Fertile Ideas: Environmental Research at McGill

SOLUTIONS FOR SUSTAINABILITY
WHAT HAPPENS WHEN THE ICE MELTS?
RIDING ON THE STORM
TURNING THE TAPS ON WATER RESEARCH

ALSO:
JODY HEYMANN ON GLOBALIZATION AND FAMILIES
TOM HUDSON AND THE HAPMAP
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Message from the Vice-Principal  
(Research and International Relations)

The theme of this, the second issue of Headway, is one of the most pressing questions facing mankind: what will it take to protect and nurture our planet, for the benefit of this and future generations?

If I can presume to provide a one-word answer, that word would be passion—and it would be hard to find a more passionate group of people than the researchers whose work is described in these pages.

When I accepted the mandate of Vice-Principal (Research and International Relations) last fall, I did so because I am convinced that this university is populated by researchers who have both the capacity and commitment to make a difference to the world in which they live and work.

In these pages, you’ll meet people whose work is conducted in the lab, in the air, in the frozen north and in the hottest, poorest countries of the Earth. They may at times be separated by continents, but they are also connected by interdisciplinary and international networks. They are all also far, far removed from the fabled ivory tower of academia, where stuffy scholars reflect in privileged isolation from the mundane. Indeed, these inspiring colleagues are obviously driven by the conviction that they are privileged to be right where they are, in the thick of this challenging 21st-century world.

When this issue was conceived, it was agreed that the environment and sustainable development would be the focus of some, but not all, of the articles. When you read through it, I think you will find that, perhaps by happy coincidence, all the research covered here ultimately touches on the long-term health of our planet, of our society and of our bodies, minds and souls.

I am honoured to introduce you to these researchers, whose passion inspires both awe and confidence.

Denis Thérien  
Vice-Principal  
(Research and International Relations)
The bug is *Clostridium difficile*, also known as *C. difficile*. In one year in Quebec, it killed almost 10 times more people than died during the SARS epidemic in Toronto. It’s extremely contagious because it can live on surfaces and be passed easily through casual human contact. In its mildest form, the bacterium causes diarrhea and stomach pain. Its most toxic form can be fatal.

Now, there are new weapons in the fight against the infection. In December 2005, researchers at McGill and affiliated hospitals announced back-to-back breakthroughs to combat the dramatic increase in highly toxic strains of the bacterium in Quebec and around the world.

*C. difficile*—so named for the difficulty researchers had growing it in a laboratory setting—has been known since at least the 1930s, and was generally considered a nuisance illness affecting patients during lengthy hospital stays. However, dangerous new variants recently emerged in Canada, the US, England and the Netherlands. The Quebec strain—a nasty bug that is resistant to antibiotics, spews out 20 times more toxins than its more common cousins and is more easily spread—kills about eight per cent of those infected. *C. difficile* caused or contributed to the deaths of more than 400 Quebecers between August 2004 and August 2005 alone.

On December 12, 2005, researchers at the McGill University and Génome Québec Innovation Centre, McGill University Health Centre (MUHC) and the Jewish General Hospital announced they had cracked the genomic code of a virulent strain of *C. difficile* prevalent in Quebec since 2003. The significant breakthrough marks the first time this variant of *C. difficile* has been sequenced. The team was led by Ken Dewar, Assistant Professor of Human Genetics at McGill and an investigator at the MUHC Research Institute, and André Dascal, Associate Professor of Medicine, Microbiology and Immunology at McGill and Senior Infectious Disease Physician at the Jewish General Hospital.

Unravelling the genetic code for the microbe paves the way for faster diagnostic tests, and should lead to new treatment and prevention strategies for a strain of *C. difficile* responsible for more than three-quarters of the cases in Quebec studied to date.

A week after this genetic breakthrough was announced, a team led by Sandra Dial, Assistant Professor of Medicine at McGill and critical care physician at the Jewish General and MUHC, published research showing that drugs that reduce gastric acidity—such as heartburn medications—increase the risk of contracting *C. difficile* infections. The researchers, including Samy Suissa, Director of Clinical Epidemiology at the MUHC and James McGill Professor of Epidemiology, Biostatistics and Medicine at McGill, Alan Barkun, Chief of Gastroenterology at the MUHC, and epidemiology PhD student Chris Delaney, believe that the lower gastric acidity provides a more hospitable environment in the stomach for the bacteria to grow. In 2004, Dial and her team had shown that heartburn drugs in combination with certain types of antibiotics increased the risk of developing the bacterial infection. Antibiotics had been the only medication found to be a factor previously.

Dial’s study, published in the *Journal of the American Medical Association*, was the first to show a significant
increase in *C. difficile*-associated infections acquired outside a hospital setting. More than 70 per cent of people in the community with these infections had not been admitted to hospital in the past year. Surprisingly, they also found that patients in the community who develop *C. difficile* are less likely to have been exposed to antibiotics than patients in hospitals. Until the publication of the findings, *C. difficile* infections had been thought to be acquired almost exclusively in a hospital setting.

The sequencing of *C. difficile* was supported by funding from Génome Québec and Genome Canada, the Lady Davis Institute for Medical Research and the Jewish General Hospital Foundation, and the Genome Sequencing Center at the Washington University School of Medicine. Research on *C. difficile* and heartburn medications was funded by the Canadian Institutes of Health Research (CIHR), the Canada Foundation for Innovation (CFI) and the Fonds de la recherche en santé du Québec (FRSQ).

Dr. André Dascal, Associate Professor of Medicine, Microbiology and Immunology at McGill and Senior Infectious Disease Physician at the Jewish General Hospital

This Algorithm Will Get You Moving

A mathematician and a musician, Godfried Toussaint is as at home using algorithms as he is keeping the beat at Sunday afternoon percussion jam sessions on Montreal’s Mount Royal.

The McGill professor of computer science has combined his twin passions of computational geometry and percussion and applied some cold calculations to the steamy Spanish flamenco.

With funding from the Natural Sciences and Engineering Research Council of Canada, Toussaint turned the rhythms guitarists keep in their heads as they play or those counted out by the hands and feet of the dancers into patterns. He compared the patterns of different dances, the buleria, solea, seguiriya, guajira and the fandango—the purported granddaddy of the flamenco—and tracked their evolution with bio-informatics, much as scientists use DNA to look at the different molecular patterns of species.

By matching patterns, he found they all traced back to the fandango from the city of Huelva in Andalusia, something that had been part of the local history but never proven mathematically.

Dr. Sandra Dial, Assistant Professor of Medicine at McGill and critical care physician at the Jewish General Hospital and MUHC

Computer science professor Godfried Toussaint, shown here in concert garb, applies cold calculations to the steamy art of flamenco
Roadwork on Memory Lane

Memory alteration has been the inspiration for many a science-fiction movie, from Star Trek to Total Recall. McGill psychology professor Karim Nader has brought the concept to real life. Nader recently found that propanolol, a drug normally used as a blood pressure medication, could ease the intensity of painful memories such as those experienced by patients with post-traumatic stress disorder (PTSD), but will not alter memories that provide context to the event in question.

That means a soldier being treated for PTSD may be able to lessen or dispel the image of losing a buddy in battle, while still being able to retain details like where he was when the traumatic event occurred.

After conducting experiments on rats, Nader, whose research is funded by CIHR, and colleagues from McGill and Harvard obtained results that suggest that recalling a memory produces changes only in its content, rather than wholesale changes. The work explains why each time a memory is retrieved and updated, none of the other memories indirectly associated with it is altered.

Nader’s previous work showed that when you remember memories, they have to be restabilized in order to persist. If you block this consolidation mechanism, then the memory is functionally no longer there. According to Nader, it is possible the initial findings, which were described in the journal Nature in 2000, inspired the 2004 film Eternal Sunshine of the Spotless Mind.
Data Laboratory a Goldmine of Stats

Researchers who rely on statistical data to draw connections, challenge assumptions and discover unexpected social links in the lives of Canadians have a new tool. The Quebec Inter-university Centre for Social Statistics (QICSS) Laboratory is an authorized repository for the reams of information gathered by major Statistics Canada surveys to help governments understand the changing nature of Canadian society and shape social policy. QICSS is funded by the Fonds québécois pour la recherche sur la société et la culture.

Sociologist Céline Le Bourdais, the Canada Research Chair in Social Statistics and Family Change, is the academic director of the lab. She says that previously, when people wanted to research the carefully guarded data gathered by Statistics Canada, they had to travel to Ottawa. This was so inconvenient that few people were using the rich information gathered in these expensive—and expansive—surveys on health, labour and families.

