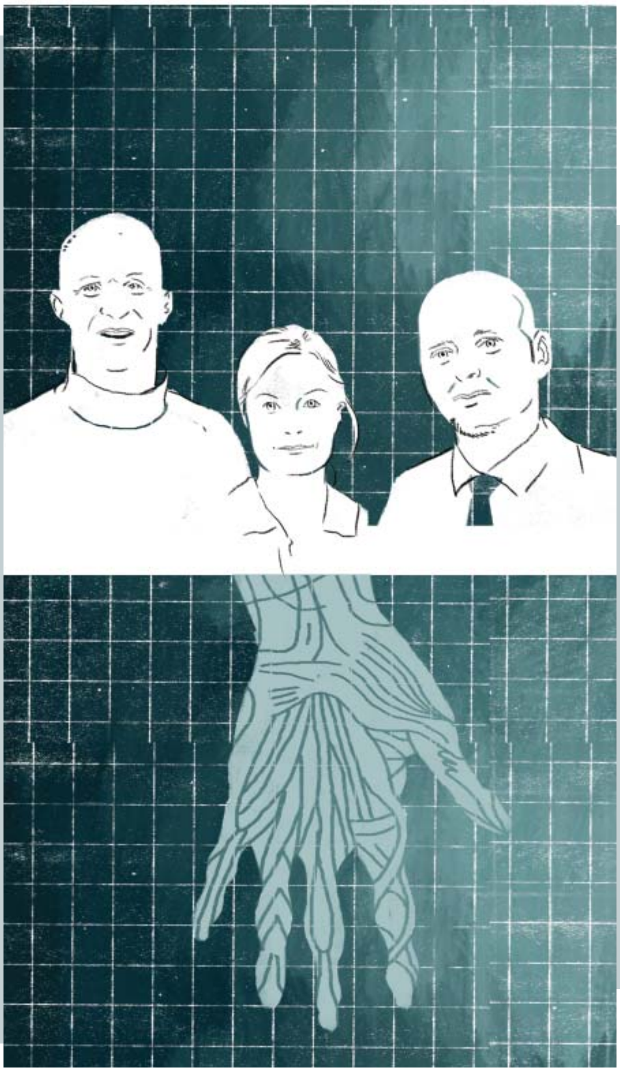
Jake Barralet is the CRC in Osteoinductive Biomaterials.

LIGAMENTS, BONE AND CARTILAGE

If we're to custom-make replacement tissue, it makes sense to start with collagen, the dominant supportive protein found throughout the body. Collagen hydrogels are already widely used in tissue engineering, but researchers **Marc McKee** and **Mari Kaartinen** of the Faculty of Dentistry and **Showan Nazhat** of the Department of Mining and Materials Engineering are looking into how to quickly form dense nanofibrillar collagen matrices—and then strengthen them by biochemical cross-linking, seed them with a patient's own cells and, ultimately, anchor them (by calcification) where they're needed in the body. The technology could be used to replace ligaments, bone and cartilage, as well as to produce graft materials to treat bone and tooth defects (whether the result of trauma, cancer or cancer treatment).

"You can't improve on biological evolution, but if you have a body part defect, you can make a bio-engineered replacement exactly to the right specs and not rely on another patient or harvesting replacements from other body sites," says McKee. In vivo studies in animal models are still underway but, because collagen is a widely used and approved material for implantation into patients, the research could have human clinical uses in as little as five years. "By increasing the amount and quality of protein, we can produce a physiologically relevant matrix with increased mechanical competence," says Nazhat. This durable end product, he hopes, will hold up to being handled, and sutured, by surgeons. "I'm not claiming we're making perfect ligaments, for example, but what we're making is something that will ultimately lead to a lifelike tissue."

This research is funded by NSERC.

