IQ

INNOVATION QUEST

Volume 1, Issue 1, Summer 2010

McMaster University's Research Newsmagazine

Searching green solutions

IN THIS ISSUE: exploring clean technologies

McMaster University

IQ INNOVATION QUEST

Our first issue!

Welcome to our first issue of IQ – McMaster's research newsmagazine. We're excited to share a few research highlights and tell you about some of the country's most dynamic, creative and innovative research that's happening right here in your community.

In this issue, our focus is on clean technologies – whether they are related to water, automotive or solar research. Our researchers are doing their part to develop the technologies and innovations that will lead to a greener and cleaner Canada for future generations. They are indeed on an *Innovation Quest* to see that this happens.

I hope you enjoy the first issue and I welcome your comments on what you've read here and what you'd like to see in future issues.

Mo Elbestawi
Vice-President
Research & International Affairs

■ On the cover: Rafael Kleiman, scientific director of the new Photovoltaic Innovation Network, catches his reflection in a thin wafer of single crystal silicon, used to make the most common type of solar cell.

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INQUIRE

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HOT TOPICS

Research

Feature Story

Industry News

Faculty Feature

Development

Top U.S. auto hybrid researcher moving to Canada, McMaster University

Ali Emadi (center) **named Canada Excellence Research Chair in Hybrid Powertrain** is joined by (from left) David Sweet, MP for Ancaster-Dundas-Flamborough-Westdale; McMaster's out-going President, Peter George; Gary Goodyear, Minister of State for Science & Technology; and Mo Elbestawi, Vice-President (Research & International Affairs), McMaster University.

Hybrid vehicle development in Canada has received a huge jolt of propulsion.

Professor Ali Emadi, a leading U.S. developer of electric powertrain technology, has been appointed Canada Excellence Research Chair in Hybrid Powertrain and will relocate to McMaster University. The appointment will see the construction of a new 15,000 square-foot hybrid vehicle research facility at McMaster Innovation Park (MIP).

His appointment was announced at MIP by Gary Goodyear, Minister of State for Science & Technology and David Sweet, MP for Ancaster-Dundas-Flamborough-Westdale. It is one of 19 new Canada Excellence Research Chair (CERC) appointments at 13 universities. Each appointment receives up to $10 million in federal funding over seven years.

Dr. Emadi is currently the Harris Perlstein Endowed Chair Professor of Engineering and director of the Electric Power and Power Electronics Centre at the Illinois Institute of Technology in Chicago. He is also the founder and president of Hybrid Electric Vehicle Technologies, Inc., a spin-off company of the Institute.

"The government's commitment to research through the CERC program and McMaster's vision for leadership in sustainable automotive research were too strong to resist," said Dr. Emadi. "I am looking forward to joining the strong network of automotive researchers in Canada and helping to advance the development of hybrid vehicles."

His hybrid and electric vehicle research facility will be part of a new 50,000 square-foot automotive resource centre being planned for MIP. The Centre is to be located within the current Careport building and bring together private and public sector organizations to develop new technologies such as hybrid engines, batteries and lightweight materials.

> "McMaster will have the greatest concentration of powertrain research anywhere in the country."

"Dr. Emadi's appointment adds to the critical mass of expertise being assembled at McMaster for developing the next generation of lightweight, energy-efficient vehicles," said Mo Elbestawi, vice president research and international affairs. "He will help attract more like-minded researchers and entrepreneurs, and his experience in spinning off start-up companies will be invaluable to the community."

Dr. Emadi's research encompasses the development of advanced electric drive vehicles, power electronics and motor drives, vehicle-to-grid interface of plug-in vehicles with Smart Grid, hybrid battery/super-capacitor energy storage systems, and adaptive vehicle control and power management systems.

Dr. Emadi will also become director of the McMaster Institute for Automotive Research and Technology, known as MacAUTO, the coordinating body for automotive research and education at the university. It encompasses some 75 researchers in engineering, science, business and other faculties involved in initiatives valued at over $100 million in programs and infrastructure.

"His appointment is part of a strategy to introduce new programs and train engineers in the area of power engineering and electronics, control systems, Smart Grid, and related technologies," said Dave Wilkinson, dean of Engineering. "McMaster will have the greatest concentration of powertrain research anywhere in the country."

Building a powerhouse for the electric car

As they search for a power source for tomorrow's electric cars, Gillian Goward and her colleagues are peering into the tiniest of worlds: the dance of the atoms in battery electrodes and electrolytes. The McMaster University researchers are seeing electrically charged ions move about in milliseconds in lithium ion batteries.