To protect the privacy of the thousands of individuals profiled in the surveys, the QICSS Laboratory is one of the most secure spaces on McGill’s campus, with a system of swipe cards and deadbolts to ensure that information doesn’t fall into the wrong hands. McGill’s data lab belongs to the Quebec Research Data Centre, which is jointly funded by Statistics Canada, the Social Sciences and Humanities Research Council, and the CIHR. The lab also received funding from the CFI.

McGill psychiatry professor and Douglas Hospital researcher Alain Gratton with Neurophenotyping Centre director Claire-Dominique Walker

Douglas Hospital Tackles Genes and Mental Health

For people with depression, life can be like being locked in a darkened room, unable to find a light-switch. The opening of the Neurophenotyping Centre at the McGill-affiliated Douglas Hospital will help researchers turn on the light for these patients.

These potential switches are genes, some of which can be activated through environmental factors. Genes linked to increased vulnerability to such illnesses as depression, schizophrenia and Alzheimer’s disease are prime targets for therapeutic research.

“The new centre will focus on how changes in the environment—including the air you breathe and the food you eat, as well as social interaction— influence how your genes are expressed,” says anatomy and cell biology professor Claire-Dominique Walker, director of both the Neuroscience Research Division at the Douglas Hospital Research Centre and the Neurophenotyping Centre.

The 15,000-square-foot facility in the Montreal hospital will serve 60 researchers and more than 180 graduate students and post-doctoral fellows, providing specialized animal research facilities, as well as labs for behavioural analysis, tissue analysis and genetic processing. Slated to begin construction in 2007, the centre is funded by the Ministère du Développement économique, de l’Innovation et de l’Exportation du Québec and the Douglas Hospital Foundation.

Guthrie Awarded $100,000 Killam Prize

Like so many virtuosos, Roderick Guthrie can trace his lifelong passion back to an early accident that left him bedridden. “I was quite a fan of Captain Hornblower and loved making model sailing ships,” the veteran McGill metallurgist recalled of his boyhood in England. “So, at 16, I figured out how to make my own cannon... I literally blew my own kneecap off, had six weeks off school and had to write an essay on metals. I became absolutely fascinated.”

His essay won the school contest and Guthrie pursued his passion for metal processing for engineering.

Among his other accomplishments, Guthrie, director of the McGill Metals Processing Centre, developed a technique for metal processing that has assured quality control in products worldwide from soft drink cans to refrigerators to Boeing 747's to high-performance cars.

And what will he do with the $100,000 prize? “Pay off the debts that I owe on my NSERC grants,” he laughed. “That’s what the accounting department has suggested. Then again, I’ll probably use it to pay off the mortgage.”

Guthrie is McGill’s 13th Killam Prize winner. In all, nearly one in every six Killam Prizes since 1981 have gone to McGill professors.
In many ways, it was just another music class. On November 17, 2005, Gordon Foote, professor at McGill’s Schulich School of Music, conducted a group of McGill jazz musicians, coaching and guiding their performance, nodding at a particularly well-chosen phrase, and controlling the tempo with the fluttering hands that are the arcane sign language of music. Near the end of the session, Foote picked up his sax and jammed with the ensemble. The subtle give-and-take graced the gathered audience with that one-of-a-kind creativity found only in snowflakes and live music. One small detail differentiated this jam session from any other—namely, the 3,700 kilometres that separated teacher from students.

Foote was in Seattle taking part in the prestigious Supercomputing 2005 conference, in which world experts from academia and industry gathered to discuss high-performance computers and networking, while the jazz band following his lead was playing in Montreal. The seamless transcontinental connection linking convention hall and music studio was provided by McGill’s Ultra-Videoconferencing system.

Developed by John Roston, Director of McGill’s Instructional Multimedia Services, Jeremy Cooperstock, Professor of Electrical and Computer Engineering, Wieslaw Woszczyk, founding director of the Centre for Interdisciplinary Research in Music Media and Technology (CIRMMT), and software developer Stephen Spackman, the system is one of the most advanced such technologies in the world—it won the award for “Most Innovative Use of New Technology” at the Seattle show.

“When you’re getting a panoramic view of an entire room where life-size people are in such great detail that you can count the hairs on their arms, you’re no longer thinking about the technology—now you’re interacting with real people,” says Roston.

On the West Coast, a trio of 65-inch plasma screens made convention-goers feel as if they were in the same room as the band. More importantly, Foote was able to make subtle corrections in fretting technique by what he saw onscreen—a far cry from the muddy, low-definition picture that has been the bugaboo of traditional videoconferencing.

Unlike conventional videoconferencing, which expends considerable effort trying to reduce bandwidth requirements, the Ultra-Videoconferencing system transmits data between the computers at both ends of the connection without any data compression. This helps keep the system latency—the end-to-end delay users experience—to a minimum, and allows for the natural give-and-take of conversation or musical performance.
As Cooperstock notes, for such applications, “latency is the interaction killer.”

The system sends video and audio streams back and forth between Montreal and Vancouver along the high-bandwidth CA*net 4 network, a Canadian government-funded system of fibre optic cables that zip information from coast to coast at two-thirds the speed of light. While home users of high-speed Internet typically receive three megabits of data per second, McGill’s Seattle team drew on speeds of four gigabits per second—a better-than-thousand-fold increase that can transmit the equivalent of an entire DVD of information every 10 seconds.

Although Ultra-Videoconferencing has myriad applications, including distance education, remote sign language interpretation and telemedicine, Stephen McAdams, Director of CIRMMT, has his own view of the system’s potential—one that is dear to his heart. “Our job at CIRMMT is to take these technologies and make art out of them,” he says.

In the near future, McAdams sees Ultra-Videoconferencing being used to solve an old problem in the recording industry. “The best studio musicians are scattered all over,” he says. “Soon we’ll be able to set up studio situations where guys are jamming and recording together from all over the continent.”

Further improvements will include additional cameras for eye-to-eye contact between musicians and more audio channels to enhance the surround-sound effect so that sounds will not only be transmitted in real time, but also from the direction they originated. Vibro-sensory equipment is being updated, allowing an audience to feel each clickety-clack of a tap dance troupe’s performance from a remote location. “It’s the whole notion of telepresence,” says McAdams. “We want to make you feel as if you are in the same space as the person you are communicating with.”

Major funders of the Ultra-Videoconferencing project are CANARIE Incorporated and Valorisation-Recherche Québec.

For more on CIRMMT, please see the McGill Reporter: www.mcgill.ca/reporter/38/15/mozart/
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Alone

Globalization puts new pressures on working families
In Tegucigalpa, Honduras, 19-year-old Gabriella works in a sweatshop at least 15 hours a day, seven days a week, earning the equivalent of $26 US a week. Her husband was recently robbed and killed by bandits, and her mother died of cancer. She is the only adult in her family. Her 10-year-old stepsister looks after her toddler in a tiny second-floor room, accessible only by a ladder that leans on the outside wall. If her stepsister goes back to school, Gabriella’s child will be left alone all day. If she doesn’t attend school, she, too, is destined for the sweatshop.

“And please don’t think that no family leaves a toddler alone all day,” says Jody Heymann, founding director of McGill’s Institute for Health and Social Policy and a pediatrician with a PhD in public policy. Heymann, cross-appointed to both medicine and political science, interviewed Gabriella and numerous neighbours in similar situations, many of whom had to leave their children alone all day as they worked—often with dire consequences.

“A number of the children had been killed—burned to death or killed in falls. It’s people like these who brought me into this area of research. For me, the important thing is Gabriella’s story—and how to change it.”

Heymann is North America’s pre-eminent expert on the plight of working families. In July of 2005, she came to McGill from Harvard, where for the last seven years she and her team have conducted thousands of interviews with families in the United States, Mexico, Honduras, Botswana, Vietnam and Russia, analyzed survey data from households in eight countries and reviewed laws and labour codes in 170 countries. The results were published this year in Forgotten Families: Ending the Growing Crisis Confronting Children and Working Parents in the Global Economy (Oxford University Press).

“While conditions are worse in developing countries, core issues are universal,” says Heymann. “Working parents the world over must find child care during the day, especially when a child gets sick. When I present our research without country identifiers, experts sometimes can’t tell if data is from Mexico, Vietnam or Canada.”