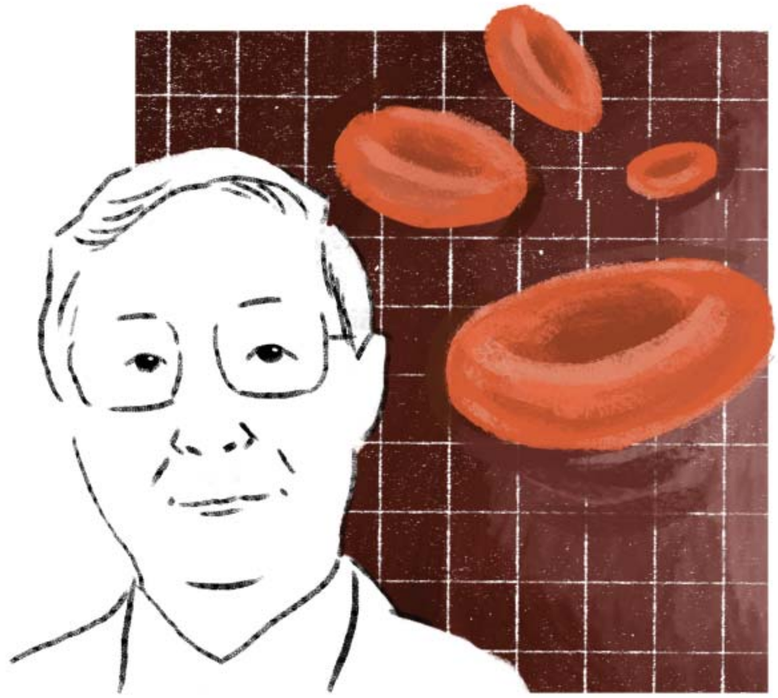


BLOOD CELLS

In 1957, while still an undergraduate, **Thomas Chang** invented the world's first artificial blood cell — in his McGill dorm room, no less. His ingenious creation was a cell-like ultrathin polymer membrane that held hemoglobin. But the world wasn't particularly interested in artificial blood cells at the time, so Chang largely shifted his concentration onto artificial cells that could be customized to contain other substances: enzymes, drugs and a host of other materials used in medicine and biotechnology. That research formed the basis for micro- and nano-systems (used in everything from regenerative medicine to gene therapy to drug delivery) that are being explored around the world. But, as HIV became a global health concern, Chang returned to his original blood work. And with good reason.

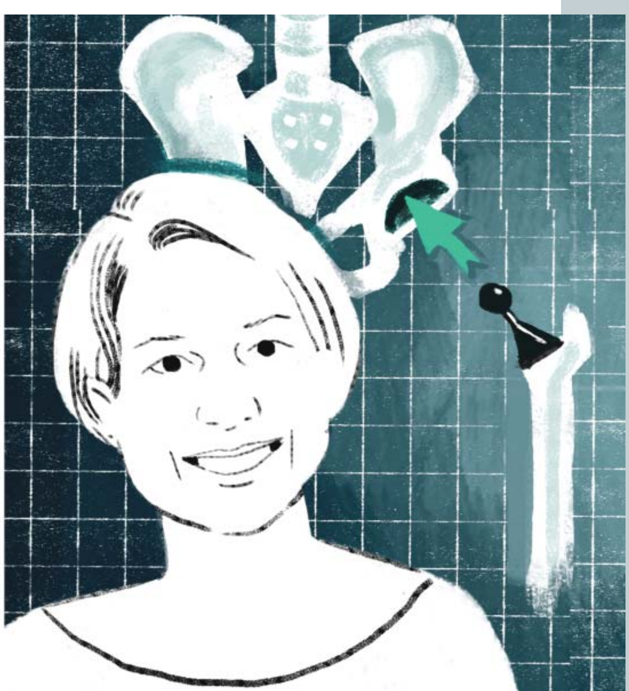
The HIV-tainted blood crisis of the late 1980s made Chang acutely aware of the need for a better artificial blood cell. In the understandable rush to create an alternative blood source, industry focused only on creating a substance that transported oxygen; the result was an imperfect product that led to serious side effects (such as constricted blood vessels) and even death. Chang, director of McGill's Artificial Cells and Organs Research Centre and a recipient of the Order of Canada, is focusing on developing a blood substitute with all the functions of red blood cells — not just oxygen-carrying capabilities. By building on his original method of cross-linking a number of hemoglobin molecules together into soluble nanodimension polyhemoglobin, he's creating cells that carry carbon dioxide as well as oxygen, and remove oxygen radicals, among other functions. These "PolyHb" cells do not have a blood group, which means they can be given to a patient immediately without knowing their blood type — and, in an emergency situation, can delay the need for donor blood by up to 12 hours. The cells can also be stored at room temperature for more than a year. Donor blood, in contrast, must be refrigerated—and, even then, only lasts for 42 days. South Africa has approved PolyHB for routine use in patients and Russia has more recently followed suit. North American approval is still pending.