Gillian Goward

Researchers must see the movements of atoms to learn how a battery performs, to understand its ionic conductivity. That calls for powerful images of nuclear magnetic resonance spectroscopy. NMR, says the associate professor of chemistry, provides "an important piece of the puzzle."

Using NMR as a tool is similar to what doctors do when they employ magnetic resonance imaging (MRI) to see within a human body. Non-invasive MRI imaging supplies high-contrast "slices" along a plane or dimension, scans whose images can show disease patterns or organ abnormalities.

The spectra seen with NMR offer information on the number and types of chemical entities in a molecule. Researchers are able to see chemical interactions, how batteries hold a charge, and what happens when a battery gets hot. NMR imaging can do that, in real-time, in the range of 5 to 10 milliseconds.

Around the globe, the hunt is on for advanced technologies in batteries that will power electric vehicles. For perhaps a decade, the standard has been the lithium-cobalt oxide battery. But cobalt is costly and a very toxic material. So, many researchers have been studying the dynamics and chemistry of lithium ion batteries.

"Lithium technology is going to be the next technology to make the plug-in electric vehicle possible," says Dr. Goward. Lithium-ion batteries are considered low-maintenance, rechargeable units that can provide both high voltage and great capacity, resulting in high energy density within the battery.

> "Batteries are only green as long as the energy is coming from a green source, and you are able to recycle the cell itself."

A note of explanation: today's hybrid vehicles are more likely to use nickel-metal hydride batteries. Such hybrids are not true electric vehicles. They combine gasoline-fueled engines with electric motors. Typically, the electric motor provides extra power to assist the engine in accelerating, passing, or hill climbing.

It was the rechargeable lithium-ion battery that energized the consumer electronics revolution, units that were used in cellphones and digital cameras. But plug-in electric car batteries must be able to survive the abuses of daily driving and must last far beyond the typical two- or three-year lifespan of a laptop.

For Goward, a "reasonable goal, industry-wise," is to develop a battery that can be recharged up to 10,000 times.

She and colleagues at the universities of Calgary and Saskatchewan study things like tradeoffs between safety, energy density, the length of storage time, the degradation of a battery's capacity, and extended cycle-life. They also study different cathode (the positively charged electrode) host materials, such as iron and manganese.

But lithium, the alkali metal, is not a truly renewable commodity like solar rays or wind. True, its use in batteries will eliminate the need for carbon-based gasoline and the resultant vehicle emissions. But lithium is not a real green-energy source, it is "an electrical currency", says Dr. Goward.

A true green source would be something like using hydrogen derived in efficient and commercial quantities, not from fossil fuels but from, say, water, via a non-emissions technology. And that hydrogen would have to be available where vehicles could be "gassed" up or be able to be stored in long-term fashion within a recyclable battery.

"Batteries are only green as long as the energy is coming from a green source, and you are able to recycle the cell itself," she said. "Ultimately, we need to be doing both those things. Batteries on their own are not going to save the day." ■

A world-leading innovation

McMaster University researchers are working hard on the 3 per cent solution. That's the estimated amount of fresh water – out of all the water on the planet – that humans can access for drinking. Yet contaminated drinking water, wastewater, and ecosystems present a clear danger around the globe.

Dozens of McMaster faculty members – from hydrogeologists to materials science engineers to water policy and climate change researchers – are part of the effort to safeguard natural water and treated water systems. One consortium, the Sentinel Bioactive Paper Network, devotes much of its resources to detecting, analyzing and treating pathogens and water-borne contaminants, such as pesticides and trace pharmaceutical compounds.


YingFu Li


Robert Pelton

"I would say 50 per cent of the work, when it becomes (scientifically proven and) successful, could easily be applied to water," says Sentinel scientific director Bob Pelton. "We're going after detection at this point."

The network is a clear world leader in developing cheap but reliable paper-based, pathogen-detection strips. Such strips immobilize enyzmes and other natural detector-agents on paper to react physically with a target toxin or toxins. The strips change colour depending on the levels of the toxin or pathogen.

Sentinel's various incarnations can be applied to tainted food, to deadly viruses, to pesticide detection and even to bioterrorist threats. But the platforms also apply to a huge issue worldwide: detection and treatment of waterborne contaminants.

Ten years ago, seven people died and more than 2,300 became ill after E.coli bacteria infected the water supply in Walkerton, Ontario. A United Nations report noted earlier this year that almost 900 million people lack access to safe drinking water.

When Sentinel scientist John Brennan and his colleagues succeeded in creating a test strip that identified a pesticide, the impact was tremendous.

"He's had hundreds of emails, from the U.S. Army to people who want to market something," said Dr. Pelton.