The developed world doesn’t necessarily have more developed social policies. For instance, Vietnam has made a commitment to early childhood education and has legislated sick leave for parents of children under age seven. As a result, fewer parents leave sick children home alone in Ho Chi Minh City than in Baltimore.

Many of the problems facing poor working families stem from the fact that major social changes occur without the public policy adjustments that are needed to cope with the resulting upheaval. This past century has seen first the mass entry of men, then women, into the industrial and post-industrial labour force, and increased urbanization, which has taken people away from extended families. So far, Heymann says, social policy has not kept pace with the transformation in how society looks after families.

“These changes have yielded greater opportunities to escape poverty and increase gender equality, but they have also transformed how we care for children and the elderly,” says Heymann. “Policies haven’t evolved yet, but that doesn’t mean they can’t. Workable solutions do exist. For example, Quebec has an early childhood care program which is remarkably effective in reaching large numbers of kids.”

By documenting what needs to be done and which social policies actually work, Heymann hopes her research will make it out of the university and into the hands of decision-makers. Already, her research on working poor families in the United States has helped reach those who need it most, providing the academic weight to the push that led to the country’s first paid sick leave legislation, in California.

Heymann has seen poverty close up in places as diverse as New York City, rural Tanzania and Central American refugee camps. “Once you live in these places and meet the people there, you can never forget how important it is to work for change,” she says. “You also realize that the most effective programs are always collaborative. You’re always learning as much as you’re giving. If you’re not learning, I don’t think you can be helpful.”

Dr. Heymann is the Canada Research Chair in Global Health and Social Policy.

Core issues are universal. When I present my research without country identifiers, experts sometimes can’t tell if data is from Mexico, Vietnam or Canada.

— DR. JODY HEYMANN
They’re the star-crossed couple of the business world. The nattily dressed manager and the rumpled computer expert come from different backgrounds and often seem to speak different languages. When they work together, beautiful things can happen for a business. When the two don’t communicate well, their misunderstandings can lead to disaster.

Enter Professor Geneviève Bassellier, a specialist in information systems at McGill’s Desautels Faculty of Management. In her research, Bassellier acts as a marriage counsellor of sorts between the suits and techies, helping them understand one another and build a stronger, healthier relationship.

One needn’t look far to see the consequences of poor communication. Bassellier cites the example of a major American university that spent several million dollars on an enterprise resource planning system before realizing that it was completely unsuitable for the day-to-day needs of the school’s students and employees.

“Information technology (I.T.) people and business people need to learn to talk to each other more, and that’s where bridging the gap comes into play,” she says. The two groups “have their own culture, they have their own vocabulary and jargon. They just don’t communicate well, as each thinks they can do everything on their own. Nowadays, you need I.T. and business to work together to leverage the opportunities offered by information technologies.”

Bassellier’s interest in effective I.T. practices started well before she began her PhD at the University of British Columbia. Growing up, she heard first-hand about the challenges of adapting management practices to take advantage of new technology from her father, who worked to bring modern I.T. to the Montreal borough of Saint-Laurent.

These experiences and her own research have led Bassellier to believe above all that the creation of “common space” between I.T. and business is crucial for effective information systems within an organization. Now she is
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sharing her insights with her students at the Desautels Faculty of Management, where she has taught since 2001, as well as with professionals.

While the challenge of fusing I.T. and business practices has interested management theorists for some time, Bassellier’s goal was to quantify precisely what knowledge needs to be shared between I.T. professionals and managers, and how that shared competence can improve a firm’s capacity for innovation and profit.

Funded by the Social Sciences and Humanities Research Council, Bassellier has worked with 17 different organizations, including financial institutions with up to 57,000 employees, government agencies with 7,000 and utility companies with as few as 200 staff. She has administered hundreds of employee surveys to better grasp how managers and I.T. professionals understand each other’s roles within their business.

She learned that I.T. professionals who were knowledgeable about other parts of the business were more inclined to partner with managers. As for managers, those who had a strong understanding of I.T. were 34 per cent more likely to be good “spouses” and understand the needs of their partners by scouting out and championing new information technology.

In part, these results confirm Bassellier’s belief that the cultural divide between information technology departments and other areas of a business can—and should—be bridged. She advocates a hands-on approach to give I.T. an appreciation of the larger goals of a business. According to Bassellier, these practices—such as having an I.T. person work in a marketing department—can augment more traditional strategies such as “seeding the line,” in which upper-level managers are drawn from I.T.

“It is so important to develop a common knowledge, a common space. Your I.T. staff will not master finance and your finance people will not become I.T. experts, but there will be a common place where the needs of the institution can be defined.”

I.T. is from Pluto

Management professor Geneviève Bassellier hopes to make managers and I.T. professionals better understand one another’s needs.
Extreme weather researcher takes to the air to help those on the ground cope with the vicissitudes of the elements.
Wings crippled by ice, a small plane battles to stay aloft in the skies over the Magdalen Islands. A lightning strike forces a white-knuckle landing on a small runway in the Sierra Nevada Mountains. Somewhere over the raging Atlantic Ocean, wet snow seizes an engine. Hairy situations, to be sure, and Ronald Stewart survived them all. In fact, the professor with the Department of Atmospheric and Oceanic Sciences is a veteran of more than 1,000 flight hours in stormy weather. “But it’s not about thrill seeking,” he’s quick to clarify. “It’s about science.”

As the Natural Sciences and Engineering Research Council (NSERC) Industrial Research Chair in Extreme Weather, Stewart wants to learn the “missing physics” behind catastrophic weather events that cause untold misfortune — even if it means taking planes into the heart of a raging storm. The “flying laboratory,” owned by the National Research Council, lets Stewart and his team customize their flight path as a storm evolves, enabling them to capture real-time temperature, wind, precipitation and moisture data that are simply unattainable from the ground.

In addition to projects that will take him to Iqaluit in 2007 to examine changing weather patterns in Canada’s North, Stewart is working with the Institute for Catastrophic Loss Reduction (ICLR), a research centre spearheaded by Canadian property and casualty insurers, to study the physical mechanisms of winter precipitation. The reasoning is simple: increase understanding and you increase prediction accuracy. Increase prediction accuracy and you give people more warning to protect themselves and their property from harm. Decrease destruction and you decrease insurance pay-outs, a billion-dollar lesson the insurance industry learned all too well from the catastrophic ice storm that crippled parts of Eastern Canada in 1998.

The kicker? Slight deviations in atmospheric temperature or moisture during that storm would have prevented all that freezing rain—and loss.

“It very easily could have been an ice pellet event in Montreal instead,” Stewart muses, “which isn’t a trivial thing, but the devastation wouldn’t have been nearly that of the ice storm.”

By bringing on-the-spot scientific observation to forecasting, Stewart hopes for accurate predictions of freezing precipitation, as well as what percentage will take the form of freezing rain, ice pellets or wet snow. Such information would help, say, Transport Canada more efficiently select the fluids used to de-ice airplane wings. (Not all fluids are equal: ice pellets, for example, severely dilute freezing rain de-icers.) “It would save money,” says Stewart, “but it would also save lives.”

The only thing worse than too much precipitation is not enough of it. Raised a Manitoba farm boy, Stewart calls the 1999–2005 prairie drought that caused billions in lost crop production and immeasurable psychological devastation “possibly the worst natural disaster Canada has ever had.” The phenomenon was particularly bewildering because there was almost as much moisture in the atmosphere as in less arid years—it just wasn’t making its way to the ground. As founder and co-leader of the new Drought Research Initiative network, he’s working with various agencies (including the Canadian Wildlife Service, Alberta Environment, Saskatchewan Watershed Authority and Manitoba Hydro) to unmask the physical features of that dry spell, and better understand drought mechanics in general.

Last year, forecasters were calling for yet another parched summer—right up until floods ravaged southern Alberta. Improved predictions could allow farmers to plant drought-resistant crops (wheat, for example, instead of canola) and help hydro companies better manage their water resources. Mental-health experts also feel that understanding the meteorological reasons behind dry seasons might help families cope better with the emotional fallout of decimated livelihoods.

“I’m a physicist trying to understand how things work. Call it a tipping point or a threshold, but we’re trying to zero in on the preciseness of what makes one condition—whether that’s ice pellets or drought—occur and not another,” says Stewart, adding, “We’re not trying to solve all the world’s problems, we’re just trying to add insight that will contribute towards making communities less vulnerable and more resilient.”