■ *This research receives funding from the Canadian Institutes of Health Research and Quebec's Fonds de recherché Santé.*



BIODEGRADABLE SCAFFOLDS

When all goes well, an implant, be it a replacement hip or a tooth, readily integrates into its new host. But when things go awry, the implant causes discomfort or infection, and may need to be replaced. According to **Marta Cerruti**, success (or failure) hinges on what hap- pens very early on. "Within a few minutes of an operation, proteins start to adhere to the surface of the implant," explains Cerruti, an assistant professor in the Department of Mining and Materials Engineering and the newly appointed Canada Research Chair in Bio-synthetic Interfaces. "If the right proteins adhere, then all is well. But if the wrong proteins adhere to the implant, the body forms a fibrous capsule around the implant to isolate it and a new implant needs to be inserted."



Cerruti wants to find a better way for implants—whether for bone or soft tissues—to integrate within people's bodies. The answer, she believes, lies in building functional, biodegradable scaffolds using a combination of organic materials and polymers. "The difficult part is directing the cells to do what we want them to do, whether that's making skin or making bone," she says. "The synthetic material should be able to communicate to the living, biological material how to react."

Each porous scaffold surface is covered with molecules particular to the task at hand; a bone implant, for example, would require molecules that encourage the formation of hydroxyapatite, the mineral component of bones. As the point of first contact between the host body and the implant, these molecules would act as biological signals and attract the desired type of proteins and cells. Then, when their work is sufficiently underway, the scaffolds simply dissolve away. (A skin implant scaffold might dissolve after a few weeks. For a longer process, like growing new bone, the scaffold would stay intact for months.)

"We don't want to just hope that the body will do what we want it to," says Cerruti. "We're *directing* it to do what we want it to by making materials that speak the body's language."

■ *Marta Cerruti is the CRC in Biosynthetic Interfaces.*

Burn, Baby, Burn

Converting waste matter into biofuel is one thing. Building machines that can efficiently use these new fuels is quite another. Researchers in McGill's Alternative Fuels Lab are working on getting the next generation of engines off the ground.

By Sylviane Duval

The Macdonald Engineering Building infamously burned to the ground in 1907. But now, over a century later, nobody minds that Jeffrey Bergthorson and his team like to play with fire in the safe confines of their newly renovated lab on the building's first floor. The researchers carefully blend the right mix of fuel and air to create small, flat flames about three centimetres in diameter. Then they use laser diagnostics to probe the combustion chemistry of different fuels. These flames are the Number One apparatus of the Alternative Fuels Lab.

The Number Two apparatus is no less unexpected: a tube containing a mix of fuel and oxidizer through which they blast a shock wave that raises the temperature of the fuel so it catches light. With this, they measure the time it takes for the mixture to ignite.

"Nothing in here looks like a jet engine," smiles Bergthorson, who is an assistant professor in the Department of Mechanical Engineering. "But these apparatus allow us to study the fundamental principles that precede engine design."

Bergthorson is part of a cross-Canada team, led by McGill plant science professor and Green Crop Network director Don Smith, that's working on developing new kinds of fuel and the engines that can burn them. The project, called Canadian Research Integration and Innovation in Biofuels Sustainability (CRIIBS) is one of the short-list finalists in the Government of Canada's 2012 Networks of Centres of Excellence competition, which supports promising collaborations between researchers and industry. (The winner of this significant funding will be announced in the spring.) Instead of processing crops that could be used for food, they're developing ways to turn waste, such as wheat straw, corn stover (leaves and stalks) or even wood salvaged from demolished buildings, into fuel. (Growing crops aren't out of the picture entirely though: CRIIBS is also looking at the energy potential of "purpose-grown biomass" — things such as willow trees or fast-growing grasses that aren't edible and don't require prime agricultural land.) Bergthorson's expertise, however, is in the combustion, not the creation, end of things: Once you've created a biofuel, how does it burn? And how can engine design be tweaked to get a bigger waste-into-energy bang for the buck?

When Bergthorson was completing his PhD at Caltech during the early 2000s, the "burning" questions in aerospace technology related to advanced high-speed propulsion and, therefore, combustion. Before turning his attention to how alternative fuels might benefit the commercial aviation industry, he studied supersonic combustion for hypersonic aircraft.

Jet fuel is strictly regulated. It must meet strict standards for energy content per litre, composition, viscosity, surface tension and other physical and chemical properties — tough criteria that make it impossible to use oxygen-containing biofuels such as ethanol or first-generation biodiesel in aircraft. As well, the industry has put its foot down on the stratospheric cost of retooling the fuel supply system at airports and upgrading the global airline fleet for non-compatible fuels.

The combustion engine isn't going away. "Renewable source or otherwise, jet fuel has got to be a hydrocarbon similar to petrofuel," says Bergthorson. "There aren't any disruptive technologies because nothing else has the high power-to-weight ratio or the necessary energy density. Hydrogen takes up too much space, and the power density of batteries is too low. There isn't going to be an electric jumbo jet."

