Cutting Edge:
Dr. Michael Cunningham and his group are world leaders in Green Chemistry and Engineering
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Welcome to the May 2010 issue of The Complete Engineer.

Those of you with a keen eye will have noticed a change to our cover. This is now the magazine of the Faculty of Engineering and Applied Science at Queen’s University.

Our Faculty has a long and proud history, and we treat its traditions with great respect. Following in-depth discussions with faculty, staff, students and alumni, and with the approval of Faculty Board, in February Senate passed a motion revising our name to the Faculty of Engineering and Applied Science. By including Engineering in our name we more accurately reflect what we do and who we are.

As I noted in the last issue, these are incredibly exciting days in our Faculty. Along with taking part in Principal Woolf’s academic planning process for the University, we are planning significant investment in our future leaders to provide the best environment for learning and discovery. Our goal is to reach higher with outstanding facilities, programming and teaching to ensure that our current students can address tomorrow’s most pressing needs, at home and around the world. I will share more on these initiatives in our Fall issue.

In this magazine you will read about just a few of the great things that our students and faculty are doing, thanks to the support we receive from government, our industry partners, and the continuing generosity of our alumni. Your contributions help us ensure our continued position as a top destination for engineering education in Canada. As we prepare to welcome this fall’s Class of 2014, I am proud to report that we continue to attract many of the brightest and the best to Queen’s.

As always, I will continue travelling to reach out to our stakeholders: our alumni, friends and corporate partners. But I would also like to encourage you to come and visit us in the Faculty of Engineering and Applied Science. This is a truly exciting place to be.

All the best,

Kimberly A. Woodhouse
PhD, PEng, FCAE, FBSE
Dean, Faculty of Engineering and Applied Science
Good teaching needs good research

DR. BRIAN W. SURGENOR, P.Eng., ASSOCIATE DEAN (RESEARCH, GRADUATE STUDIES AND EXTERNAL AFFAIRS)

A story in Maclean’s magazine this past summer has re-ignited a debate that’s been swirling within academic circles for a number of years. The article, based on interviews with presidents of Canada’s five largest universities, suggested that national research funding should be reserved exclusively for these institutions – leaving the country’s other 85 universities to focus solely on undergraduate education. It’s a radical idea based on a real concern over funding for universities – but it loses sight of the students who attend them.

There’s no debate that research funding in Canada is, in a word, meager, particularly for smaller universities. The “Big 5” universities whose leaders spoke with Macleans – McGill, UBC, Montreal, Toronto and Alberta – currently receive 40% of the country’s total research funding.

Despite this anomaly, Queen’s is consistently rated number one among all Canadian universities in national research awards per full-time faculty member. 80 percent of our 2009 NSERC applications were funded, compared to 63 percent nationwide. We have 53 Canada Research Chairs, 25 Queen’s Research Chairs and four Industrial Research Chairs. This, despite the fact that Queen’s is a mid-size university not located in a major Canadian centre. Clearly, size doesn’t always matter.

Arguably, universities do need to be big enough to allow for the multi-disciplinary nature of research and access to facilities and resources that support discovery. But in our evolving world, technology has created entirely new ways to share knowledge. Scientists no longer toil alone in labs, unaware of the efforts of others. Today, researchers and their students routinely collaborate on projects with colleagues around the world.

Pooling resources and expertise isn’t, however, always a bad idea. In fact, Canada’s National Centres of Excellence are based on this approach. These inter-university centres foster multi-disciplinary partnerships between universities, government and industry sectors – and because they are located across the country, they are accessible to a wider range of educators and students. Another example of these partnerships are the research centres supported by the Ontario Research Fund, with the new Centre for Energy and Power Electrics Research (ePOWER) and the Queen’s-RMC Fuel Cell Research Centre as Queen’s based examples.

But perhaps the most compelling reason for maintaining research as a strong component of the university structure: our students. Unless we intend to send all graduate students to five institutions, pooling research funding sacrifices the primary reason for universities in the first place: to teach. The adage “tell me and I’ll forget; show me and I may remember; involve me and I’ll understand” is represented on every campus across our country, as researchers mentor young minds who may someday hold the key to a discovery of global dimensions.

There will always be the perception that we face government underfunding for teaching and research. Regardless, as Theodore von Karman said “A scientist studies what is, an engineer studies what never was.” As engineers, our infinite curiosity about the world around us will continue to drive our quest for greater knowledge. That quality is too good not to be shared.
Take four different engineering departments at two universities, add support from industry, and what do you get? The Queen’s-based GeoEngineering Centre, a groundbreaking collaborative venture that links Queen’s and Royal Military College to create one of the biggest geoengineering graduate training programs anywhere.

The Centre provides expertise and research for virtually everything under the ground – rock and soil, groundwater, mines, and buried infrastructure such as pipes and culverts. The benefits of collaboration are obvious, says Executive Director Dr. Ian Moore.

“Working under one roof, as it were, allows us to have a collective identity, as well as shared graduate programs, research facilities and mutual support through shared grants,” says Moore, a professor and Canada Research Chair in Infrastructure Engineering at Queen’s Department of Civil Engineering.

One important research initiative at the Centre is the Barrier Systems Project headed by Dr. Kerry Rowe, a professor of Civil Engineering and Queen’s Vice-Principal for Research. Its objective is to ensure that composite liner systems – geomembranes and geosynthetic clay liners – used in municipal solid waste landfills remain effective over the long term.

Liner or barrier systems have been used in landfills for the last quarter-century and have performed well, says Rowe. But today’s large, modern landfills are built to more exacting standards. “These systems are going to have to work effectively for periods that could range from a hundred years to several hundred, preventing any contaminant migration from the landfill that could have a negative environmental effect on surface or groundwater.”

Rowe’s project operates a test site north of Kingston in collaboration with partners including the Ontario Ministry of the Environment, consultants involved in landfill design, and manufacturers of geosynthetic materials used in barrier liners.

Societies will always need landfills, says Rowe. “Even if incineration is allowed, which has its own environmental implications, there’s still ash to be disposed of in an appropriately designed landfill facility.”

The Centre’s geotechnical research also includes earthquake engineering, carried out by applied scientists who study how tremors affect structures such as foundations and retaining walls and who develop quake-prediction models for Canada.

Moore says financial support from the GeoEngineering Centre’s industrial partners is extremely important. In his case, “about half of my financial support comes from industry, and half from the federal and provincial governments.”

Dr. Ian Moore

Dr. Kerry Rowe
It was 1995, and Queen’s alumnus Dr. Michael Cunningham, BSc’85, MSc’87, was enjoying a flourishing corporate career with 25 patents to his credit. During a speaking engagement at his alma mater, however, he had the opportunity to tour a newly invigorated Chemical Engineering department with then-Department Head Tom Harris. That tour, which revealed a burgeoning culture of creativity, lured him back to academia. Now, fifteen years later, Cunningham is at the forefront of that creative environment, working as an Ontario Research Chair in Green Chemistry and Engineering to nurture the next generation of scientists and engineers and to re-imagine manufacturing solutions for a cleaner, greener planet.