Ronald Stewart’s work is funded by NSERC, the Institute for Catastrophic Loss Reduction and Environment Canada.
McGill researchers confront
the world’s challenge of living
with limited resources

By Mark Reynolds
The country has just emerged from the warmest winter on record, according to Environment Canada. With temperatures nearly four degrees above normal averages, it marks the highest temperature spike experienced in any season—spring, fall or summer. Winter 2005–06 joins a parade of eight years of higher-than-average temperatures in Canada.

None of that is proof of global warming, but it is one more frightening piece of evidence that the world’s population is going to have to learn to live within the means of a planet that might not look quite the same in a few decades.

Here at McGill, researchers are confronting one of the greatest challenges facing the world today: how to live sustainably on a planet with limited resources, where our activities and industry can have far-reaching and unforeseeable effects on the climate and environment. And while researchers might differ in the details, they are in full agreement that solving the problem will mean examining our policies, reinventing technology and even rethinking how and where we live.

Sustainability—the ability to reduce inequality and provide for our needs without leaving future generations unable to provide for theirs—is a growing concern of scientists, academics, politicians, business executives and others across the globe. This recognition of the scope of the problem is reflected at McGill, where environmental research is fast becoming the Green Giant on the University’s two campuses, whether through the study of how forests react to ecological pressures or through helping developing countries absorb the masses of rural poor flooding their cities.

Much of the effort is aimed at rising global temperatures caused by greenhouse gases, summed up as climate change, three syllables which promise a variety of ills including melting polar ice caps, flooding in some areas, widespread drought in others and wholesale ecosystem change worldwide. Some of the largest sources of these gases are the industry, transport and power plants that define life in the developed world.

The single biggest initiative to prevent this global transformation is the United Nations Framework Convention on Climate Change, known as the Kyoto accord. The Kyoto accord commits signatory countries to reducing emissions of gases like carbon dioxide and methane. The protocol has been widely criticized as ineffective for many reasons, only one of which is the failure of the world’s biggest greenhouse gas emitter—the United States—to ratify the treaty.
TILTING AT WINDMILLS

The critics might have the right idea, according to McGill economist Chris Green, who says that while there is a general consensus on the nature and rate of climate change and its causes, there is far less agreement on what it will take to put the genie back in the bottle. Green is interested in the technological and economic ramifications of pursuing various solutions to “stabilizing climate.” He started as a public finance and industrial organization economist, but in the late 1980s his work began to move toward the economics and technology of mitigating climate change when the then chair of economics asked him to represent the department at a climate change talk organized by the Department of Atmospheric and Oceanic Sciences.

Intrigued by what was happening in the field, Green became a charter member of McGill’s Centre for Climate and Global Change Research, which has now been transformed into the Global Environmental and Climate Change Centre, funded in part by the Fonds québécois de la recherche sur la nature et les technologies. Not all of what he has to say is welcome to environmental activists. “What many activists are saying is that it wouldn’t be difficult to limit emissions sufficiently to stabilize climate. I think that this is terribly wrong,” he says.

Green argues that many existing technologies, like solar or wind power, are simply not reliable enough to produce the large-scale energy supply to displace fossil fuels. “We know how to catch solar and wind, but until we have a way of storing them on a large scale, their direct and intermittent delivery to the grid in significant amounts would produce blackouts. In effect, the cure would be viewed as worse than the disease,” he says.

Solutions like the Kyoto accord, which sets a deadline for countries to meet emissions reduction targets, are actually a part of the problem, according to Green. To meet their targets, countries are forced to put resources into short-term approaches that have little impact on a problem of this scale. “We send Rick Mercer out to promote the One Tonne Challenge (to reduce personal energy use),” says Green. “How anyone can take this seriously, I don’t know.”

A better approach, according to Green, is to research and develop innovations that, although less predictable in time and outcome, would in the long term make alternative energy sources viable. Currently, solar, wind and the large-scale use of biofuels like ethanol are problematic. Nuclear can contribute, but its large-scale expansion faces a variety of limitations that will require some technological breakthroughs.

“Biomass is being hyped beyond belief—it gets a tremendous amount of attention because it supports agriculture and sounds so green. But unless you can reduce the energy input in producing the fuel itself, there are little or no energy savings.”

THE ENGINE OF CHANGE

Plant science professor Don Smith is well aware of the limitations of biofuels, but his approach to solving the problem is close to Green’s prescriptions. As leader of a national plant sciences network, Smith is coordinating the work of 55 researchers from 13 universities. Sponsored by BIOCAP Canada, a foundation funded by the Natural Sciences and Engineering Research Council and other federal agencies, provincial governments and industry partners, the network has a goal of researching ways to reduce greenhouse gas emissions from agricultural activities.

Smith describes this work as “upstream” from the Kyoto accord. In other words, where Kyoto focuses on reducing greenhouse gas emissions at the end of industrial or energy
production, his work is looking to find ways to reduce them at the beginning: from the production of the fuel itself.

As a result, Smith’s laptop is full of graphs and facts that would be more in keeping with an oil company executive than a plant science expert. His charts show that global production of petroleum fuel is peaking now, and it is unlikely that new reserves will reverse what will soon become a downward trend. Alternative fuels are therefore not simply ecological good sense—theyir development will be key to maintaining our economic well-being.

Already, biofuels are seeing more use in industrial countries, which Smith points out is actually a back to the future scenario: the first diesel engine and early Ford cars were designed to run on peanut oil and ethanol, respectively. But now, the energy input to create such biofuels as ethanol can be too high to make it a viable alternative.

Although Smith is optimistic about the potential benefits of biofuels, given current technologies and attitudes towards energy consumption, there are limits to what can be achieved. “If you covered all of the area of Europe with these crops, you’d only provide about half of the total energy needs the continent currently gets from fossil fuels—that’s only so far you can go with this,” he says.

New biofuel technologies are only a part of what Smith and his colleagues hope to accomplish to help Canada meet its emissions-reduction targets. Agriculture is a major source of greenhouse gases, from plowing, fertilizers and even some of the crops themselves. For Smith, this represents a potential area to make a significant dent in our emissions.

“We’re a northern country, so we produce a lot of greenhouse gases for heating, transport and the like, and something in the order of 10 per cent of that comes from agriculture,” says Smith. “With about half a per cent of the world’s population but huge amounts of agricultural land, we have this interesting opportunity in Canada.”

Smith says that Canada has released one billion tonnes of carbon into the atmosphere from soil tillage, much of that in the last hundred years. He hopes to address the problem biological processes—Nicell hopes to find natural treatments to neutralize the environmental toxins. “We’re looking to take waste materials and grow micro-organisms on them that produce the enzyme. So we’re turning the waste material into a resource, creating a high-value enzyme and adding that to the treatment system,” he says.

James Nicell’s research is funded by the Natural Sciences and Engineering Research Council of Canada and the EJLB Foundation. For more information on green chemistry please see the McGill News: www.mcgill.ca/news/2005/summer/green/
by exploring creative approaches to crop use. Through genetic manipulation and breeding, crop varieties that require less fertilizer and trap more greenhouse gases in the soil—and therefore out of the atmosphere—could be developed.

“When you push plants, you can go a long way,” says Smith.

**BRANCHING OUT**

While Smith works on ways to adapt plants to our ends, natural resource sciences professor Jim Fyles is looking at how plants adapt to change in their own environment. Fyles’s office is only a short walk down the hall from Smith’s, but his research is several hundred kilometres removed from the agricultural fields that are Smith’s concern.

As scientific director of Canada’s Sustainable Forest Management (SFM) network, a federally funded Network of Centres of Excellence, Fyles is at the heart of a collaborative research and knowledge exchange effort involving government, industry, academics, NGOs and First Nations, who are partners in the funding, planning and execution of the network’s research.

“The complexity of the problem needs different voices and approaches,” says Fyles. When the opportunity to become scientific director of the SFM came up, he took up the challenge, partly because of his experiences working at McGill’s School of Environment, where professors from different faculties bring their own perspectives to collaborate on environmental questions. With stakeholders from so many groups, the SFM network provides a similar experience.

“The whole thing is fascinating, because it’s constantly crossing cultures—between aboriginal and ‘Western’ societies, across regions, sectors and disciplines, between provinces and the federal government,” he says.

Fyles’s research focuses on the boreal forests of northern Quebec, which he sees as the canary in the climate change coal mine. “Some of the biggest stretches of untracked wilderness in the world remain in Canada in the boreal forest,” he says. “And it’s this forest that is going to see the greatest impact from climate change.”