The question is not *whether* alternative fuels burn — we already know that any hydrocarbon burns in the heat and pressure of an engine. It is *how* they burn… the way their physical and chemical properties affect the performance of the engine…and *what* comes out of the proverbial tailpipe.

One issue is materials compatibility. Alcohol- or vegetable-oil-based biofuels, for example, are corrosive and can wreck rubber seals by changing the way they swell. (It's serious business: The space shuttle *Challenger* tragedy was caused by rubber seal failure.) Another issue is physical properties. A biofuel with a different viscosity than petrofuel will spray into the engine differently, change how the fuel and air mix and, therefore, affect combustion. Both are problems for Bergthorson's collaborators at other universities.

Bergthorson himself is experimenting with different blends of alternative fuels, to see what happens to the sequence of chemical reactions that converts fuel and air into carbon dioxide and water. This includes extinction behaviour (how easy it is to blow out the flame), flame speed and stability; type and quantity of emissions; fuel droplet evaporation; and reignition at low temperatures. The last point is crucially important for restarting the engine after a flameout incident at 30,000 feet.

However, lighting a small flame in a lab and kick-starting a jet engine on a runway are worlds apart. In between the two lie gas-turbine combustor experiments and the inherent complexities added by the fuel spray and evaporation processes. Instead of this, Bergthorson has adopted an experimental and modelling approach that allows him to assess the effect of industrially relevant turbulence levels on the flame without using an actual combustor — and without cramming a jet engine into his lab. The results will inform other research work to integrate alternative fuels into transportation and power-generation systems and help develop new engine designs that improve efficiency and reduce emissions.

Soaring petroleum prices, concerns over climate change, European cap-and-trade schemes that affect airlines, and the International Air Transport Association's goal to reduce its carbon footprint by 50 per cent by 2050 — it all adds up to very keen interest in research that explores bio-derived fuels that will keep costs and emissions down. Bergthorson is involved in several large-scale collaborative efforts with industry. Pratt & Whitney Canada, for one, has called on him — as have experts at Université Laval, Ryerson University, the National Research Council's Gas Turbine Research Laboratory, the Indian Oil Company, and other partner organizations and universities in India — to investigate the performance of different biofuel and petrofuel blends.

"Synthetic kerosene has been approved for use in jet engines. It meets the fuel standards but, because it is made from gasified coal, its environmental footprint is worse than petrofuel," says Bergthorson. "Bio-derived fuels are now being shown to be engine-compatible *and* carbon friendly. The industry is already certifying hydrotreated vegetable oils, thereby opening the doors for widespread adoption."

Could we also see these blends at the neighbourhood gas station in the future? Bergthorson shakes his head.

"True, we could obtain fuels similar to gas or diesel from these processes," he says. "But because they have to meet the standards for jet fuel, they need more processing and that leads to higher costs. There will be cheaper solutions for the gas tank than bio jet fuel."

In another collaboration, Bergthorson is working with Rolls Royce Canada, five Canadian universities and the National Research Council on novel fuels for gas-turbine engines.

Rolls Royce's Energy Division converts aviation gas turbine engines into power-generation systems suitable for remote or off-shore uses or for peak power generation by replacing the combustor and other key parts.

"The first two things a customer cares about when buying an engine are cost and reliability," says

Sean Salusbury

Bergthorson. "But increasingly, they are asking if they can burn this, that and the other fuel depending on what is available and what is cheapest."

The research on gaseous fuels (syngas or biogas blended with natural gas) and liquid fuels (biodiesel, alcohols and upgraded pyrolysis oils blended with petro-diesel) will provide data that will help Rolls Royce meet ever-tightening emissions standards for these engines. As a result, Rolls Royce will be in a better position to evaluate what alternative fuel mixtures will work in existing engines and what design changes can be made to next-generation engine combustors to allow further fuel flexibility.

The The Alternative Fuels Lab is funded by the Natural Sciences and Engineering Research Council of Canada, the Fonds de recherche du Québec — Nature et technologies, the Canada Foundation for Innovation, the Consortium de recherche et d'innovation en aérospatiale au Québec, Pratt & Whitney, International Science and Technology Partnerships Canada, Quebec's Ministère du développement économique, de l'Innovation et de l'Exportation, Rolls Royce Canada and Mitacs.

Whatever is going to get the airplanes of the future off the ground, says Jeffrey Bergthorson, an assistant professor in the Department of Mechanical Engineering, it will need to be chemically similar to petrofuel. "Nothing else has the high power-to-weight ratio or the necessary energy density — there isn't going to be an electric jumbo jet."