Green Chemistry focuses on the conservation of resources and the use of renewable and non-toxic materials in product development and manufacturing processes. Cunningham’s research within the field is both highly collaborative and diverse, with projects that include both the minimization of solvents and chemicals in production and their complete elimination through alternative processes.

Much in the way that doctors pledge to “do no harm”, Cunningham and his colleagues are working to prevent harm by changing the way polymeric materials are manufactured – compounds that are used to create everything from televisions to tires. “Researchers in green chemistry and engineering are guided by the twelve principles developed by John C. Warner, considered one of the founders of this field,” says Cunningham. “He believes that it is better
to prevent waste than to treat it or clean it up after it is formed. Much of my work involves finding ways to do this.”

Of course, as Sesame Street’s Kermit the Frog points out, it’s not always easy being green. “Ideally, we’d like to eliminate the use of solvents completely,” he says, “but sometimes we need to work on being ‘greener’ until we discover the complete solution.” Working with Professor Robin Hutchinson and PhD student Nicky Chan, for example, Cunningham is studying new ways to dramatically minimize the use of copper catalyst in specialty polymers.

That complete solution, however, may come in the form of groundbreaking research to replace toxic solvent-based processes with water-based systems that have a minimal impact on the environment. Cunningham is currently collaborating with Dr. Timothy McKenna and PhD students Ula El-Jaby and Jordan Pohn to design more efficient chemical engineering processes for water-based polymerizations, work that may provide the opportunity to create new types of tailor-made polymer products, such as biomedical instruments, microelectronic devices and detection systems.

This research has already attracted international attention, boosting Queen’s and Canada’s reputation as a leader in manufacturing new materials with “intellectual capital”. PhD student Mary Thomson’s doctoral project on developing water-based polymerizations, for example, involves collaborations with U.S.-based Arkema Group, as well as professors at the Swiss Federal Institute of Technology in Zurich. A researcher from Toagosei Chemical Company in Japan, Kenichi Nakamura, is currently visiting Cunningham’s laboratory to learn these same techniques.

Cunningham also collaborates extensively with colleague Dr. Phillip Jessop, a Canada Research Chair in Green Chemistry, on Jessop’s switchable surfactants concept. This involves developing smart nanoparticles that can control properties through a non-toxic trigger – in this case, carbon dioxide. Postdoctoral fellow Dr. Masatoshi Mihara and graduate students Candace Fowler and Catherine O’Neill are using this theory to conduct research that could initially result in a number of important applications – such as fast-drying paint, a valuable tool for industries that consider time an economic factor – but may also drive further research for future discovery.

It’s clear that students benefit significantly from this work – all of Cunningham’s projects involve graduate and undergraduate students who gain valuable research experience while contributing their own theories and ideas. “I love the contact with these young minds, especially the top-quality students that we see at Queen’s,” Cunningham says. “Their enthusiasm is infectious.”

He notes that these research and collaborative opportunities, however, are possible only through vital funding and the support of the University. Cunningham’s prestigious Ontario Research Chair award, worth $1.25 million over five years, is the latest in a series of accolades, including a Premier’s Research Award and Chancellor’s Research Award. “These awards have been pivotal to my work and to my ability to include students in that work,” he says.

“Green Chemistry is a young field, and there’s still so much to discover,” Cunningham adds. “Each day brings new ideas that need to be propelled from speculation to potential discovery. At Queen’s, we’re working together to make that happen.”
Recently, *The Complete Engineer* sat down with Dr. Jim McLellan, Head of Chemical Engineering and Engineering Chemistry, to talk about growth, challenges, and what lies ahead.

Q The Chemical Engineering program has seen tremendous growth. Why are so many students attracted to this area of Engineering and Applied Science?

We have a very strong program with an excellent faculty – a great blend of experienced professors and new minds with fresh ideas. We also provide tremendous opportunities for learning beyond the classroom through projects and special lecture series.

The Chemical Engineering and Engineering Chemistry disciplines have significant roles to play in addressing pressing issues such as energy, water, health and sustainable manufacturing. You’ll see this reflected in the research we are doing in green chemistry, bio-processes, fuel cells, and biomedical engineering, as well as work to advance the design and operation of more conventional processes such as low-solvent high-solids polymerization reactors for coatings.

Having both the Engineering Chemistry and Chemical Engineering programs places our department at a critical interface between science and engineering. This attracts the type of quality student that we most often see at Queen’s.

Q What sets the teaching apart?

Our people – dedicated faculty and support staff that are committed to providing a high-quality educational experience and to promoting inquiry through open-ended projects and research. We have a strong project-based component to our programs, ranging from design projects associated with engineering fundamentals courses to industrial projects, design projects in industrial catalysis, and open-ended laboratory opportunities.

Teaching and research aren’t distinct entities; they are both part of the continuum of discovery. Our undergrads spend a good deal of time collaborating with upper years, grad students and researchers as part of their education, and that gives them the ability to fully explore new theories and ideas. As well, many of our faculty are cross-appointed across a range of allied science disciplines, including chemistry, math and statistics and microbiology. That provides our students with a wealth of learning opportunities.

Q Tell me about your students

We tend to attract bright minds who want the challenge of science and engineering. These are independent thinkers who aren’t afraid to ask questions and challenge theories.

Many of our students already have strong leadership skills that they developed in high school – skills that they want to continue to hone once they arrive at Queen’s. Our student clubs are very active and they provide great opportunities for advancing those skills and forming lifelong friendships and synergies. Recently, our graduate students created their own association, both to offer social experiences and to provide important input to our graduate and seminar programs.

Q What are the biggest challenges for the program?

Enrolment in both our undergraduate and graduate programs has more than doubled over the past eight years – but our space and facilities have not. We are increasingly struggling to manage limited lab space and larger classes, and working against constraints such as fume hood capacity. Our students enjoy having a close relationship with faculty, and we want to maintain that experience for them but this is more challenging when there are classes of 150 students for core courses. We also want to be sure that we are providing the tools they need to learn and participate in leading edge research.

Budget is, of course, always a challenge – but we are constantly seeking out new partnerships that offer mutual benefit along with vital funding for our programs. We are also fortunate to have loyal and generous alumni who work to ensure our continued success.

Q What’s in the future?

We’re certainly not sitting still! This is a rapidly changing field, and we’re determined to maintaining our reputation for developing strong leaders in Chemical Engineering and Engineering Chemistry. Our programs have distinguished themselves on many levels – with the right resources, we can continue to grow and truly reach our full potential.
Can E.coli help prevent heart attacks?
Queen’s students use bacteria to win bronze medal in international synthetic biology competition

At first glance, the prospect of using E.coli as a medical treatment appears somewhat incongruous – after all, this bacteria typically conjures up images of food poisoning and product recalls. The Queen’s Genetically Engineered Machine (QGEM) team, however, recently won a bronze medal at an international competition by demonstrating how E.coli can be used as a novel way to treat atherosclerosis - and perhaps one day help prevent heart attacks and stroke.