Understanding the complex ecology of Canada’s woodlands is important to all Canadians who work and play in the sylvan wilderness, and the flora and fauna for which it is home. From an industry point of view, how the boreal forest responds to ecological pressure—whether clear-cutting, fires or insects—could have huge ramifications.

More than 350 communities in Canada are directly dependent on boreal forests. According to Fyles, Quebec and Ontario drew a line in the muskeg several years ago,

Some of the biggest stretches of untracked wilderness are in the boreal forest, and it’s the forest that will see the greatest impact from climate change.

“— PROFESSOR JIM FYLES
barring forestry activity above a set latitude in their northern forests, a ban that might not be strictly necessary if forests respond differently to disruption than is assumed. Opening up the North could be a boon for forestry—if we understand how the forest will respond to what is proving to be a complicated process of change.

The predominance of black spruce in the boreal forest over more southern varieties of trees like aspen has been attributed to subtle temperature differences: black spruce likes it cold; aspen prefers slightly higher temperatures. But Fyles has found that temperature is only part of the story—spruce thrives because of a blanket of sphagnum moss.

"If you had a fire that burnt right back down to mineral soil, you'd probably have an equal chance of aspen or black spruce establishing themselves," he explains. "But if the sphagnum moss comes in first, it produces this thick organic matter that insulates the soil and is very acidic"—conditions the aspen hates. When the boreal forest and its sphagnum moss are disrupted by logging roads, the aspen will follow the new tracks far into the North, flourishing alongside the black spruce. This suggests that we will have to look a lot harder to see the forest for the trees.

"The response of the ecosystem to climate change is way more complex than a simple 'It's colder up there,'" he says. Fyles suspects climate will play an important role, but not just on the trees. An increasingly warmer northern climate will cause organic matter to decompose faster, meaning it will insulate the soil less, which will in turn retain less water. Fire patterns will change as a result. Fyles says fires—more than temperature or even logging—are the greatest ecological driver in the boreal system. This will have a large effect on the forest ecosystem. Small changes in climate, acting on a complex system, may lead to large changes in the landscape.

**GARDEN CITY**

While Western governments juggle the political and policy dilemmas of protecting future economic growth without destroying the Earth's ecological balance, the developing world is struggling with more basic questions of how to sustain life now. Worldwide, the number of people living in cities has increased to 47 per cent from 14 per cent a century ago. Much of this migration has happened in poorer countries that lack the infrastructure to cope with these new arrivals, many of whom end up in shanty towns, which lack such basic services as sewage and water systems.

Vikram Bhatt is developing a solution to help cities cope with the myriad problems associated with such poor neighbourhoods while allowing residents to create their own wealth.

Called "Making the Edible Urban Landscape," Bhatt’s project is associated with the School of Architecture’s Minimum Cost Housing Group, and has participants from both Architecture and the McGill School of Environment, as well as the Resource Centres on Urban Agriculture and Food Security in the Netherlands. The International Development Research Centre and the United Nations Human Settlements Programme (UN-HABITAT) Urban Management Programme funded the project, which is working with cities in Asia, Africa and South America to develop neighbourhoods and upgrade existing squatter settlements to incorporate small-scale agriculture so residents can grow some of their own food and sell the surplus.

"Cities need not just be places of consumption. Why ship vegetables thousands of kilometres when we can grow a lot of them here?" says Bhatt.

Working with UN-HABITAT, he solicited applications from cities around the world that demonstrated a commitment to the project. Colombo (Sri Lanka), Rosario (Argentina) and Kampala (Uganda) were selected.

In conjunction with local officials and residents, graduate students developed designs for the different challenges faced by the three neighbourhoods. While the shantytown in Colombo was established decades ago, the area in Kampala is a former brickyard that the local government now wants to make habitable. The Rosario neighbourhood is scheduled for major infrastructure upgrades that will change the face of the current development.

Each required a very different approach to incorporate Bhatt’s ideas of an “edible landscape.” Kampala is working on plans to use the non-potable water that has collected in the former brickyard’s trenches for irrigation, while the cramped alleys of Colombo will require rooftop or wall-based gardens suspended on trellises.

“Our belief is that people are already engaged willy-nilly in growing, so why not integrate it into design?” says Bhatt. “In the scriptures, Paradise was a garden, and a good neighbourhood should be like that—flowers, greenery and fruits.”

For more information on climate change research at McGill please see the McGill Reporter: www.mcgill.ca/reporter/35/09/c2gcr/
Winds

Top: PhD student Jill Lambden braves – 40°C temperatures as part of her work with human nutrition professor Harriet Kuhnlein.

Above: Wildlife biologist Murray Humphries paddles past a beaver dam on the Whirlpool River in Manitoba as part of his research on species migration.
As the country shakes off its white blanket of winter and emerges, blinking and grateful, into the warm sunlight of spring, most Canadians are happy to swap their toques for T-shirts. But while their peers are locating their sunscreen, many researchers at McGill bundle into their woollies and chase the receding frontier of snow into Canada’s Arctic, joining colleagues who visit the North year-round for their research.

The image of the stark, unchanging landscape of the North is firmly lodged in the imagination of Canadians as a part of our national identity. In reality, it is undergoing dramatic transformation, in both environmental and human terms. Understanding the nature of these changes is as pressing a need for the people who live in the farther reaches of the country as it is for everyone else.

PLUMBING THE ICY DEPTHS

The frozen North holds keys to understanding climate change, and geology professor Wayne Pollard is digging deep to find them. From early spring to late summer, Pollard, an ice archaeologist in the Department of Geography, may be found drilling in the permafrost at McGill’s High Arctic Research Station on Axel Heiberg Island in the Arctic Ocean.

“A lot of the ice is thousands of years old, so we can use it to interpret what the climate was like. Ice is a reflection of history,” he says. “Understanding the history is important for prediction models.”

More than 50 per cent of Canada’s land mass is frozen year round, to depths of up to a kilometre. Knowing how much ice is present under the surface is a first step in predicting what type of changes will occur above ground as temperatures rise.

“As permafrost melts, it will expose the ice, which will also melt; landslides, big holes and depressions will occur. Stable ground will become unstable. The area will look as if somebody went over it with a bulldozer,” says Pollard.

This cartographer’s nightmare has a huge impact for northern communities: in the Yukon, Dawson City’s municipal works budget has increased by 50 per cent, in part due to damage caused to infrastructure by shifting permafrost. If the melting continues, the streets of towns like Dawson City could become impassable swamps dotted by islands of half-sunken homes.

As part of the ArcticNet research consortium that evaluates the impact of this change on northern communities, Pollard might help stem the mucky tide. With funding from the Canadian Institutes of Health Research (CIHR), the Natural Sciences and Engineering Research Council (NSERC) and the Social Sciences and Humanities Research Council (SSHRC), ArcticNet is developing models to predict the amount of erosion and better understand the impact of climate change on northern people.

The increasing impermanence of permafrost will have effects beyond broken sewer lines in the North. The frozen soil of the Arctic is a giant cold-storage unit of centuries’ worth of natural and unnatural contaminants like soil carbon and mercury. Once the permafrost breaks down, it opens a Pandora’s icebox, releasing these substances into the environment. Using a shallow drilling technique developed by PhD student Nicole Couture, Pollard’s team is measuring carbon levels in the ground of Axel Heiberg.

The wind-lashed lands at the latitude of the island are hostile enough to life to qualify as Arctic desert. But surprisingly, beneath the surface, the permafrost is home to billions of micro-organisms, which thrive in unimaginable cold and darkness. Environmental microbiologist Lyle Whyte’s research team is studying these strange and little-known organisms in the hope of discovering novel microbes that will give us a greater understanding of the low-temperature limit of microbial life on earth.

Whyte’s work is funded by NSERC, the Canada Research Chairs program and the Canada Foundation for Innovation, as well as the Canadian Space Agency and NASA—which are interested in the Far North because its harsh environs are an excellent stand-in for the frigid and barren surface of Mars for testing technology. He focuses on bacteria...
growing in two specialized environments: those that live in cold saline springs and those in the permafrost on Ellesmere Island. The high salt concentration—up to seven times that of seawater—in the springs means the water never freezes, even though the outside temperatures may reach –50ºC. Even more remarkable is that Whyte and PhD student Nancy Perreault have detected never-seen-before micro-organisms that produce hydrogen sulphide and methane, while others may be using those compounds as energy.

Permafrost micro-organisms could have a real impact on the environment, especially climate change. “It is possible that following permafrost melting, the activities and populations of these bacteria will increase. They will produce more methane and/or carbon dioxide, creating a positive feedback loop on global warming,” says Whyte.