Carmen Jensen

Five Steps for Feeding the World

By James Martin

We can't keep eating like this. The United Nations' Food and Agricultural Organization estimates that, by 2050, we will have to increase food production by 70 per cent in order to nourish the world's population. Geography professor Navin Ramankutty and his team of international colleagues have a five-point plan that they think just might do the trick.

Sometime in autumn 2011, the world population hit the seven billion mark. It was a bittersweet occasion, as our growing population threatens to push our resources to their breaking point. After all, that milestone baby, along with the other 6,999,999,999 of us, needs to eat. Once you consider that the human race is set to crack nine billion by 2050, the world's collective pantry shelves are looking mighty bare.

That's the bad news. The good news is that we can do a much more efficient, and Earth-friendly, job producing the world's food. Navin Ramankutty is an associate professor in McGill's Department of Geography and a researcher in the Global Environmental and Climate Change Centre. Along with Jonathan Foley, professor at the University of Minnesota, Ramankutty is a team leader on an international research project that aims to improve food production and consumption around the world. In the October 2011 issue of *Nature*, the team—which brought together researchers from McGill, Minnesota, Arizona State University and the Universities of Bonn, California at Santa Barbara, Stockholm and Wisconsin—published a five-point guide for feeding ourselves, sustainably (see sidebar). "Solutions for a Cultivated Planet," the first in a

(Without Wrecking the Planet)

series of articles to be published in various journals over the coming months, stems from a study that pairs agricultural census data and satellite images with mathematical models of our world's crop production systems. The approach offers an unprecedented degree of geographic exactness that would have been unheard of just 20 years ago.

"We need this kind of geographically explicit data," says Ramankutty. "It's not enough to just know that six per cent of Canada is cultivated without knowing exactly where. Even today, many scholars do analysis using national statistics. So they have one number for all of the U.S., one number for all of Canada, and so on. Some may get state-level or provincial-level data. But with satellites, you can get into much greater detail; you can tell exactly where agriculture is happening, kilometre by kilometre."

By combining satellite data and census statistics, the researchers have developed spatial information on the area and yields for 175 different crops around the world. They also have climate and soil data, at the same resolution. "Now we're able to build models that relate all this data," says Ramankutty, "because we know where land is being used for agriculture, exactly what kinds of crops are being grown, how much fertilizer is being

used, how much irrigation is being applied. When we overlay all that data, we can find out exactly how much nitrogen fertilizer is being used to grow maize in southern Quebec, for example."

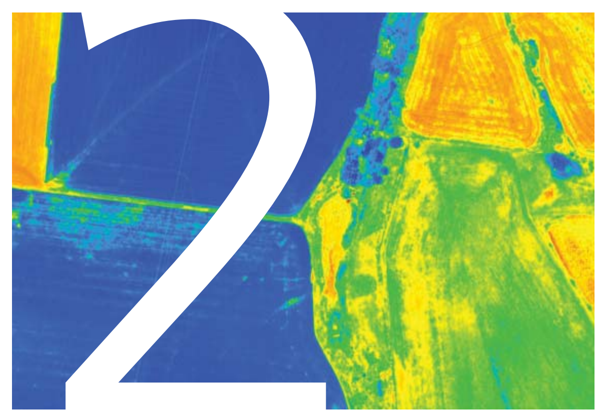
The solutions being proposed aren't new. What is new about this study, however, is its ability to quantify how much difference each change could make. "Qualitatively, we knew these things were useful, but we didn't know if they were key leverages or small players," says Ramankutty. "Would closing yield gaps solve 10 per cent of the problem or 50 per cent of the problem? For the first time, we can quantify these things. Now we know that if we make a concerted effort in the right geographic areas, these five things can play a big role in feeding the planet without destroying it."

This research was funded by the Natural Sciences and Engineering Research Council of Canada, the National Aeronautics and Space Administration and NSF International.

In their research paper "Solutions for a Cultivated Planet," Navin Ramankutty and his colleagues propose five steps for producing more food without damaging the planet:

Stabilize land in production.