The chemical engineer has his own idea about using paper to trap contaminants. He's looking at the potential of bioactive toilet tissue. Paper fibre embedded with polymers would absorb trace contaminants of pharma drugs or headache tabs that pass through the body. Treatment plants can more easily filter such drugs if they are on flushed tissue paper than if they were in a diluted liquid stream.

Based at McMaster, Sentinel has partners at 10 other Canadian universities, 20 companies, and three governments. And the consortium expects word soon on a proposal to create a national bioactive paper centre under the national Centres of Excellence for Commercialization and Research.

This work is well beyond proof-of-concept stage. When Sentinel products near market, other considerations dominate. Government agencies must give regulatory approval, says Sentinel biochemistry-lab chief Yingfu Li. Liability is "a huge issue," he notes. And industrial partners and financing must help take the various platforms to market. But the elegant science, and the offer of an inexpensive paper detection strip, is appealing:" If you had something that cost maybe 10 cents or 20 cents, I would buy it," says Dr. Li. ■

By the numbers

■ Sentinel Bioactive Paper Network

Funding	
Natural Sciences & Engineering Research Council	$7.5M
Industrial Partners and the Ontario Centres of Excellence	$2.5M
Partners	
University Partners	10
Industry & Government Partners	7
Researchers	
University	22
Trainees	42

DISCOVERY

Laying a claim to No. 1

Everyone wants to be No. 1. But it's not often that a university can lay claim to being the academic leader in a high-tech cutting-edge field. McMaster University can stake that claim with its new Biointerfaces Institute, which received more than $14 million in federal and provincial investment. University funding and vendor participation brings the total budget up to about $22 million.

The institute should be operational early next year – installing high-throughput screening (HTS) equipment, robotics, data processing, and imaging mass spectrometers takes a while. Normally, this kind of infrastructure is found in industrial settings, such as at drug discovery firms. Very infrequently is it found at universities, and even less often for high throughput synthesis and screening of new bioactive and biocompatible materials and surfaces.


John Brennan

HTS allows a researcher to rapidly prepare and assess thousands, or millions, of materials, and can accelerate the development of new biosensors, implantable materials or responsive materials for drug delivery. "We will know almost immediately how an artificial material might react with biologicial entities," says institute director John Brennan.

"This is massive," he says. "Literally, there are only one or two places on the planet that are using an HTS approach to develop and optimize new materials."

Dr. Brennan and Sentinel went to the top of the must-call list around the world when they announced that they'd developed a paper-based biosensor strip that could detect a range of organophosphate pesticides. Such pesticides and herbicides, which run off fields into groundwater, can be lethal.

These simple paper strips can be engineered to detect all kinds of deadly food- and water-borne bacteria and viruses, trace chemicals of antibiotics and pharmaceuticals in drinking water, even endocrine-disrupting compounds that crash fish populations and cause adverse biological effects in animals and humans.

But the Biointerfaces Institute has a far wider horizon. Its high-throughput technology will expand the ability to characterize surfaces that will adsorb biomolecules. This will provide a greater understanding of how biological and synthetic materials interface. Some possible applications: the study of biosensors, of drug delivery, contact lenses, and implantable devices. ■

IQ research feature — Capturing

Written by Peter Calamai

McMaster University's Rafael Kleiman is heading a research effort to make one of Einstein's strokes of genius pay off for Canada.

If Kleiman and his collaborators across the country succeed, Canada may be able to come from behind to capture a niche in the burgeoning solar energy market by the end of the decade.

■ Rafael Kleiman is looking through a scale model of the Zincblende crystal structure, which is typical for compound semiconductors such as GaAs and InP. The atomic spacing in the model is about 100 million times larger than the actual atomic spacing. Kleiman and his research group are growing compound semi-conductors epitaxially on single crystal Silicon to make high efficiency solar cells.

Otherwise the risk is that the country's abundant sunshine could wind up being harvested by photovoltaic devices developed and manufactured elsewhere, much as our forests are today harvested by Finnish machinery.

"If we don't develop new intellectual property, Canada could lose everything since I don't think we can compete with other countries on manufacturing costs," says Kleiman, a professor of engineering physics.

Intellectual property is legalese for patents, licences and other ways of benefiting from research discoveries. In this case, that research centres on photovoltaic cells, devices that transform the sun's rays into electricity. Originally designed to power satellites in space, the cells then turned up on hand calculators and lately have made the jump to roof panels and large-scale solar farms, both supplying subsidized electricity to the grid.