**ANIMALS ON THE MOVE**

Warmer temperatures will also have an effect on the larger creatures that make their home in the North. The margin of survival is razor thin in the harsh northern environment, making animals there especially vulnerable to climate change. Wildlife biologist Murray Humphries studies mammal ecology and physiology in Canada’s North, but the experience of working in the Subarctic goes beyond simple science for him.

“Technically, beaver are a boreal species surrounded by trees, but they are way up into the tundra landscape, in a narrow band of alder and willows along the rivers,” says Humphries, who is funded by NSERC, SSHRC and ArcticNet. His students are doing surveys to predict how far north Canada’s national rodent will get, and how quickly.

This migration might seem like a good thing—the animals are, after all, expanding their range to thrive in new environments. On the other hand, it amounts to your neighbour moving into your house because you set the thermostat higher. Beaver, along with red fox and moose that have also settled in like unwelcome guests in the living room of the caribou and polar bear, are effectively invasive species in their new environments. This infiltration of the North is an acceleration of what has been happening since the glaciers retreated, which Humphries says may be related to the onset of increased industrialization.

“Everything adds up pretty strongly that we have unprecedented rates of warming and acceleration of warming trends that are due to anthropogenic gas emissions in the atmosphere.”

This territorial change of northern animals also concerns Harriet Kuhnlein and Grace Egeland, who are both affiliated with the McGill Centre for Indigenous Peoples’ Nutrition and Environment. They are encouraging communities in the North to rely less on store-bought “southern” food and more on traditional food harvested from the land, which Kuhnlein says the local population deeply appreciates.

“Work on traditional food systems resonates well with communities, and especially with those still closely linked with their traditional food system,” says Kuhnlein.

Delicacies like musk-ox steak are not something shoppers will find in the local IGA. Store-bought food might be more convenient than the traditional methods of hunting, but
Egeland says that “market food has more trans- and saturated fat, lots of refined carbohydrates and less protein, and the usual shopping cart doesn’t include many fresh fruit and vegetables.” However, all recognize that market food is here to stay, and that better quality food in the stores, more income and wider education are all needed to use it in ways that don’t have negative effects on people’s health.

A diet composed mostly of today’s store-bought food is causing higher rates of cardiovascular disease and diabetes, especially in younger individuals, as well as iron and vitamin D deficiency. According to Kuhnlein and Egeland, both of whom are funded by CIHR, many essential nutrients and vitamins are contained in the staples of northern cuisine. Whale skin, for instance, has levels of vitamin C equivalent to those of oranges, and dried whale meat has more iron than any food on record, according to Kuhnlein. Together with Inuit and Gwich’in communities, she and Egeland are developing plans to make traditional food more available to the community and to create education programs—including radio broadcasts—to encourage people to “eat North.”

The pressures that make it difficult to cook a nutritious meal are the same for parents in the North as they are for those in the South. With the competing demands of work and school schedules, sometimes it’s impossible to resist the temptation to throw some Kraft Dinner in the pot and call it supper, rather than chase down some caribou. Kuhnlein is hoping that northern community spirit might provide a solution. “We are exploring with the communities the possibility of having communal hunters who are compensated for their effort, and communal freezers where the meat can be stored.”

McGill’s northern researchers all speak poetically of the vast beauty of the North, the wilderness and the northern lights. And while Egeland may have come for the research, she has learned some unexpected skills to take back home, citing a meeting she had with community leaders on Baffin Island.

“It started with small talk on our families, the weather, the upcoming fishing derby and so on. Then the mayor abruptly switched gears—decisions were made quickly and decisively. I really admire that Inuit style—I wish I could transport some of that down South.”

For her part, Kuhnlein has developed some pretty exotic tastes from her northern travels. “You’ll never forget caribou stew once you taste it.”
Turning the Tide on the World’s Water Crisis

Brace Centre researchers plunge into water issues at home and abroad
The world’s population has doubled since 1960. The water supply has not.

The United Nations Environment Programme predicts that in 25 years, more than half the world’s population will struggle with water shortages—with no part of the globe left unaffected. Already, international conflicts abound over shared water resources like the Nile. Rising sea levels precipitated by global climate change threaten to spoil freshwater sources in low-lying countries like Bangladesh. And one needn’t look further than the *E. coli* outbreak in Walkerton, Ontario, to appreciate the deadly consequences of a compromised water supply.

If water proves itself “the oil of the 21st century,” as so many people believe, researchers at the Brace Centre for Water Resources Management at McGill University believe now is the time to think seriously about the wet stuff, even in Canada, a country (once) known for abundant, sparkling rivers and lakes.

“Canada has 15 per cent of the world’s water supply, but we’re not wise stewards of water,” says Chandra Madramootoo, founding director of the Brace Centre and Dean of the Faculty of Agricultural and Environmental Sciences.

“The city of Montreal, for example, has one of the world’s highest water-use rates for a city, and water levels in the Great Lakes and St. Lawrence Seaway are getting so low that it’s hard for ships to navigate.”

The Brace Centre is drawing together agricultural, environmental and engineering experts to ensure the world’s finite water resources don’t dry up. Thanks to a bequest from the late Major James Henry Brace, a civil engineer who spent much of his career building water-related projects, the original Brace Research Institute was founded in June 1959 as part of the Faculty of Engineering. The Institute’s research mandate concentrated on making dry land agriculturally viable. Forty years later, the Institute joined forces with the Faculty of Agricultural and Environmental Sciences’ Centre for Drainage Studies. The Brace Centre was born, and with it a research focus on the control of water quality and a renewed drive to change the way we think about water.

“What we want to do is educate people,” says Madramootoo, “both in Quebec and internationally, about the need to conserve and protect water, the need for clean water and how we can maintain that clean water.”

*By James Martin*

Camels walk past a ship that rests on what was once the floor of the Aral Sea. Poor water management has devastated the region.
These multiple streams of research flow well into the Centre’s Lake Champlain project. Phosphorus levels in Lake Champlain—a 1,130-square-kilometre body of water straddling Quebec, Vermont and New York—and its Missisquoi Bay are of particular concern. While phosphorus helps plants grow on land, unnaturally high levels of phosphorus in the water cause excessive aquatic plant growth, including toxin-producing blue-green algae, which throw the entire ecosystem off balance. The main contamination comes from manure on nearby farms, from which phosphorus travels through the soil and into watersheds.

For the past five years, the Brace Centre has deployed engineers and environmental scientists, health specialists and climate modellers to the Missisquoi Bay to tackle the problem at many levels. First, the team maps, then ranks, the extent of phosphorus pollution in various parts of the bay to identify watersheds contributing most to Lake Champlain’s contamination.

At the next stage, that information feeds into field investigations. Using state-of-the-art soil probes and water-sampling equipment, the team measures how the level of pollution differs according to type of crop, soil and climate. Intensive analysis of the problems found in the field moves the research up to the next level: developing hydrological models and computer simulations.

The knowledge gleaned from the theoretical models doesn’t stay locked on the researchers’ hard drives for long. It’s used to help make practical changes benefiting the region. “We’re going one more level up to figure out best management practices to reduce pollution,” says Madramootoo. “We’re working with watershed councils and agricultural producers to put remedial measures and water-quality treatment mechanisms in place—and going back into the field to evaluate the efficacy of those mechanisms.”

Once the polluters are identified, the researchers can suggest precise changes at the level of individual farms. According to Nathalie Tufenkji, a Brace professor and a Canada Research Chair in McGill’s Department of Chemical Engineering, such changes might include something as simple as deciding how much manure can be safely spread at a certain distance from a water source. Tufenkji is a chemical engineering professor who is just beginning a three-year study of the mechanics of how various organisms interact with different soils to determine potential for contamination.

“Not all pathogens behave the same, especially in different soil types,” she explains. “Are they being retained in the gravelly soil but not in sandy loam? Are they being washed away into the rivers or groundwater? Understanding this behaviour is crucial to stopping the pollution.”

**MANY STREAMS OF RESEARCH**

Falling under the jurisdictions of Quebec, Vermont and New York, Lake Champlain serves as an apt metaphor for the local and global importance of clean water, as well as the Brace Centre’s international vision. The Centre’s researchers are working with the Lake Champlain Research Consortium, Quebec’s Ministère du Développement durable, de l’Environnement et des Parcs and the Vermont and New York departments of agriculture—they’re even using satellite images from the US National Oceanic and Atmospheric Administration in their modelling.