Need to grow more food? Devote more land to farming, right? Wrong. "If we look at the last 40 years," says Ramankutty, "most of our increased food production hasn't come from expansion — it's come from increased intensification using irrigation and fertilizer." (A country like India, where more than half the land is already devoted to agriculture, doesn't have much room to grow anyway.) Expanding agricultural endeavours, especially into sensitive tropical ecosystems, can have a detrimental impact on biodiversity, carbon storage and the planet's general well-being. And tropical deforestation in the name of agriculture isn't just bad for the environment: It doesn't result in a whole lot of extra food. Many deforested regions in the tropics don't yield much food. (And those that have high yields are often because their crops are being used for biofuels, not food.) "Halting farmland expansion and land clearing for agricultural purposes, particularly in the tropical rainforest, will yield huge environmental benefits," says Ramankutty, "without dramatically cutting into agricultural production or economic well-being. We're not saying tropical countries can't develop, but maybe they can be compensated for limiting their expansion, through economic incentives such as the United Nations' proposed program, Reducing Emissions from Deforestation and Degradation."

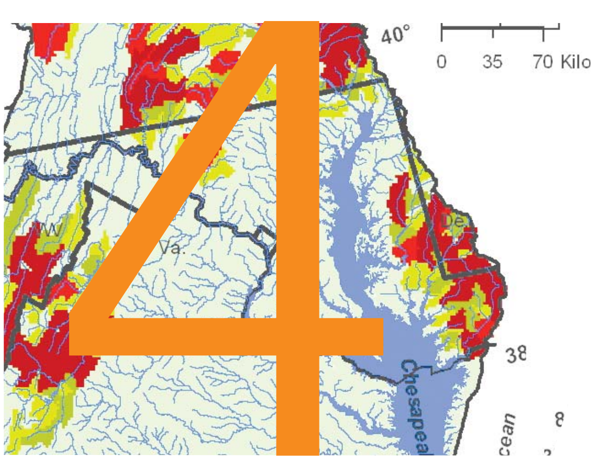


Get more out of the land.

Simply put, we could be getting much more out of the land that we're already farming. "Many agricultural regions in Africa, Asia and Eastern Europe are not living up to their potential for producing," says Ramankutty. "It's what we call 'yield gaps': when actual production is less than potential production." Better management and crop genetics would increase yields. Other factors include improved access to markets, irrigation infrastructure, fertilizers, and information. The researchers' analysis of 16 key crops shows that using best practices and technologies to increase crops to within 95 per cent of potential would add 2.3 billion tonnes of new production. The downside is increased water use, and pollution. Ramankutty suggests it is important to mitigate environmental impact by "using lessons from precision agriculture and alternative agriculture systems."

Eat less meat.

"Only 62 per cent of the world's crop production is used to produce actual food, the stuff that goes to feeding human beings," says Ramankutty. "Much of the rest goes to feeding the animals that we eat. America grows a lot of corn, but most of it doesn't become tortillas; 60 to 70 per cent of its corn goes to animal feed." It's hardly an efficient exchange: When we eat an animal, we receive only 10 per cent of the nutritional energy of all the grain that animal was fed. (We'd get ten times the energy from eating a cow's feed than we'd get from eating the cow.) Ramankutty and his team estimate that if 16 major crops were used exclusively as human food, not animal feed, global food production would increase by more than a billion tonnes (or 28 per cent) annually. "It's not to say everyone should become vegetarian," says Ramankutty, "but the amount of meat consumed in North America is huge." He notes that even smaller changes, like choosing poultry or pork — or even pasture-fed beef over its grain-fed brethren — could greatly enhance food availability and reduce the environmental impacts of agriculture.



Use water and nutrients more strategically.

Irrigation isn't a bad thing. Without it, global cereal production would decrease by some 20 per cent. But some plots aren't as thirsty as others. In fact, the researchers found that the application of water — as well as nutrients — suffers from what they call "Goldilocks' Problem": some places use too much, some places use too little, and far too few places are just right. The study identifies "hotspots" of inadequate and excessive nutrient use. "By some estimates, you could cut China's nitrogen fertilizer use by 30 to 60 per cent, to use just one example, and still get the same yield. What works in one place doesn't necessarily work in another; we need to start looking at approaches targeted to specific regions. In China, for example, maybe they need more phosphorous than nitrogen." The researchers also suggest the need for additional incentives for farmers to be more strategic in their resource allocation. In North America, fertilizer is heavily subsidized (that is, cheap) and electricity for agricultural water pumps is free in India — conditions not conducive to voluntary conservation.

Waste less.