"Photovoltaics are a game-changer," says energy guru Walt Patterson, author of Keeping The Lights On: Towards Sustainable Electricity,

"Instead of a commodity coming from some remote location, electricity becomes part of what your building delivers. Photovoltaics, evolving at breathtaking speed, will be a key technology for high-performance, low-carbon energy systems."

But other countries, like Germany and Japan, are well ahead of Canada in the development and manufacturing of photovoltaic cells, currently the fastest growing energy technology with production doubling every two years.

So Kleiman and researchers at a dozen other universities along with a score of industrial and public sector partners recently created the Photovoltaic Innovation Network financed by $5 million from the Natural Sciences and Engineering Research Council (NSERC), a federal granting agency.

Over the next five years the Network, centered at McMaster with Kleiman as scientific director, will pursue 13 novel projects aimed at lowering production costs and improving the efficiency of commercial photovoltaic cells, the best of which convert less than 20 per cent of sunlight's potential energy to electricity.

"I don't think there will be a single killer app in photovoltaics for some years and I don't think we know enough now to choose the likely winners and losers," says Kleiman who holds the Canada Research Chair in MicroElectricalMechanical Systems.

"If you're playing catch-up like Canada is, you're sometimes better off giving up on existing technologies and instead trying to leapfrog to new technologies."

One leapfrog approach being pursued by the Network is to take advantage of the transformations in properties at the nanoscale. (A nanometre is one-billionth of a metre and a human hair is roughly 10,000 nanometres wide.)

Using highly specialized lab equipment to work in this Lilliputian realm, Network researchers will try to sculpt the surface of the silicon that is a common material in many photovoltaic cells. Currently the smooth silicon surface reflects as much as 40 per cent of the incoming light. Create the correct contours, however, and much more the light will be trapped and available for possible conversion to electricity.

Another Network theme is focused on a hybrid photovoltaic cell that would combine the low cost of organic materials such as polymers with the longevity of inorganic materials such as silicon or exotic crystals such as gallium arsenide.

That hybrid approach is also a way of deliberately bringing together chemists – who work mostly on organic cells – with physicists – traditionally favouring inorganic materials.

"They're two different communities that look at things in different ways and use different language. But they have a lot to offer each other so we have to work to break down those barriers," says Kleiman.

the solar energy market

An emphasis on collaboration is a hallmark of the Photovoltaic Research Network. On average each of the 13 research projects involves participants drawn from three member institutions as well as researchers from two of the four research themes – organic, inorganic, hybrid and nano-structured.

Another hallmark is an overarching emphasis on training. Most of the $5 million grant is earmarked for nurturing 88 future photovoltaic researchers – 39 undergrads, 22 Master's students, 23 PhD candidates and four post-doctoral fellows. In addition to salaries for working with the Network's researchers, the trainees will get money for travel to conferences and to take part in week-long hands-on courses where they will actually design and make photovoltaic devices.

Kleiman says Canada lost a generation of photovoltaic researchers when interest in alternate energy sources plunged with the return of cheap oil in the 1980s. But now both high-priced oil and concern over climate change have aroused serious political interest in solar energy, as demonstrated by Ontario's recent multi-billion-dollar green energy announcements

The Network's 11 industrial partners have also promised to provide paid internships and co-op positions for the 88 over the five year span.

Photovoltaics industry pioneer Ian MacLellan says the Network, and its focus on the next generation of researchers, is crucial in helping create a solar energy industry in Canada.

"We may not be able to compete head-to-head with the biggest players in the world but I think we can develop niches," says MacLellan, founder and vice-chairman of Waterloo-based ARISE Technologies, a photovoltaic manufacturer with sales of $30 million last year.

The Photovoltaic Innovation Network is only the most recent of three major undertakings in this frontier research field for Rafael Kleiman and McMaster.

In March 2008 Kleiman's research team received a $4.1 grant from ARISE and the Ontario Centres of Excellence to speed commercialization of a technique to make photovoltaic cells that could reach 30 per cent conversion levels through high-purity crystals and precision layering.

Then last year McMaster received matching $5.1 million grants from the Ontario Research Fund and the federal Canada Foundation for Innovation to allow Kleiman to outfit a world-class photovoltaic research facility. Plans for modifying existing lab space are being drawn up and the new machinery and instruments is scheduled to be in place next year.

"We'll be able to do a much better job of analyzing why we're not getting more of the energy out of the sunlight," says Kleiman.

And that all leads back to a conceptual leap by Einstein in 1905 for which he was later awarded the Nobel Physics Prize.