“It’s gone from a provincial to a national to an international level of collaboration right here in our backyard,” says Madramootoo. “We’re working with stakeholders in Quebec, but the impact of that research is international. We’re working at the full spectrum, from the field level right up to government ministerial level.”

The research flowing from the Brace meets a deep thirst for water management expertise all over the world. In addition to a decade-long investigation into how Egypt can conserve and reuse irrigation water, Brace is active in five former Soviet Central Asian republics. For the past five years, the Centre has trained people in Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan to use water wisely during the region’s dry season. Fifty years ago, the Aral Sea was the world’s fourth-largest inland body of water. Decades of gross water mismanagement, however, took a horrible toll, reducing the sea’s volume by 75 per cent and tripling its salinity. The Aral Sea will never return to its former glory.

“It just sort of collapsed,” says Donald Smith, an associate Brace researcher and James McGill Professor of Plant Science. “The Russians expanded the irrigation system substantially in the ’50s to grow cotton. It’s a high-value crop—‘white gold,’ they were calling it. But expanding the area of irrigation means taking more and more water out of the rivers.”
Smith travelled to Uzbekistan to investigate irrigation approaches that would return the most nutritious food using the least amount of water. Irrigating every other row saves 20 to 30 per cent of water without compromising the crop yield, Smith found, a reduction that is “not trivial in a place that is so water limited.” Planting drought-adapted, high-protein vegetables that thrive on low water, such as green gram, a legume indigenous to Asia, is also helping farmers adapt to the newly arid conditions.

The Egypt and Central Asia projects are close to completion, but international demand for water management will continue to keep the Brace Centre hopping. In September 2006, the Centre will offer Canada’s first Master’s in Integrated Water Resource Management. In the field, a new pilot project will explore how phosphorus-hungry reeds can safely, and naturally, filter polluted water. Smith is excited to further explore the peculiar physiologies of plucky plants. Tufenkji is beginning an examination of how nanotechnology (those super-tiny, custom-manufactured structures that are set to revolutionize everything from energy production to stain-resistant trousers) is dispersed in the environment, particularly with respect to contaminating water supplies. On a larger scale, the Brace is starting a new Canada-wide examination of water quality—funded by the Max Bell Foundation—with an eye towards encouraging good agricultural practice and penalizing pollution. And this is just the beginning.

Quebec farmers have already implemented some of the Brace Centre’s recommendations—conservation tillage, improved drainage, riparian buffer strips—but Madramootoo cautions that it’s too early to expect results. “It’s a slow process,” he says. “You need a critical mass of producers working with you. It takes 10, 15, 20 years before you see changes. That’s why it’s so crucial that we’re working on these problems of water quantity and quality right now… Open up a newspaper and you’ll see all the problems we’re working on. Phosphorus in lakes, bacteria causing the closure of beaches, Walkerton, North Battleford… “The crisis is already here.”

We’re working at the full spectrum, from the field right up to the ministerial level.

“…Dr. Chandra Madramootoo

Funding for the Lake Champlain project came from the Fonds québécois de la recherche sur la nature et les technologies. Funding for the Aral Sea project came from the Canadian International Development Agency.
Mapping the DNA of the World

McGill professor was cornerstone of international research effort to compare genomes around the globe
Like creeping ivy, a pair of sinuous DNA strands ascend a cement structural support pole that interrupts the view of the slopes of Mount Royal from Tom Hudson’s office windows. It is art with particular relevance to the life and work of the director of the McGill University and Génome Québec Innovation Centre.

Hudson received the painting as a gift from Jacques DesHaies, an artist who illustrates covers for the prestigious science journal *Nature*, which, in the fall of 2005, prominently featured Hudson’s contributions to one of the largest international scientific accomplishments of the last decade. Part of a network of hundreds of scientists from a half-dozen countries, Hudson and his colleagues in Montreal were instrumental in completing the comparative map of the human genome—called HapMap (for haplotype map)—that will allow scientists to identify genetic variants that cause disease.

When the sequencing of the human genome was completed to great fanfare in 2001, it was hailed as one of the greatest advances in our understanding of how DNA works. But it was a limited tool—the sequence was based on the code of a single individual. The next step would be to catalogue the genomes of enough individuals that comparisons could be made across the whole genome. This information would allow researchers to have a de facto “normal” genome as a model to compare with the DNA of individuals.

“So how could we look at the whole human genome from the sequence of one person? We had to create tools to scan genomes to find mutations,” explains Hudson, who also played a key role in the Human Genome Project during his time at the Whitehead Institute for Biomedical Research, which is affiliated with the Massachusetts Institute of Technology. With three billion base pairs, this would be a daunting task unless some method were found to break the genome down into smaller, yet still meaningful chunks.

The breakthrough that led to HapMap came in 2001, when Hudson and his colleagues at MIT discovered that genes linked to inflammatory bowel disease tended to mutate in predictable groups clustered together in regions.
Called haplotypes, these groups of linked variants are like bar codes that correspond to certain complex genetic characteristics. For geneticists, these groupings of genes can reduce the puzzle of genetic disease from billions of pieces to “only” 100,000 or so. Locating these bar codes was the goal of the HapMap project.

Even with the task relatively simplified in this way, the project was enormous and required contributions from an army of scientists, statisticians, ethicists and community outreach workers from China, Japan, Canada, the United States and the United Kingdom. Together, those countries contributed $180 million to see the project through. DNA was collected from donors in Africa, Asia and North America to ensure geographic diversity, and the greatest care was taken to guarantee informed consent and anonymity.

“When there’s enthusiasm for an idea, it crosses the globe very quickly. It certainly was seen to be a feasible project with, potentially, a huge impact, and a good investment for the community,” says Hudson, whose contributions to HapMap were funded by Genome Canada and Génome Québec. When the project was conceived in 2002, desire to participate was widespread. In the end, only those scientists with the greatest ability to contribute to the massive undertaking were selected. With his established record in the field and the best equipment at his disposal, Hudson and the Innovation Centre at McGill were natural choices.

“Research has gone global, and alliances are formed between groups who complement each other well in terms of expertise. All the expertise for a project like this doesn’t exist at McGill, it doesn’t exist in Boston. And it’s expensive—even the US, which has a lot of money, wouldn’t be able to fund something like this. We were able to create a mesh of labs with complementary abilities,” says Hudson.

The eventual goal of the HapMap project is to identify genetic bar codes so as to be able to characterize and potentially devise treatments for disease, work that has already begun. In addition to its utility as an analytic tool, HapMap has provided insights into the human genome on its own.

Hudson says that it was already fairly well understood that most individuals are 99 per cent identical, genetically speaking. HapMap shows that genetic variations from individual to individual, and population to population, also tend to be similar. In other words, a haplotype bar code that corresponds to curly hair will be the same whether the person was born in Beijing or Brandon, Manitoba. “It actually redefines what genome variation looks like in world populations. In fact, most variations you’ll find in
Opened in 2002, the McGill University and Génome Québec Innovation Centre, a concrete and glass monument to modern science on Montreal’s Dr. Penfield Avenue, has established itself as one of the best in the world.

Tom Hudson and his colleagues at the Centre were an obvious choice to take a leading role in the international HapMap project. The Centre has roughly 120 primary investigators associated with it, drawn from McGill faculty. In its brief existence, it has become the go-to facility in Canada for genotyping work.

The numbers are mind-boggling—more than 260 labs from across the country have used the Centre’s expertise in genotyping, sequencing, DNA and proteomics. Additional work with the Montreal Heart Institute in pharmacogenetics aims to bring genomic and proteomic developments to clinical practice.

Last year, Hudson says the Centre performed more than one billion genomics tests, worth over $12 million. Much of this revenue is invested directly into new equipment, so the Centre remains at the forefront of technology in the field. Hudson proudly asserts that it is a model for similar institutions in other countries.

When HapMap came calling, Hudson was ready. Hudson’s portion of the project required mapping haplotypes on roughly 10 per cent of the genome. The huge job went much faster because of the Illumina technique used at McGill, the most up-to-date technology in the field. Using this technique, DNA segments are tagged with synthetic markers that will bind to known portions of the DNA molecule, branding each with a particular colour. Pencil-thin devices, each containing 50,000 fibre optic filaments, can then light up these segments and isolate them. Hudson’s lab would do 1,500 tests of 25 identical segments at a time—the duplication necessary for statistical accuracy.