The final suggestion may seem obvious, but would make a huge difference. One-third of the "food" produced by farms doesn't ever make it onto someone's plate. Instead, resources are being squandered on crops that end up being thrown out, spoiled or eaten by pests. In developing countries, poor storage and transportation result in the loss of more than 40 per cent of post-harvest food. Industrialized countries lose much less during production, but retailers and consumers can waste 40 per cent of food. Waste not, want not, indeed. ■

Big Lessons
(Few Words)

By Everett Martin

Founded in 1882, and now some 2,000 people strong, the Royal Society of Canada is the senior national body of distinguished Canadian scholars, artists and scientists. Each year, new Fellows are selected by their peers for outstanding contributions to the natural and social sciences, in the arts and in the humanities. On November 26, 2011, nine McGill researchers joined these prestigious ranks. *Headway* asked some of McGill's new RSC Fellows to share the single most potent lesson from their own areas of expertise — in 50 words or less:

"Numbers can be misleading and don't always tell the whole story. The worlds of families might seem constant upon first glance, and it is only through doing real investigative work that you can tease out the changes that are hiding behind the statistics."
— **Céline Le Bourdais**
(Department of Sociology), Canada Research Chair in Social Statistics and Family Change

"Creating knowledge to improve our world and our well-being requires individuals who are innovative, honest, persistent, and careful about recording their discoveries. Above all, however, success in the quest for knowledge can only come from love, for the process of inquiry itself and for those who will benefit from that."
— **Eduardo L. Franco**
(Department of Oncology and Faculty of Dentistry)

"In the study of history and culture, one must find a way to balance the parochial and the general, and, on the other hand, find a way to distinguish individuals from their group memberships. Such groupings seldom if ever act collectively as one person."
— **Gershon Hundert**
(Department of Jewish Studies)

"Avoid the trap of 'post hoc, ergo propter hoc' ('after this, therefore because of this')."
— **Dr. Michael S. Kramer**
(Departments of Pediatrics and Epidemiology, Montreal Children's Hospital)

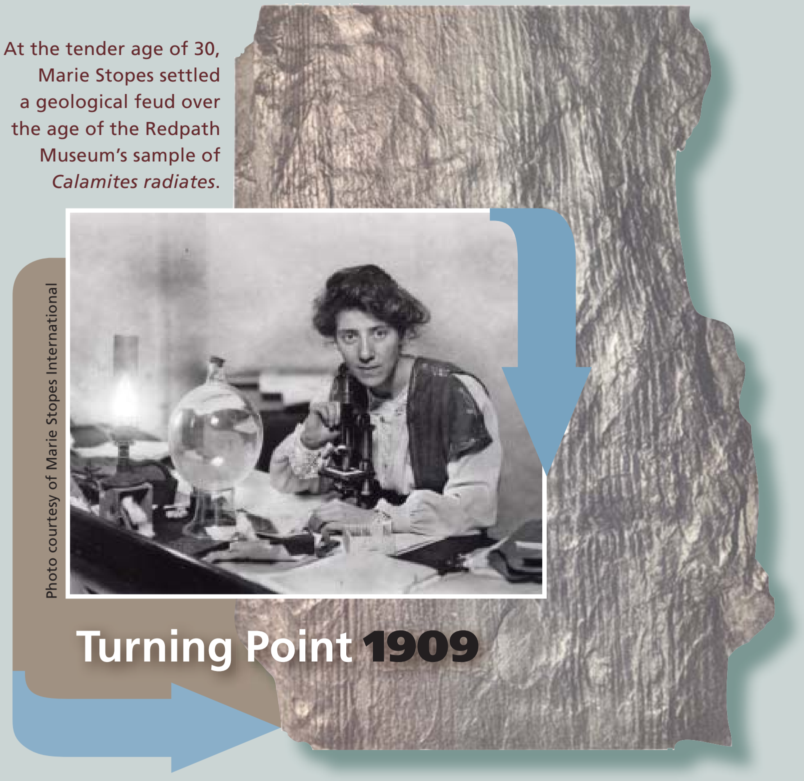
"'Take your time,' said the philosopher Wittgenstein. Humans and human institutions rush to judgment and jump to conclusions. Some are impatient to make an impact, some are arrogant and prejudiced, some confuse production with worth. In a world beset by ignorance and uncertainty — a world rather like ours — thorough reflection is vital."
— **Desmond Manderson**
(Faculty of Law), CRC in Law and Discourse. (Professor Manderson left McGill at the end of 2011.)