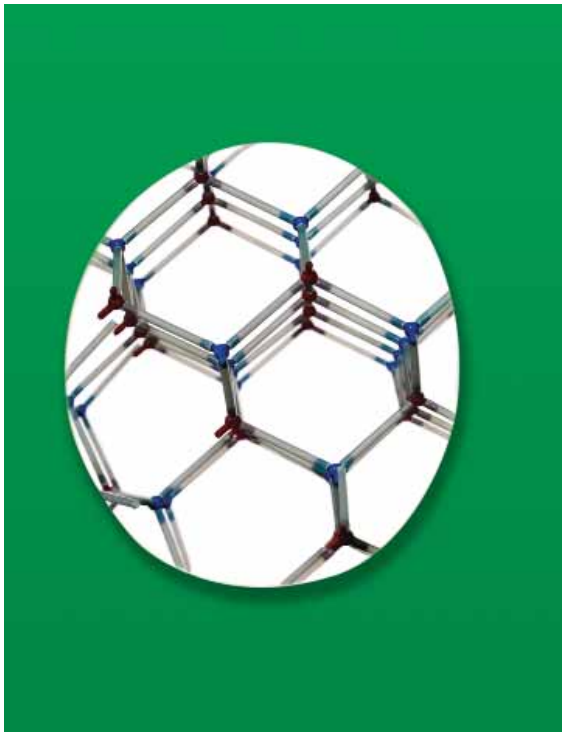
Until then science had considered that light and other forms of electromagnetic radiation behaved like waves, which is why we still refer to light waves and radio waves.

But the wave model couldn't explain the actual energy levels measured in the electrons that light knocked loose from inside the atomic structure, the action involved in the closely related photoelectric and photovoltaic effects.

Einstein resolved the paradox by demonstrating that light also behaved like a stream of separate packets of energy which he called quanta and which are now known as photons.

So in a use of the phrase that is almost scientifically accurate, you can say that Kleiman and his colleagues are aiming for quantum leaps in photovoltaic cells. ■

■ The most common type of solar cell is made from a thin wafer of single crystal Silicon. The wafer is made into a photodiode, which converts light from the sun directly to usable electricity. Silicon absorbs light in the visible, near infrared and ultraviolet parts of the spectrum, with commercial devices achieving up to 22% efficiency. Reflected in the cell is a scale model of the Zincblende crystal structure.



By the numbers

■ NSERC Photovoltaic Innovation Network

Funding	
Canada Foundation for Innovation	$5.1M
Natural Sciences & Engineering Research Council	$5M
Ontario Research Fund	$5.1M
Partners	
University Partners	13
Industry Partners	11
Government Partners	8
Researchers	
University	29
Trainees	88

IQ industry news

Innovating and marketing the new green


Ashish Pujari

Developing green product lines and climate-friendly technologies was not new in Europe when Ashish Pujari completed his PhD in marketing with a focus on 'new product innovation and sustainability' almost fifteen years ago.

When Pujari came to McMaster from Britain in the summer of 2001 he had more than our Canadian winters to adapt to – he also had to acclimatize to a marketplace that was still in the very early stages of 'going green'.

Pujari – chair of McMaster's department of strategic market leadership and health services management at the DeGroote School of Business – notes that while Canada still lags behind many peer countries on the Conference Board of Canada's annual report card that gives our country "C" for environmental performance and a "D" for innovation, "Canadian businesses are becoming increasingly 'enviropreneurial' – more willing to introduce ecologically beneficial product lines, services and corporate policies that will reduce our collective carbon footprint."

Professor Pujari believes that many Canadian organizations have gone through what he describes as a "first phase": discovering that they can be green and competitive using innovation and technology.

"Sustainability makes not only good environmental sense, but good business sense too," says Pujari.

When Sears Canada was exploring the feasibility of offering a home improvement line that was energy-wise and eco-friendly, they sought Pujari's expertise to help determine if sustainable goods would be a preferred choice with customers. Funding from the Ontario Research and Development Challenge Fund and Sears Canada helped Pujari and a colleague survey 900 homeowners to provide Sears with the knowledge they needed to understand consumer behaviour towards energy-efficient homes and products.

Much of Professor Pujari's research addresses how companies innovate for environmental sustainability and develop new green products, services and technologies. Supported by Social Sciences and Humanities Research Council (SSHRC), Pujari is currently investigating how companies develop dynamic capabilities for sustainability innovation that help their bottom line. His research also identifies that fine balance between what corporations are willing to invest to 'green' their goods and services, with what consumers are willing to pay for the latest in earth-friendly merchandise and technologies.

According to Pujari, it's not enough that an organization offers just a little "greenwashing" of their corporate image. Consumers are looking for more than only one environmentally friendly product or service from the companies they patronize – they want to know that there's a corporate-wide commitment to sustainability.