The HapMap goal was to be able to map out the genome to every 5,000 base pairs. That 1:5,000 degree of accuracy compares well to topographical maps, the best of which use a scale of 1:25,000. By early 2005 they had already improved on that, mapping to every 3,000, which brought the research to the end of Phase I. Those results were released in late 2005 in one of the largest articles that the prestigious journal Nature has ever published. Once the HapMap data were in, researchers at McGill were among the first to use the powerful new tool.

“We did wait for the end of HapMap to start analyzing data. Colon cancer, adult diabetes and multiple sclerosis were our three largest projects last year,” says Hudson. McGill professors are revealing the mechanisms of contagious disease using HapMap—genes linked to susceptibility to leprosy have now been identified by the research of Erwin Schurr, from the McGill Centre for the Study of Host Resistance.

Research has gone global, and alliances are formed between groups that complement each other well in terms of expertise.

— DR. TOM HUDSON

Toronto, you’ll find in Africa, and most variations you’d find in Asia, you’d find in South America.”

Hudson says this finding has some exciting implications for science. “If most haplotypes are the same across populations, then it will be the same with mutations. The things that cause asthma in North America are most likely the same things that cause asthma in Asia.”

The kind of genetic screening that the HapMap project allows can dramatically improve the survival rates for diseases such as colon cancer, for instance, where there is a 90 per cent chance of a cure if tumours are caught early. But for many people, genetic screening raises fears as to how the results will be used. Genetic screening could be used to discriminate against individuals for employment or insurance, for example. While there is a five-year moratorium in the US barring such practices, the laws in Canada are less stringent, which Hudson says has to change.

In some ways, the HapMap is already being misused—or at least misrepresented—by organizations with their own agenda. “My colleagues have been quoted in articles that are trying to justify racism. Hate groups do exist in this world, and I didn’t realize that before I saw some of these websites,” says Hudson.

“There is no such thing as race—there’s no boundary in genomics to show that one population is different from another,” he emphasizes. If anything, the HapMap results go a long way to dispelling myths about human populations, proving that our differences are even less than theorized. The research shows that, genetically, humankind is one big family.

For more information on Tom Hudson and HapMap please see the McGill Reporter: www.mcgill.ca/reporter/38/06/hudson/
Brian Alters, Tomlinson Chair in Science Education, is founder and director of the Evolution Education Research Centre, a collaboration between McGill and Harvard universities. A prolific author and award-winning teacher, he was one of six expert witnesses, and the only witness from Canada, called to the stand, testifying for the plaintiffs in the high-profile US federal trial on intelligent design, Kitzmiller v. Dover. The trial became known as Scopes II, a reference to the famous 1925 case on the teaching of evolution. In late December 2005, the judge ruled that the Dover, Pennsylvania, school board could not order the teaching of the theory of intelligent design in classes discussing evolution.

What brought you to research on evolution education in particular?

As a child I was taught that evolution was not only scientifically inaccurate, but fundamentally evil... However, while in high school, I took local community college classes where I learned the science of evolutionary theory. This caused a dissonance between what I was being taught in college versus high school and at home. I thought how incredibly interesting that so many people are so divided on the issue.

If, as you stated several times in your testimony, the scientific debate on the occurrence of evolution is over, why is it necessary to research the teaching of biological evolution?

The scientific debate concerning whether evolution happens ended long before I was born, although scientists certainly do have serious arguments over how evolution occurs. What we do in science education research is explore how people learn about evolution, how misconceptions are engendered and how to best correct them.

Not only does evolution appear to be counterintuitive or religiously offensive for many, there is also a powerful anti-evolution industry working to discredit evolutionary science. Shockingly, about half of North Americans reject evolution—they seem to feel that the teachers, textbooks and scientists are dead wrong. As the biggest problem in science education, evolution should be of great concern to science education researchers.

Why have we not seen similar debates in Canada?

The debates are certainly in Canada but don’t receive as much attention as in the US, where the more decentralized education system has allowed small groups to cause great commotion in local school districts. At McGill’s Evolution Education Research Centre, we get calls from teachers across Canada about anti-evolution problems. We sense a de-emphasizing of evolution by teachers because of pressures they are experiencing or believe they may receive. A recent poll by the Globe and Mail indicated that about one in four Canadians feel intelligent design should be taught in public schools.

Is the difference in educational values between the US and other countries in the world part of the research mandate of your centre?

Yes; we are definitely concerned about evolution education worldwide. For example, we recently received a grant from the Social Sciences and Humanities Research Council to investigate how Muslim teachers, students and parents understand evolution in Pakistan, Indonesia, Saudi Arabia, Turkey and Iran, as well as in Muslim communities in Canada. Islam is the fastest-growing religion in the world, including here in Quebec, yet most of the West knows little about Islamic thinking on the foundational issue of evolution.

What was it like to be cross-examined?

You don’t have the luxury of knowing what will be asked nor of thinking for 10 minutes about your reply. Your responses are expected to be almost instantaneous—and extremely accurate. After spending about six hours in sworn deposition and another three hours on the stand testifying, I tell people the best words I’ve heard lately are, “Dr. Alters, you may now step down from the stand.”

What was it like being in the centre of such a media storm?

It’s been a blast! I get interview requests from around the world and have encounters that would be exceptionally rare without the trial experience. For example, recently, I was at a play in New York about the Scopes trial starring Ed Asner, the Emmy and Golden Globe-winning former president of the Screen Actors Guild. He had been told that I was an expert witness in the intelligent design trial. After the play, we met and he surprised me by saying, “It’s an honour to meet you.”
Ernest Rutherford’s groundbreaking work on the nature of radioactivity may have been conducted in one of the best labs in the world, but his work was so far out on the edge that the Professor of Experimental Physics at McGill from 1898 until 1907 found he often had to construct his own devices to prove his theories.

The Rutherford Museum, in McGill’s Rutherford Physics Building, has many of the Nobel Laureate’s apparatus on display. In an experiment to describe the nature of alpha rays, Rutherford constructed the device shown here (in exploded view). Professor Jean Barrette, curator of the Rutherford collection, explains that this device was used by Rutherford to measure the deflection of alpha rays by electric fields, which, in combination with other experiments, allowed him to determine the charge-to-mass ratio of the alpha particles. He showed that this ratio is the same for alpha particles expelled from the different radio-elements and is equal to half that of the hydrogen ion. This work led to the revolutionary theory of radioactive transformation for which Rutherford is famous.

A Contentious Collaboration

No one would ever accuse Ernest Rutherford of modesty. Told by a colleague that he was “riding a wave”—a turn-of-the-century term for being trendy—Rutherford famously replied, “Well, I made the wave.”

That confidence was in evidence heading into a debate organized between the young physicist and Frederick Soddy, a demonstrator in McGill’s chemistry department. The topic of discussion was Rutherford’s revolutionary theory that atoms were composed of smaller particles. He wrote to a colleague, “We are having a great discussion tomorrow in our local ‘Physical Society’ when we hope to demolish the Chemists.”

Soddy was not to be dismissed, eloquently attacking Rutherford’s ideas: “Possibly Professor Rutherford may be able to convince us that matter as known to him is really matter as known to us, or possibly he may admit that the world in which he deals is a new world demanding a chemistry and physics of its own, and in either case, I feel sure chemists will retain a belief and a reverence for atoms as concrete and permanent identities, if not immutable, certainly not yet transmuted.”

Rutherford was shaken by this attack, but Soddy was intrigued by the New Zealander’s ideas. The debate eventually led to one of the greatest scientific partnerships McGill has ever seen. Within months, the two scientists were engaged in what today would be called an interdisciplinary collaboration to describe the nature of the atom, each approaching the problem from their respective backgrounds.

Working in a brand-new lab funded by generous bequests from Sir William Macdonald, Rutherford and Soddy published nine important papers describing the nature of radioactivity, for which Rutherford was awarded the Nobel Prize in 1908. Soddy would also go on to win a Nobel Prize in 1921, for his investigations into the origin and nature of isotopes.
The annual congress of the Association francophone pour le savoir (Acfas) is the largest French language gathering of its kind in the world. McGill University is proud to have been selected to host the 74th edition, with a record number of symposia and delegates.

The relevance of the theme "Knowledge: The fabric of modernity" is evidenced in the great diversity of symposia and in the number of sessions weaving together different disciplines.

Like Acfas, McGill has built up its local research networks while reaching out to the international research community. Between us, McGill and Acfas have been working to advance knowledge for almost 275 years!

For more information: www.acfas.ca/congres/

McGill Headway can be found online at www.mcgill.ca/headway/