QGEM’s multi-disciplinary team, comprised of students in Biology, the Bioengineering option of Chemical Engineering, Engineering Chemistry, Life Sciences and Biochemistry, competed against 110 international groups to win bronze at MIT’s annual synthetic biology conference. The competition challenges teams to develop a project in the rapidly developing and interdisciplinary field of synthetic biology and is based on a basic question: “Can simple biological systems be built from standard, interchangeable parts and operated in living cells?” Each team receives a kit of standard biological parts and works throughout the summer to create their project.

“Our team was incredibly focused and dedicated,” says Chemical Engineering graduate student Jonas Gerson, BSc’09, who helped to organize the team and raise money for the trip. “They really pulled together to create a solid competition entry.” The team, mentored by faculty from Chemical Engineering, Biochemistry, Biology, Microbiology and Immunology, Pathology and Molecular Medicine, used E. coli as an engineered microorganism to deliver beneficial drugs to the site of the plaque in arteries.

Gerson notes that synthetic biology, which combines molecular biology and engineering to construct biological systems, offers intriguing possibilities for Engineering and Applied Science students who collaborate with peers across the science spectrum. “The competition provides the perfect opportunity to combine talents,” he says.

Do you own a Kindle? You may not realize that Amazon.com’s popular new electronic book reader has a Queen’s connection.

For faculty in the Engineering Chemistry program, the Kindle is more than an evolution in reading – it’s an example of just one of the many ways that the program’s students are contributing to global development and innovation.

The flexible display technology that led to the Kindle was developed in part by Queen’s Engineering Chemistry graduates. Other graduates are employed in a wide range of industries developing products and processes such as sustainable chemical products, energy-saving manufacturing processes and automated systems for global water testing.

Unique in North America and Queen’s second-oldest engineering program, Engineering Chemistry offers a challenging education for motivated students who want to combine the mechanics of engineering with the pure science of chemistry. The departments that support the program are amongst the largest producers of intellectual property for Parteq, Queen’s renowned technology-transfer and commercialization office.

“We’re really combining the fundamental processes of engineering with the creative science of chemistry,” says Dr. Scott Parent, who graduated from the program in 1991. “Our goal is to teach students how to see the possibilities entwined within the two disciplines.” Despite a heavy workload that requires students to complete both a major engineering project and a chemistry thesis for dual accreditation, enrollment in the program has doubled over the past ten years.

Dr. Ralph Whitney says the program curriculum is designed to help students excel in many new areas of research and development.

“Our program teaches them how to develop creative approaches to these problems,” he says. “Once they learn to do that, they can take their education anywhere.”
The practice of alchemy might be considered by some to be an ancient discipline, long eclipsed by the modern methods of chemistry. But in the Queen's Engineering Chemistry program, researcher and Associate Professor Scott Parent, BSc’91, is practicing what he refers to as modern alchemy: transforming everyday commodity materials into advanced plastics and elastomers. He takes the same approach to educating our next generation of engineers – using modern teaching methods to transform them into creative, critical thinkers.

Dr. Parent’s research involves the chemical modification of polymers for use in specialty applications. “Large-scale commodities offer small profit margins,” says Parent. “We focus on creative applications of industrial chemistry to make these commodity polymers function in new ways.” Instead of turning lead into gold, Parent and his group are turning commercial grades of butyl rubber into anti-microbial derivatives, clean curing products, and strong-bonding adhesives for use in biomedical, automotive and packaging applications. These technologies were developed by Parent and Dr. Ralph Whitney of the Department of Chemistry in collaboration with Lanxess Inc, a global specialty chemicals company that has been manufacturing butyl rubber in Sarnia, Ontario since the Second World War. These new materials are showing great commercial promise, prompting Lanxess to purchase five patent families from Queen's University.

Parent, an alumnus, who has been with Queen's since 1998, applies the same philosophy to educating students. “Our students are naturally interested in applying the science of chemistry to solve practical problems,” he says. “Our role is to nurture that curiosity while helping them gain the tools they need to come up with creative solutions to challenging technical problems.”

Parent believes that the Canadian chemical industry is in constant need of new technology, and that researchers face an increasingly competitive and global environment. “Good ideas make the difference,” he says. He notes that Parteq Innovations, Queen’s technology transfer office, has worked hard to bring these ideas to market. He hastens to add, however, that the work is not solely about commercialization.

“It’s wonderful that we can bring money back to Queen’s through patent assignments and licensing,” he says. “But the real goal is to have a positive impact on the community by helping industry solve its problems, and by developing students that can put these solutions into practice.”

The recent 2010 Oil and Gas Speaker Series Conference attracted nearly a hundred Queen’s students eager to learn more about the oil and gas industry. The conference, held in January 2010, featured a number of leading industry professionals, including many Queen’s alumni who traveled back to campus to share their experiences with students.

Series organizer David Mody, BSc’88, noted that this event attracted students from a number of programs, including Engineering, Geology, Commerce, Law, and Arts and Science. “Students recognize the value of learning more about the vast opportunities in this industry – from exploration through to delivery and environmental remediation and protection,” he said. In a post-conference survey, 92% of the attendees indicated that they increased their knowledge about new opportunities in the oil and gas sector.

For many, it was also a chance to meet alumni who could provide valuable advice about post-university life. “We were thrilled to welcome back many successful alumni who work in this industry,” says lecturer Mody. “They are excellent role models, and our students are exceptionally fortunate that our alumni travel from far and wide to help them. Now that’s Queen’s spirit!”

The Oil and Gas Speakers Series is supported with generous donations from Shell Canada, Paramount Energy Trust, Encana, and Suncor. For more information, please visit: www.oilandgas.chemeng.queensu.ca.
Alumni fund offers life changing experience

A fourth-year Chemical Engineering student who spent eight weeks abroad to educate youth about HIV and AIDS says the experience has had an incredible impact on his life and his education. Bryan Hoy traveled to Kenya last year through the alumni-funded Centennial International Exchange Endowment Fund on an outreach project designed to bring international students together in a quest to improve global health for the next generation.

Hoy originally traveled to the region with his family at the age of 12. “During my first visit, I wasn’t really aware of HIV/AIDS and how it was devastating this region,” he says. “This time, I wanted to face the issues and make a difference.”

Hoy traveled to Kenya as part of Queen’s Health Outreach (QHO), a student-run charity on campus that promotes health awareness and education around the world. Currently the group runs projects in Kenya, Belize, Guyana and northern Canada, and a local project in Kingston. QHO has been operating on campus for over 20 years.

In Kenya, QHO partners with the Youth Empowerment Strategic Scheme, a Nairobi-based association of university students who work with Queen’s students to develop curriculum and materials based on a range of topics including HIV/AIDS, responsible sexuality, abuse, life skills, gender and discrimination, self-esteem and empowerment. In the classroom, the students pair up – one Kenyan, one Canadian – to teach students in secondary schools. Teams spend a week at each of five secondary schools in rural Kenya.

Hoy notes that the trip has given him a new perspective on global health issues, as well as a first-hand view of the diversity of various cultures. “The trip really opened my eyes to how different things can be in another part of the world,” he says. “It’s definitely been a valuable component of my education.”