Pujari acknowledges that while consumers want more environmentally sensitive options, they might not always be willing to actually pay more for the green products or ecologically responsible services that sometimes cost corporations more to manufacture and deliver.

"There is a difference between consumer attitude and consumer behaviour," says Pujari, and finding that tipping point is the next hurdle, the "phase two" of the green innovation and marketing challenge. ■

HIGHLIGHTS

Restoring wetlands


Pat Chow-Fraser

More than 33 million people live in the Great Lakes' watershed. As global attention turns increasingly to the ecological, social, geopolitical and economic importance of water, Pat Chow-Fraser is studying the human impact on those lake and wetland ecologies.

A professor of biology, Chow-Fraser has developed biological indicators using various organisms and environmental parameters to assess the ecological status of hundreds of Great Lakes coastal wetlands. That information is now part of a GIS database she developed called Wetland Inventory for Research and Education Network (WIRE-net). It is used to devise and launch strategies to protect and restore wetlands, including one of the largest biomanipulation projects on the Great Lakes in the Cootes Paradise Marsh located right in McMaster's backyard. By documenting how human activities impact our wetlands, Chow-Fraser is providing valuable information that can be used to ensure the health of our lakes and rivers – and our enjoyment of them – for generations to come. ■

Safe drinking water


Sarah Dickson

More than a quarter of Canadians depend on groundwater for their domestic water supply. Making sure that water is safe to drink is the focus of civil engineer Sarah Dickson, an expert in water and environmental engineering. Her research combines field- and laboratory-scale experiments with computer modeling to identify situations causing water resources to become vulnerable to pathogen and chemical contamination.

Dickson also develops and evaluates new technologies to reverse the contamination. Her application of pulsed arc electrohydraulic discharge for the remediation of contaminated groundwater won her an Ontario Early Researcher Award. Her research results will provide the public with better science to guide water protection legislation and, ultimately, protect the health of individuals relying on groundwater for their drinking water supply. ■

IQ faculty feature

ALTAF ARAIN Getting high with nature to study dramatic climate change


Altaf Arain

On certain days of the year, you might find Altaf Arain making his way anxiously up one of three high towers near Turkey Point, southwest of Port Dover. Or perhaps he might be wading through deep forest cover up near Timmins.

He pores over instruments that record water vapour, carbon dioxide and heat exchanges between the ground and the atmosphere. In Italy, another researcher also keys in similar numbers. The story is the same in Brazil and Australia. They're all part of Fluxnet, a global network of micrometeorological tower sites that track local ecosystems.

Dr. Arain's walks through the woods are only a tiny part of research ongoing at the new McMaster Centre for Climate Change, an institute that takes in four faculties, seven disciplinary areas, and more than 20 professors. The disciplinary areas include studying physical climate and (computer) modelling, paleoclimate (climate change through time) and isotopes, hydroclimate and water resources and the impact of climate change on vegetation ecosystems, infrastructure, human health and societies.

"I think it's unusual to have this much diversity (in a climate-change institute)," says Dr. Arain, director of the new centre and associate director of the School of Geography and Earth Sciences. "Many of the faculty were involved in diverse research (areas) but they were all affected in some way by the climate."

That diversity means the centre deals with local issues, such as the effect of climate change on respiratory health or how climate change impacts local water systems. But it also contributes to a wider Canadian and global understanding of what is happening to world ecosystems and to the atmosphere. Thus the hikes into the woods.

McMaster researchers have discovered that periods of early-summer drought and heat dramatically reduce the ability of trees to absorb carbon dioxide. That's a key role that trees play. In general, forests are what is called carbon sinks, great holding reservoirs for man-made emissions. Much of carbon dioxide not taken up by trees and plants ends up in the atmosphere. And hotter periods promotes water evaporation into the atmosphere.

A $1.5-million gift from the RBC (Royal Bank of Canada) Foundation that set up a Water and Health Initiative helped fund centre activities as well as a citizen-outreach program. The program – which will look at water quality, air quality, wetland health and forest health – is meant not only for the public but also for conservationists, city planners, and resource managers. ■

CARLOS FILIPE Helping to make water systems safer


Carlos Filipe

For Carlos Filipe, being part of the Sentinel Bioactive Paper Network is like coming full circle. The assistant professor in chemical engineering earned his PhD in wastewater treatment technologies and has co-authored a textbook on biological treatment of wastewater.

Now, a large part of his research deals with detection and treatment of pathogens and contaminants in water systems. He's also working with Sentinel Network scientific director Bob Pelton on the idea of a bioactive toilet paper, something that would entrap molecules, such as pharmaceuticals, that pass through the body. They end up in wastewater treatment plants and then enter the environment.