"Knowledge is not absolute. Science is a journey where the means justify the ends."
— **William J. Muller**
(Department of Biochemistry, Rosalind and Morris Goodman Cancer Research Centre), CRC in Molecular Oncology

Also admitted to the Royal Society of Canada in 2011: McGill researchers **Dr. Frederick Andermann** (professor of Pediatrics and Neurology and Neurosurgery, and director of The Neuro's Epilepsy Clinic and Research Unit), **Allan Greer** (professor in the Department of History and Classical Studies and the CRC in Colonial North America) and **Michael Petrides** (professor in the Departments of Psychology and Neurology and Neurosurgery, and director of The Neuro's Neuropsychology/Cognitive Neuroscience Unit). ■

Today, Marie Stopes is remembered as a pioneering sex educator. In addition to writing many books on sex, marriage and birth control, she founded Britain's first family planning clinic in 1921. (Now called Marie Stopes International, it encompasses 629 clinics in 40 countries.) But back in 1909, she was a hot-shot paleobotanist who took a McGill legend to task.

At the tender age of 30, Marie Stopes settled a geological feud over the age of the Redpath Museum's sample of *Calamites radiates*.

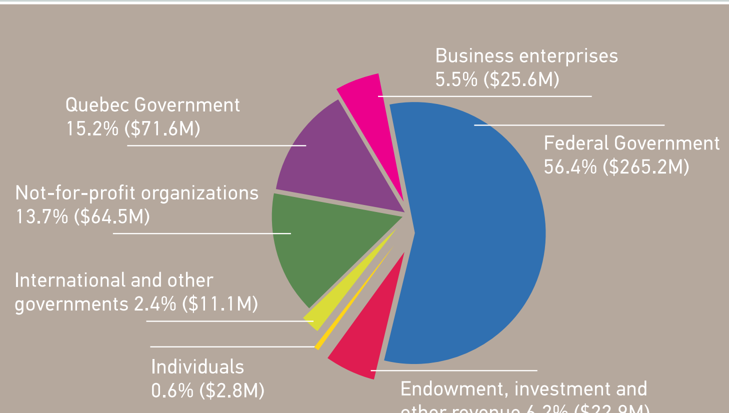


Sir John William Dawson was principal of McGill (1855 to 1893) and a dedicated geologist who made important contributions to the field — such as his discovery of fossils that helped prove the common lineage of reptiles, birds and mammals. Not all his geological insights, however, were met with universal acceptance. Case in point: fossil plants found in the Fern Ledges of Saint John, New Brunswick. Dawson dated the fossils to the Devonian era (some 360 million years old). The date was important because it suggested that associated insects, fish and amphibians were also 360 million years old — a revelation that would make them the earliest known examples of such beasts by some 65 million years. Dawson's opponents disagreed. Strongly. Scientific infighting over the matter was being increasingly played out in public, to the point that an embarrassed Geological Survey of Canada had to take action. It called in 30-year-old Marie Stopes from Manchester, England.

Stopes came to McGill's Redpath Museum in 1909 and set about examining Dawson's fossils, as well as those she had personally collected from the Fern Ledges. When she came to specimen number 3339, a fine sample of *Calamites radiates*, Stopes cried foul. Picking up her quill, she corrected the geological record with two simple words: "Not Devonian." In her 1914 memoir, published by the Geological Survey, she concluded "the Fern Ledges represent plant debris from…that period of time in the Coal Measures which is best known as the Westphalian." Dawson's detractors were right: The great man had erroneously tacked some 50 or 60 million years onto the age of the fossils.

As life would have it, the Fern Ledges project proved to be Stopes' last hurrah as a paelobotanist (albeit a very loud hurrah) and the beginning of her second career. While at McGill, she met and married Canadian geneticist Reginald Ruggles Gates. The marriage was short-lived and, one assumes, served as a catalyst for what would prove to be Stopes' life work. In 1918, she published *Married Love: A New Contribution to the Solution of the Sex Difficulties*, the first in a long series of books and activism relating to women's sexuality and health. ■

McGill's research funding sources 2009-2010: $469.729 million*



*McGill and affiliated hospitals

As Canada's R&D capital, Montreal continues to attract the world's brightest minds and has earned a global reputation as a leader in the knowledge economy.

Thanks to the visionary Knowledge Infrastructure Program, established by the governments of Canada and Quebec, McGill and Montreal's other universities and institutions of higher learning are in the process of developing many projects, creating and renewing the quality of research and development here. At McGill, KIP funding has been used to:

- Create a brain imaging centre at the McGill-affiliated Douglas Mental Health University Institute
- Make major renovations to buildings housing chemistry facilities
- Renew the life sciences facilities at the McIntyre Medical Building
- Renovate the Macdonald Engineering Building

All told, both levels of government have invested more than $300 million into Montreal's universities since 2009, creating thousands of jobs while consolidating Montreal's international position as a *ville du savoir*.

THE KNOWLEDGE INFRASTRUCTURE PROGRAM:
AN INVESTMENT IN A BRIGHT FUTURE

McGill