The Centennial International Exchange Endowment Fund was founded by alumnus Jerry del Missier, Sci’85. It provides grants to full-time undergraduate students in Chemical Engineering and Engineering Chemistry to enable them to gain international experience outside the traditional classroom environment. Mr. del Missier was inspired to donate the money after he spent a summer overseas in Italy in the midst of his undergraduate studies in chemical engineering at Queen’s.

SHELL MAKES TEAM, WORK!

Queen’s is proud of its academic programs – but every professor knows that there’s nothing like a taste of the world outside the university to help students better understand their education and career goals. At Queen’s, a novel fourth year course that links industries with students offers great opportunities for students to develop connections, work with peers in multiple disciplines, and contribute their expertise and ideas to real projects and problems.

The Queen’s Technology Engineering and Management (TEAM) Program – Empowered by Shell Canada provides an opportunity for students in their fourth year to work in interdisciplinary groups on projects ranging from carbon sequestration to manufacturing vaccines. The course is available to all Queen’s faculties and has attracted students from a number of programs, including commerce, law, environmental studies and biology.

“This is definitely a win-win situation,” says Dr. Jim McLellan, the Head of Chemical Engineering and Engineering Chemistry. “Our students get to work on projects with real impact, network with industry partners and learn more about different sectors. And our industry partners get to work with motivated, creative students, possibly leading to career opportunities.”

TEAM is an expensive program to mount, and Shell Canada’s investment helps make it possible. Shell invested $400K for a three year period in 2005, and a further $400K for a three year period beginning in 2009. In addition to Shell’s financial support, Shell employees are actively involved with Queen’s faculty and students through the Campus Ambassador Program (CAP), providing project ideas and employee mentors who work with students in a number of courses.

“The Shell CAP team is known within Queen’s for their enthusiasm and support for their alma mater” observed Jim McLellan, “and we are extremely grateful for the support that they have provided.”

“We are proud of our involvement with Queen’s and the success of TEAM,” said John Courtright, Managing Counsel, Heavy Oil, Shell Canada Limited and Queen’s CAP Team Leader. “We want to provide the best support for students and institutions as well as expose our company to the best and brightest new graduates.”

Students apply to TEAM in their fourth year. TEAM projects range from assessing techniques for carbon capture and storage during steam-methane reforming to produce hydrogen, to assessing the potential of gasification/methanation of mountain pine beetle wood for providing an alternative energy source for oil sands processing, to developing mathematical models to predict the recovery of trace metals in electronics such as cell phones and flat panel televisions. Last year, a TEAM group investigated strategies for avoiding industrial accidents – a successful project that was published by the Canadian Society for Chemical Engineering as an official report.

During the course, students work closely with industry professionals, traveling around the world to meet clients and learn more about their chosen field of study. Contacts with the companies provide ongoing mentoring throughout the project, helping students develop critical project management, leadership, business and communication skills.

Given the benefits, McLellan says it’s no surprise that the program has grown dramatically since its inception. “We’ve grown from 64 students working on 14 projects four years ago to 124 students working on 31 projects this year,” he says. “It’s very clear that students see the value of this experience.”
The first floor of McLaughlin Hall contains one of Queen’s best-kept secrets: a fabrication facility and engine lab packed with state-of-the-art equipment that mechanical engineering students learn to use as they work towards their undergraduate degree.

Many aspiring engineers work with manufacturing equipment like this after they graduate. Given this fact, it’s surprising that this facility at Queen’s is a rarity. “There is similar equipment at other Canadian universities, but none have a fully fledged laboratory program for students, staffed with technicians,” says Manufacturing Engineering instructor Dr. Jack Jeswiet. “Other institutions who are contemplating starting their own programs have sent people to visit us, and they’re absolutely floored by what we have and do here.”

The equipment inventory is indeed impressive. The shop/lab contains lathes, mills, drills, grinders, simple sheet bending tools, arc and spot welders, measuring tools and a FARO arm which laser-scans parts. Also included are a Rapid Prototype machine and a water-jet cutting machine – both funded by alumnus Donald McGeachy Sc’40 (Mechanical) in 2007. Although some equipment is manually operated, most are Computer Numerically Controlled (CNC), meaning that, after designing a prototype part using a Computer Aided Design (CAD) program, students can use another program to digitally specify the machine’s “tool-path” – the cut it’s supposed to make – with extraordinary precision. It’s the kind of technology that increases productivity. “You can program it, stand back, and off it goes. You just have to know what you’re doing,” says Jeswiet. It all means students can make both prototypes and actual parts.

The students get their initial hands-
on exposure to this advanced technology through a mandatory second-year core course, Mech 213, which gives them two hours with each device in ten manufacturing laboratories. The shop supervisor, Andrew Bryson, four other staffs and teaching assistants are there to offer guidance during the labs.

One floor down from the machine shop is the Engine Lab. Its primary users are the Formula SAE team, a student squad that each year designs and builds a sleek, single-seat race car with which they compete in a prestigious annual international design and track-test competition. The Engine Lab’s centerpiece is a dynamometer that allows the students to tweak engine parameters – such as air-to-fuel ratio and timing – and measure changes to power output in real time in order to calibrate the engine for maximum performance. “It’s a really sophisticated piece of equipment,” says Dan Chown, the Formula SAE team manager. “There’s no way we’d ever get to train on one this good unless we were in a professional setting.”

Machine shop supervisor Bryson says “the training is both invaluable and inspiring, since many students later spend countless hours in the labs building the Formula SAE car, the Mini-Baja racer and other extracurricular design projects.” (And with some success: the Mini-Baja team won first prize last year, beating all other mainly North American Engineering schools.)

Equipping, maintaining and staffing such top-notch facilities is expensive – but it’s money well spent. It gives Queen’s ME students a high quality education and brings together theory and practice.

“Our students come out knowing, when they design something, how it’s actually going to be built,” says Bryson. “They’ve been in the machine shop, they’re aware of the smells and the noises and everything else, so when they get to a machine shop they’re more confident when they’re around these big pieces of equipment. They also know how to speak the language of the machinists on the shop floor. In my opinion, learning those things brings a more well-rounded engineer out to society.”

The machine shop is sponsored by Sci’62 and Sci’73 along with many partners from industry.

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**North American World Robotic Sailing Championships Coming to Kingston**

The Sailbot and the World Robotic Sailing Championships are unusual regattas in which student teams race sophisticated self-navigating sailboats that the teams design and build themselves. Respectively, they are the North American and European showdowns for the best robotic sailboats in the world, and this year Queen’s will host both contests. Queen’s Sailbot squad, dubbed the Mostly Autonomous Sailboat Team (M.A.S.T), experienced technical setbacks at last year’s competition in Annapolis, Maryland and finished in the middle of the pack. This year, says team manager Marc Burnie, they’ve designed a new boat from scratch and expect to fare better. The 2010 regatta may include up to 10 teams – the most ever – and will be held at the Kingston Yacht Club from June 7 -10.