"That's always been there, Sentinel's application to water, drinking water. The (bioactive) sensors all of us are using are based on water, on dipping strips into water (to test for presence of a potentially toxic organic chemical, for example). One of the big issues, the big problems in the last 10 years or so, is looking at these trace contaminants."

If researchers could develop toilet tissue – embedded with polymer substances that capture things like chemo drugs, or birth control hormones, or even recreational drugs like cocaine – that might trim the contaminants that exit treatment plants into waterways. Removing such drugs in a plant's solid-waste stream is far easier to do than in the diluted liquid stream.

Dr. Filipe has already been a player in one McMaster breakthrough. Scientists at the Sentinel consortium came up with a reliable yet inexpensive innovation: using a paper dipstick to detect the presence of a potentially dangerous toxin or a pathogen.

The trial-and-error process involved biologists, biochemists and chemical engineers, polymer specialists, materials scientists, and other experts who applied ink-based silica nanoparticles and immobilized enzyme agents on coatings on paper. When the enzyme is exposed to a toxin, engineered molecules in the ink change colour.

"Nobody had done it before and we had made it possible," he recalls. "To see it working was quite exciting... It's like you put a lab on a piece of paper, put an entire room, all of that equipment, all of those processes and all of that complexity. I think it's just really cool work." ■

IQ faculty feature

GAIL KRANTZBERG Public Policy and the Great Lakes


Gail Krantzberg

With new and innovative technologies being designed to tackle pollution in our Great Lakes, we all should all be breathing a collective sigh of relief.

But don't hold your breath on a quick fix, cautions Dr. Gail Krantzberg, director of the Dofasco Centre for Engineering and Public Policy at McMaster University and an adjunct professor of the United Nations University's International Network on Water, Environment and Health located at McMaster Innovation Park.

While moving in the right direction, technologies alone are not the sole answer to respond to the destruction that has plagued our waters over the last century, she said.

Dr. Krantzberg has spent more than 20 years working to get policies introduced that will have an impact in advance of destruction, not after the fact. She's an expert in the fields of ecology, biology, chemistry and toxicology, and she's determined to lessen the gap between innovators and policy makers.

She believes there has been a disconnect between the technical and policy sides of clean-up, but is confident that is now changing. "Finally, science is telling us that we need new public policy reforms if we are to have success in getting chemicals of emerging concern, like pharmaceuticals and personal care products, out of our receiving waters."

Fresh off presenting at the inaugural Canadian Water Summit – a one-day workshop bringing together a diverse group of stakeholders to discuss the new water reality – Dr. Krantzberg is a bit more optimistic about the opportunities that lie ahead for our Great Lakes. She's also pleased to see the province move forward on its Water Opportunities and Water Conservtaion Act.

According to Krantzberg, two major things need to happen. First, we have to renew Great Lakes public policies – exploring what they need to consider in the future to address new threats to ecological and economic integrity of the region, keeping in mind that the current binational policy regime is nearly four decades old. Second, we need to focus on regenerating "livable communities," communities that can accommodate both built environments, in terms of infrastructure and transportation systems, and our natural environment.

"Great Lakes governance is really about managing human behaviour," she said, noting that behaviour will be more easily managed when we have bridged the gap between scientific experts and policy makers – the raison d'etre of the centre she directs.

Since the Centre's inception in 2005, some 50 engineers have graduated and are working primarily in governments, industries and NGOs. ■

MIKE WADDINGTON Protecting a vital piece of Canada's boreal ecosystem


Mike Waddington

Mike Waddington studies peat. He tramps through peat bogs, digs peat up, studies the partially decomposed organic material in McMaster University labs, and works with a company that wants to make peat pellets to use as biofuel. He knows that peat is an unsung 'environment hero' and a vital part of Canada's natural heritage.

"Ontario has some of the largest peatlands in the world, from Muskoka region up to the James Bay Lowlands, which are hundreds of kilometres in size....We're studying how to find the right balance of how to use it and how to preserve it," said Dr. Waddington, who spends perhaps 10 weeks each year in nature's peatland laboratory.

Very slow-growing peat is an under-recognized 'hero' in that it regulates emissions of greenhouse gases. Peatland ecosystems are natural carbon sinks. That is, they store carbon-containing material, acting to control atmospheric carbon dioxide levels, a prime greenhouse gas. But carbon within peat can also be a renewable energy source.

Ontario's energy ministry figures that 8 million tonnes of peat fuel can generate up to 3200 megawatts of electrical power. In general, the denser the peat pellet, the higher its caloric value.