M.A.S.T is supported by Sci’68 and Sci’67, as well as many industry partners.
New Prof formulating a safer future

The most recent generations of nuclear reactors – including G-IV fission reactors and fusion reactors such as International Thermonuclear Experimental Reactor (ITER) – are designed to generate more power and fewer toxic byproducts, and nuclear energy proponents say the more efficient plants will be necessary in the future to meet the world’s insatiable demand for electricity and reduce greenhouse gas emissions. The major technical hurdle lies in the fact that the new reactors burn nuclear fuel at significantly higher core temperatures – as high as 600 degrees C, as opposed to about 300 degrees C – than traditional heavy-water reactors such as the Canadian-made CANDU. Since joining the Department of Mechanical and Materials Engineering in August 2009, Dr. Zhongwen Yao and his colleagues in the Nuclear Materials Research Group have been collaborating with nuclear testing facilities around the world to develop ways to formulate metals used in nuclear reactors – including steel and alloys of zirconium, nickel and graphite – more resistant to high temperatures and corrosion resulting from constant bombardment by neutrons and other nuclear-reaction byproducts. “New reactors are definitely the hope of humanity,” says Yao. “But they have to be safe, and we’re trying to make that happen.”

The Dynamic Field of Fluid Dynamics

Mechanical Engineering Professor Ugo Piomelli is the first to admit that when you think “sexy subject”, computational fluid dynamics (CFD) is probably not the first thing that springs to mind. But if you talk to Piomelli, the HPCVL-Sun Microsystems Chair in Computational Science and Engineering, you’ll soon realize that his field of research affects us all. Fluid dynamics studies the motion of liquids or gases, and computational fluid dynamics is the discipline of using powerful “supercomputers” – like the High-Performance Computing Virtual Laboratory headquartered at Queen’s – to perform the complex calculations necessary to predict the flow behavior. This is Piomelli’s specialty – he also holds a Canada Research Chair in Computational Turbulence – and the theoretical knowledge he produces helps people develop better airplane wings, understand how bottom sediment builds up and moves in ocean harbours, how weather patterns form and how blood flows through our veins. Piomelli came to Queen’s in the summer of 2008 from the University of Maryland and was recently made a fellow of the American Society of Mechanical Engineers.
“Can you hear me now?” Researcher traces telecommunications woes to solar activity

Don’t blame your service provider the next time an important cell phone call ends abruptly. The culprit could be the sun.

In 2007, Queen’s University Engineering Math Professor David Thomson and his team of researchers concluded that during huge solar eruptions, phones using cell phone towers with antennas facing the sun showed a higher rate of dropped calls.

Dr. Thomson began working on the problem while at Bell Labs in the United States, continuing his research into the effects of solar radiation on telecommunications as Canada Research Chair in Statistics and Signal Processing in Queen’s Department of Mathematics and Statistics. Solar radiation and other solar activities affect the electron content of the ionosphere which in turn affects various radio frequencies used in telecommunications.

One of his key research tools is a solar radio telescope designed to operate within the communications bands. After repairs, the observatory should be back in use atop Jeffery Hall this summer. While it may not be the optimum choice, “it would have been nicer to have it out in the middle of nowhere, but for convenience and getting students to work, having it here made a lot of sense”. There’s no shortage of work for Queen’s researchers who will be assisting with the upgrade and redesign of the solar monitoring program at the Dominion Radio Astrophysical Observatory near Penticton, B.C., as well as interference cancelling problems.

Solar radiation affects more than just cell phones.

In March of 1989, a major solar flare eruption blasted the earth’s atmosphere with a wave of ultraviolet and X-ray radiation creating a surge of charged particles and electrons triggering the collapse of the Hydro Quebec grid. Six million people spent nine hours without power.

At the moment Thomson explains we understand “quite a bit and not very much” about how the sun works. “For example, we don’t even know the rotation rate of the sun’s core.”

The sun has an 11-year activity cycle with two extremes; solar maximum and minimum. Solar Max features more sunspots and solar flares with the increased risk of power blackouts, fried satellites and malfunctioning GPS receivers. Activity has been picking up for the past few months with the next solar max expected in 2012.

A graduate of Acadia University and the Polytechnic Institute of Brooklyn, Dr. Thomson arrived at Queen’s in 2002, after 36 years at Bell Labs. “I started off in physics, switched to electrical engineering, and then moved more into statistics and data analysis. My career continues to be a lot of fun.”
Picture a human hair. Now imagine something 100,000 times smaller. That’s the realm of nanotechnology, a relatively new and rapidly growing aspect of science and engineering which involves controlling matter on the atomic and molecular level.

On the metric measurement scale, a nanometer is a unit of length equal to one billionth of a metre.

While the terms “nanoscience” and “nanotechnology” were first coined in the late 1990s, the concept dates back to 1959 with a visionary speech by American physicist Richard Feynman entitled “There’s Plenty of Room at the Bottom”.

Feynman, who won the Nobel Prize for Physics in 1965, is also credited with pioneering the field of quantum computing.

Dr. Stephen Hughes at Queen’s heads one of several Nano Research Groups within the Department of Physics, Engineering Physics and Astronomy. Hughes is an Associate of the CIFAR (Canadian Institute for Advanced Research) Nanoelectronics program, and his research specializations include Nanophotonics and Semiconductor Quantum Optics.

He describes Nano as a relatively unexplored technology involving an entire spectrum of science from chemistry to biology, engineering, and physics. Hughes calls it a hybrid zone tapping into all those different areas. Inevitably, as devices continue to get smaller and smaller, technologies will have to exploit nano effects that traditionally belong in the domain of physics, such as quantum mechanics. This is why Engineering Physics students at Queen’s are so well equipped to contribute to nanotechnologies. Engineering Physics students get to learn the root of why things work, as well as just how we can get them to work better, or explore new technologies.

There are plenty of challenges. One of the biggest is how to make nanostructures or nano-sized things in a controllable way.

According to Hughes, “we can see nanoscale structures and objects, but actually trying to manufacture them, in a controllable way, is very,
very difficult. At the moment it is still out of reach, but advances are being made every month.”

Dr. Alastair McLean, who heads another nano research group within Stirling Hall, designs and builds scanning tunneling microscopes to study the properties of surfaces and nanostructures. Scanning probes allow us to see things that were, prior to 1980, hidden from view. At this time a curtain was raised and the atomic structure of surfaces and materials became visible. This advance was made possible by an instrument invented by Binnig and Rohrer at the IBM research laboratory, Switzerland.

A staple of science fiction since the term first came into use; nanotech is on the verge of becoming a reality and has already had a dramatic impact on the computer industry. For example, the nanoscale phenomenon of Giant Magneto Resistance (GMR) lead to the dramatic miniaturization of hard disk drives, for which Albert Fert and Peter Grünberg won the 2007 Nobel Prize in Physics. Meanwhile, the latest Intel chips have transistors that measure just 40 nanometres.

As Hughes explains, “As chips and other devices become smaller and smaller, eventually you will start to change the underlying physical properties of how the device works. The question is can you do something different or unique by going to that smaller scale? GMR is an excellent example of fundamental nanophysics research revolutionizing the technologies we use in every day life.”

In July of 2008, Hughes and another Queen’s physicist Dr. James Stotz, together with collaborators at National Research Council of Canada, University of Victoria, University of Waterloo, and the University of British Columbia, received almost $4.2 million in funding for a project to develop novel sources of light that could radically change the landscape in secure communications over networks. Their project, entitled “Nanostructure Single and Entangled Photon Sources for Quantum Information Processing” was one of five of the 50 submitted proposals funded by the Natural Sciences and Engineering Research Council (NSERC), the National Research Council (NRC), and the Business Development Bank of Canada (BDC). The nano research team, co-lead by Hughes and NRC Scientist (and Queen’s Adjunct Professor) Robin Williams, aims to combine unique, “nano-sized” electronic and photonic structures that use single photons (particles) of light for new computing and encryption technologies.

Two years into the project, Hughes says that their multidisciplinary team of scientists and engineers has shown some major successes in the ability to manufacture, understand, and design nano-scale objects (semiconductor quantum dots), which can now trap and manipulate single electrons and single photons simultaneously.

The result could be completely secure communications, guaranteed by the laws of quantum mechanics. Such quantum light sources are also an important first step toward chip-based quantum computing.

Hughes describes nanophysics as a no-man’s land between classical and quantum mechanics, and envisions that future applications are limitless. Indeed, there is already compelling evidence to suggest that nanoscience and nanotechnology will be the science and technologies of this century.
The sky’s the limit for Colette Heald, Sc’00

Since graduating from Queen’s in 2000 with an undergraduate degree in Engineering Physics, the Ottawa native has earned her doctorate in Earth and Planetary Sciences at Harvard University and spent two years as a postdoctoral fellow in the U.S. National Oceanic and Atmospheric Administration (NOAA) Global Climate Change program at the University of California in Berkeley.

Dr. Heald is currently an Assistant Professor in the Department of Atmospheric Science at Colorado State University in Fort Collins, Colorado. Her research focuses on understanding the composition and chemistry of the troposphere, which is the lowest layer of Earth’s atmosphere and the place where almost all weather occurs.

Q Where did your interest in science come from?
I have always enjoyed the problem-solving aspect of science – that it isn’t about knowing the answer right away, but knowing how to put the pieces together to find the answer. I actually struggled to decide what I should specialize in at university. I have always loved history and literature as well as science and it was a tough decision to make, particularly since the demands of the engineering program left little time to take extra classes in the humanities. When making this decision, my sister told me, “You can always read and learn about history and art as a hobby, but it’s tough to do science on the side.” That decided me!

Q What attracted you to Queen’s, and how did that initial university experience shape your future?
Queen’s was a great fit for me. It offered a strong engineering program as well as a great community with wonderful school spirit. I knew the engineering physics program would be challenging, so I wanted to be somewhere that would encourage me to get out and have fun as well! I think Queen’s taught me the value of keeping that balance in life and I try to keep that alive every day.

Q How healthy is the Earth’s atmosphere, based on current pollution levels?
The health of the atmosphere depends on where you live. Folks living in mega-cities like Beijing and Sao Paulo are subject to unhealthy levels of ozone and particulate matter and this smog has been linked to impaired cardiovascular performance, asthma, and, ultimately, reduced life expectancy. Atmospheric pollution can also reduce agricultural productivity, degrade visibility, and harm natural ecosystems – for example, through acid rain. Primary pollutants are regularly monitored for these reasons, and weather forecasts are now starting to include an air quality index so that people can consider this kind of information before planning outdoor activities.

Thinking about the “health” of the atmosphere is a bit tricky, as you might want to know how much of an impact humans have had on the atmosphere. This brings up the issue of all the carbon gases, particularly greenhouse gases such as carbon dioxide and methane that we have been emitting into the atmosphere. These gases serve as a blanket that essentially re-radiate [heat] back to the Earth’s surface and warm the climate. Because these gases are long-lived, even if we stopped emitting today it would take many years for our atmosphere to recover to “natural” conditions.

Q CU’s Atmospheric Composition and Chemistry web page includes a bit of Canadian content other than you. One illustration shows an American satellite with a Canadian instrument called MOPITT (Measurements of Pollution in The Troposphere). Would we be able to understand what’s going on in the atmosphere without satellite data?
Satellites have revolutionized our understanding of the atmospheric composition. Some of the best examples of this are the pictures of the stratospheric ozone hole over the Antarctic that were produced from NASA’s TOMS instrument in the early 80’s. Today’s instruments track pollution in the lower atmosphere as well (including the Canadian MOPITT instrument), and these are invaluable for mapping a global picture of pollution that is changing day-to-day. In particular, there are a lot of remote regions of the world where surface monitoring is not possible, including the oceans. Satellites allow us to track pollution plumes as they travel long distances, even from one continent to the next. These measurements help us put together the larger picture of pollution sources and their effects far down-wind.

Q Given your area of expertise, what do you make of the global warming/climate change naysayers who claim it’s based on faulty or inexact science?
Understanding the climate system is a real challenge. It’s complex, and not the kind of system we can just test in the lab. However, climate scientists have studied this problem for many years and I think they are best qualified to assess the state of the science.

I am a strong supporter of scientific consensus and believe that the scientific ethic of searching out the truth is strong. The climate issue is controversial because there are tremendous policy and economic implications, but it’s important that we separate the science and the politics and consider the source of information when filtering through the arguments on this topic.

At the 2006 International Young Scientists’ Global Change Conference in China, Colette Heald received the honorable Professor Crutzen Prize for best paper. About 100 conference participants from 35 countries were selected from over 700 applications by an international review panel.
How can we save our planet and ourselves? After almost two centuries of environmental and human exploitation with little forethought to renewal, how can we ensure that the work and growth of humanity is thoughtful, respectful, and aimed at conserving resources for future generations?

Many feel the answer lies in one word: sustainability.

But what does this word actually mean? For Dr. Anthony Hodge, Queen’s first Kinross Professor in Mining and Sustainability, it’s “not just a greening concept, it’s got to do with human well-being, too.”

That philosophy is the heart of one of the most exciting and cutting-edge courses in any mining department, Mining and Sustainability. According to department head Dr. Laeeque Daneshmend, the idea for the course originated about five years ago when he and his colleagues realized that, more and more, the challenges their graduates faced on the job consisted of more than just technological problems – they had broader dimensions that required a different type of knowledge.

“They have to be able to understand the societal, economic, and social justice issues that come up very early on in the lifecycle of a mining project, issues integral to an ethical way of practicing engineering,” says Daneshmend. “They have to learn how to communicate with stakeholders. We were looking for someone who could provide strength and wisdom in that area.”

Hodge’s passion for sustainability has ignited the imagination and innovation of Queen’s mining students, but also galvanized key global mining companies and leaders in committing themselves to sustainable practices.

Eighteen months after his Queen’s appointment, Hodge was appointed President of the International Council on Mining and Metals (ICMM), a collaborative of 19 mining companies that serves as a change agent across the industry.

“We look at mining in the context of its contribution to the spectrum of issues that link human and ecological well being,” explains Hodge. “We also involve people outside mining – such as indigenous groups, academics, civil society organization workers, government, and other thinkers and practitioners interested in the issues – to collaborate on finding solutions and designing best practices. We demonstrate through practice that social justice, environmental, and human-relationship issues are integral not only to mining, but to other industries as well.”