Peat Resources Ltd. is a Canadian company studying the wet harvesting of peat as a biofuel that might replace coal in generating stations. Dr. Waddington and other researchers are working with the company to understand how best to harvest peat, how to rehabilitate harvested lands, and the resiliency of the wetlands after peat extraction.

Perhaps surprisingly, the resiliency news is good. In Quebec, Waddington's research has found that the carbon sink function of peat resumes maybe a decade after careful harvesting. Just as a replanted forest sprouts new tree cover, wet harvesting and reclamation – as opposed to draining land to get at the peat – allows the ecosystem to make a slow and steady recovery.

But researchers worry about the resiliency of peat after harvesting and also about fire damage. In addition, mining firms in the so-called Ring of Fire of the James Bay Lowlands want to exploit such minerals as chromite and platinum. Exploration could have horrific consequences for the peatlands if it is poorly managed. ■

IQ development – Hamilton is going sunny-side up

Hamilton is going sunny-side up as rooftops on apartment blocks, at companies, and government buildings will soon carry solar panels, sending electricity into the province's energy grid. Within a year, the city may sport millions of square feet of panel coverage, including a network at the renovated city hall.

The sunroof program is part of a new strategic energy alliance – complete with its own trademarked slogan, 'Ontario's Solar Sunbelt' – that includes the cities of Hamilton and St. Catharines, McMaster University, Mohawk College, and Horizon Utilities Corp., the giant utility in Hamilton with 240,000 customers.

McMaster's vice-president of research, Mo Elbestawi, says the Alliance has the potential to produce both great and "green" benefits for this region.

Elbestawi says the partnership with Horizon will allow the University to build on its research capacity as its students and faculty will gain access to the data for Horizon's solar fleet.

Working with Horizon, building owners who negotiate leases would get a long-term revenue stream as they send solar-generated electricity into Ontario's grid. The sunbelt program would supply not only renewable energy but also act as an incentive for 'green' companies to set up shop in Hamilton.

Max Cananzi, head of both Horizon Utilities and the newly created Horizon Energy Solutions believes that 100 solar-equipped Hamilton rooftops "is fairly do-able" within a year, providing panel coverage of more than 2 million square feet. That is comparable "to a large wind farm", he said. Horizon will put up the panels and related infrastructure with "a zero up-front cost" to the building.

McMaster is both hosting panels at its main campus and providing research expertise in several areas, including at its new laboratory for advanced photovoltaic research. The university will have access to data from the sunbelt program and offer innovations to enhance panel design and improve power performance.

Photo: David Gruggen

■ Pictured above are Alliance partners, from left: Mo Elbestawi, McMaster's vice-president (research & international affairs); Max Cananzi, president, Horizon Utilities; Brian McMullan, Mayor of St. Catharines; Sophia Aggelonitis, MPP and Minister of Consumer Services; Fred Eisenberger, Mayor of Hamilton; and Rob MacIsaac, president of Mohawk College.

At McMaster, Tony Cupido figures that about 50,000 square feet of panel coverage could go on several roofs at the university. That's on top of two separate and unrelated solar installations, one of which will feature 100 panels to preheat the pool water at the Ivor Wynne Centre.

"We will have many of the panels in place by August under a federal grant initiative," said the assistant vice-president of facility services. "The buildings fronting on Main Street will have the panels from Horizon. By the end of this summer, it will look very different here on campus."

"The City of Hamilton is very keen on moving into the greener economy," says Jennifer Patterson, senior business development consultant. "We want manufacturers here who are involved in clean technologies... everyone's in the game. It's a hurry-up-and-get-it-done world because of the province's Green Energy Act. But Hamilton definitely is on the radar because we have all these assets."

She's thinking of the research assets at McMaster University and of Mohawk College, now seeking federal funds for an applied research centre in energy technologies.

There's Horizon itself, the strategic energy alliance, and the harbour, a good staging area for access to the Great Lakes, perhaps an exit point for off-shore wind farms.

But why Hamilton, why should producers open factories here? In its post-steel phase, the city is trying to develop several sectors, including advanced manufacturing, life sciences, agri-business, and transportation logistics. Long an industrial giant, Hamilton also wants to be known as a centre for cleantech and renewable energies.

Employers who stop in Hamilton will need trained employees and the presence of both McMaster and Mohawk graduates is extremely appealing.

"McMaster, already home to some of the world's best minds and laboratories, is an attractive proposition to investors – local, national and international – looking for the kinds of intellectual capital and sophisticated equipment that resides on our campus," Elbestawi said. ■