“Everything Dr. Hodge talks about is from first-hand experience,” says Daneshmend, noting that his colleague has been to the World Economic Forum in Davos and regularly meets with the board at ICMM, which includes the top miners in the world. “He knows the practical issues they face. This perspective brings tremendous value to the department and the students.”

“The early thinking on sustainability was dominated by controlling inputs in order to yield certain outputs,” says Daneshmend. “For mining, that’s hopeless because the natural system is so complex. Every mine is different. You need to tailor everything for local conditions.”

For instance, the long time horizons for a mining project – from decades of exploration, to potentially hundreds of years of restoration after the mine is closed – means companies must consider the long-term environmental, political and social impacts of their activities. “For example, putting in a road that provides access to land previously inaccessible can have huge environmental implications,” says Daneshmend. “In the continued on next page
For three grueling days in February, a dozen Queen’s mining students competed with their peers from across the nation at the annual Canadian Mining Games – the Olympics of Canadian mining departments – at Dalhousie University in Halifax.

Student-organized and generously sponsored by mining companies including Teck Resources, Suncor, Orica, Hatch and the Canadian Institute of Mining and Metallurgy; the main events included mine design, ventilation, drilling, mineral processing, mine rescue, rock mechanics and mechanical design.

In the mine rescue event, the sponsoring company set up a scenario in which someone is injured or trapped underground. Each team got to role-play a rescue and demonstrate their safety knowledge while their rescue efforts were timed.

“The games are fun, and also a great networking opportunity,” says Maegan Ayotte, a fourth-year mining student who captained the Queen’s team. Her teammate, Jim Duncan, a second-year mining student, who participated in an AutoCAD competition to create a mine plan and in a “mystery event” that turned out to be rock climbing, enjoyed chatting with company reps at mealtimes. “It was a great experience,” he says.

Students hoping to land a spot on the team submit their names to a lottery, and most team members come from fourth-year mining – but neither seniority nor marks are criteria for choosing the final roster. “Grades are not necessarily the best way to judge potential performance, especially for the practical events,” says Ayotte. “We include a few second- and third-year students to give them experience.”

Like any competitive sport, training is required. “Two students went to the Norcat training facility in Sudbury to get experience on the jackleg drill [a 120-lb mining-specific drill],” says Ayotte.

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“Our team did well this year, although the University of Alberta was the overall winner,” says Ms. Ayotte. The prize? A trophy and bragging rights.
As winter in Kingston deepened its grip in early February, 44 Queen’s Mining students and professors flew to warmer climes and an eye-opening adventure in Chile. ‘Field trips bring a lot of additional value, because they bring the practice rather than the theory of mining into the program,’ asserts Ursula Thorley, a doctoral candidate in mining. “Chile has a long history of mining, just like Canada, but the mining is not the same. It’s important to expose students to different standards and approaches than they would see in Canada,” adds Chambers’ classmate, Maegan Ayotte. Another difference, says Chambers, “is that some mines get sunshine year round and don’t have to deal with snow.” McIsaac adds, “But it does snow at 4,000 metres, sometimes up to ten feet in a day, disrupting operations for periods up to a week.”

Travelling approximately 800 KM north to south over the course of two weeks, the students visited eleven projects, ranging from large underground or pit mines to smaller operations with unique characteristics. They also visited one manufacturer and heard talks about two more projects.

“One of the mines produces 140,000 tonnes of ore a day. In Canada, we produce 3,500 tonnes a day underground,” says McIsaac. Ms. Thorley adds, “Chile has world-class copper deposits. It was a great opportunity for students to see hard-rock mining and metal extraction and apply what they learned in the classroom.”

Oscar Rielo, Mining Technologist, describes the problem-solving strategies and resourcefulness in Chile as “beyond anything I’ve seen,” such as the flotation method that took advantage of a waterfall. “The waterfall provides a sustainable source of energy and does not require maintenance.”

Of particular note for many of the students were the safety standards. “The mine operations are orderly, clean, and take the right precautions when people go underground,” observes Ms. Ayotte.

Dr. Laeeque Daneshmend, Head of The Robert M. Buchan Department of Mining, made sure resources were available for the trip to happen. “Field trips to distant places not only expand students’ technical horizons, but also provide some measure of cultural exposure.” In addition to ensuring everyone’s safety on the trip, Mr. Rielo, who is from Argentina, also facilitated the cultural experience.

Barely a week after the students returned, the infamous earthquake measuring 8.8 on the Richter scale hit the area. Ms. Thorley reports, “Nearly every mine we visited spoke of their earthquake preparedness with respect to design choices.” With a sigh of relief, Daneshmend adds, “We’re just glad they all came back safe and sound!”

Field Trips
Give Mining Students a Global Prospective
Finding innovative ways to build things – and to ensure they last, or can be effectively restored or repaired – is a cornerstone of civil engineering. And a group within Queen's Civil Engineering Department is doing just that by experimenting with fibre reinforced polymer (FRP), a space-age material that could be a game-changer in the construction industry.

**Material Applications**

Dr. Mark Green, BSc’87, a leading Queen’s FRP researcher, says the material can serve as an alternative to steel reinforcement in new construction. It can also be used to strengthen and repair structures where concrete has deteriorated or that must be altered for a different use – for instance, an old bridge that needs to carry heavier vehicles, or a roof or building that must be rebuilt to bear a heavier load.

“This material is actually aerospace technology,” says Dr. Amir Fam, a Canada Research Chair in Innovative and Retrofitted Structures at Queen’s who specializes in FRP structural applications research.

Civil engineers have used FRP for the past 15 years or so in a number of forms: as a sheet or plate, a stay-in-place form, a tube, even as a spray. The supports of the Route-40 bridge in Virginia, for example, are made from concrete-filled fibreglass tubes with no internal steel reinforcement – the first project in which the tubes have been used in this type of construction. Fam says piles, footings in the ground, made of unreinforced, concrete-filled FRP tubes support hundreds, if not thousands, of other structures (such as piers) across the U.S..

Another FRP application – stay-in-place forms – represents a huge step forward in building innovation. “Traditionally, forms have been made of wood and steel and are stripped away once the concrete has set,” says Fam. “The FRP stay-in-place forms are not removed, which makes them structural as well, since they can replace steel.”

**Material Benefits**

The two greatest advantages to FRP are its durability and its ease of application. Unlike steel, it doesn’t corrode. Also unlike steel, its application doesn’t require heavy equipment: it is very light and can be handled by a few individuals with no specialized gear.

Green says these features offer enormous benefits for structural rehabilitation. Stay-in-place FRP forms save time and money because less labour is required to strip off wooden or steel formwork. This translates into faster construction times. Also, since builders using FRP don’t require internal steel reinforcement, they cut the costs of materials.

FRP also protects concrete from aggressive environments and substances such as salt water, ice and road salt. And when FRP is used to contain concrete, it fortifies the supported structure. “The more you confine concrete, the stronger it gets,” says Fam.

**From Fire to Fibre Optics**

“An important piece of the work that Queen’s is doing is looking at innovative ways to insulate FRP so that it can perform better in a fire,” says Kent Novakowski, Head of Department for
Civil Engineering, “We are one of the few groups in North America doing this work.”

The innovations around FRP extend beyond material applications. As a partner in the federal Networks of Centres of Excellence Program, the research team was a major player in the Intelligent Sensing For Innovative Structures (ISIS) project, which combined fibre-optic technology with FRP so that the material can be used to not only increase the carrying capacity of structures, but also to monitor how well those structures perform in the field.

Green is also planning a strategic collaboration with a new faculty member, Dr. Neil Hoult, and researchers at the Universities of Ottawa and Toronto to integrate advanced fibre-optic technology into smart monitoring of the health of highway bridges.

**Slow Adoption vs. Strong Influencers**

Although FRP has been widely and successfully tested in the field over the last 20 years, it is still a relatively new material that has not yet been adopted by the construction industry.

“The industry is conservative because it is concerned about public safety,” explains Fam, “It takes time for things to happen. But we have a good track record from the bridges built in Canada and the United States.”

To ensure Queen’s engineers consider FRP as a viable option, graduate and undergraduate courses expose students to the material in a variety of ways. “We have the strongest research group in the country working in this area,” asserts Green.

Both Green and Fam are also in positions of influence, which helps to increase awareness and knowledge about FRP technology. Green sits on a code committee for FRP structures at the Canadian Standards Association (CSA) and helps develop standards and regulation documents for building codes. He also chairs the Canadian Society for Civil Engineering (CSCE) Technical Subcommittee on Advanced Composite Materials and co-chairs the American Concrete Institute (ACI) subcommittee 440-F on Repair with FRP. Fam, meanwhile, chairs an ACI committee called 440-J FRP Stay-In-Place Forms.

![Queen’s among the top sliders at the 36th Annual Great Northern Concrete Toboggan Race](image)

**At the end of January, 31 Queen’s students from diverse academic backgrounds proudly donned gold engineering jackets, kilts and tam o’shanter hats to compete in the 2010 Great Northern Concrete Toboggan Race. Held at McMaster University in Hamilton, Ontario, it’s the oldest and largest engineering competition in Canada.**

The Queen’s team did their school proud. Their concrete design finished a close second, and the team members received high marks for their technical display, report and presentation. Queen’s finished just off the cherished podium, placing fourth overall. Not bad, considering that the competition included 400 competitors from 19 other Canadian universities.

Queen’s has consistently ranked among top five teams at the toboggan race, a crowd-pleasing event that was established in 1975. “Given the tough competition this year, our finish was very impressive,” says team member Heather Murdock. “Everyone worked tirelessly this past year, especially in the three months leading up to the competition, and our energy in Hamilton was unsurpassed.” Indeed: Queen’s took home the Best Team Spirit prize for the second year in a row.

Team captain Nathan Murdoch says Queen’s newfound experience and understanding of where it needs to improve just might produce a winning entry in 2011. “I think this team has a great opportunity to challenge for first place at next year’s event.”

Media sources including Radio Canada, Global News and CTV News and a variety of local newspapers covered both the competition and the team. A few Queen’s members were also interviewed by Kingston radio personality Brian Scott for the FLY-FM morning show.

The Queen’s Concrete Toboggan Team would like to thank MetalCraft Marine, the Science ’70 Alumni, Three Streams Engineering, Calfrac Well Services and all of its sponsors for their continued support.

![The Queen’s team](image)
A pair of Queen’s engineering grads are a heartbeat away from delivering a device that will save lives by detecting previously unnoticed signs of heart disease and reduce its staggering economic cost.

Mike Kulesza (Electrical Engineering’06) and Sami Torbey (Computer Engineering’06) are the founders of Ocorant Inc., a medical device company rooted in design projects the students completed in their fourth year. The two later teamed up to develop a heart monitor and business plan that won the 2007 Queen’s Entrepreneurs’ Competition and $15,000 in seed capital.

Since then, however, the project has evolved to meet a need that emerged during the development stage in collaboration with the cardiology research team at Kingston General Hospital (KGH).

“We started with one idea and another came up that would allow our technology to be proven,” explains Kulesza. “The device – that we call the ‘Synapse’ – and its base design comprise a cardiology research platform that can be adapted to meet custom research and clinical needs.

“It’s the first machine of its kind. It will be used by cardiologists to uncover new insights and dispel assumptions when interpreting electrocardiograms (ECG). We have developed the software to help analyze the ECG signals, so that instead of taking hours to scroll through lengthy ECG recordings, doctors will be automatically directed to the trouble spots.”

The device will bridge a critical gap, says Kulesza.

“Because current devices don’t provide enough information, a lot of patients are misdiagnosed – thought to be low to moderate risk until they have a heart attack. We can uncover critical information which will help lead to earlier, life-saving diagnoses.”

The device is now in its final testing stage and will be delivered this spring. It will be key to Ocorant’s development of a mobile (wireless) heart monitor that will allow a complete long-term, high-resolution recording of every heartbeat, with automatic symptom recognition and faster, more accurate interpretation of results. Also in the works is a mobile heart monitor vest designed in collaboration with students from Toronto’s George Brown College’s Nursing, Engineering Technology and Fashion Technology programs, that may be worn discreetly underneath clothing for up to 30 days.

Kulesza, Ocorant’s Chief Technology Officer, says the past two years have been a huge learning experience for him and Torbey, but notes that the Queen’s Engineering program had prepared them well. Now that they are on the verge of delivering their first device, their excitement is palpable.

“I’m looking forward to it,” Kulesza says. “The team at KGH is at the forefront of the cardiology research, and we get to enable that. Heart disease affects a lot of people and most times it is preventable. We have the ability to do something about it.”

ECE grad hands off OLYMPIC TORCH to Queen’s

It was over in less than a minute, but what happened in that brief time will take pride of place forever in the memory of Queen’s student Siavash Khallaghi and in the halls of the Faculty of Engineering and Applied Science and the Department of Electrical and Computer Engineering (ECE).

In that minute Khallaghi, an ECE grad student studying medical imaging processing, ran – or, as he describes it, “flew” – 300 metres, with the Olympic torch held aloft in one hand and a smile on his face that radiated from ear to ear.

Khallaghi ran his leg of the relay on November 15 in Trenton, cheered on by hundreds of school children who lined the street.

“I felt like a gold medalist,” said the 23-year-old from Tehran, who is in his second year of a Master’s program at Queen’s ECE.

“There was a feeling of glory, a feeling of...
A team of Electrical and Computer Engineering (ECE) students is venturing into the world of hackers, crackers and cyber attackers, and what they're finding there could propel them to the top of the job market and improve computer security in ways yet to be imagined.

The Network Security Student Team was established last year by ECE Associate Professor Dr. Thomas Dean, PhD’94, who researches computers and networking. “Network security is probably one of the most important areas in software engineering,” says Dean. “Although I cover it in my courses, the security team students get to really get their hands dirty.”

The explosion of the Internet and the emergence of “hackers” over the past decade have pushed the security issue to the forefront, explains Dean. “The whole game has changed. Whereas before it was one person in a basement attacking IBM, this type of crime is now very organized. There are people who just ‘collect’ home machines; they break in and install software that sends out spam, launches service attacks or overwhelms other computers. They can even store illegal material on your computer without you knowing about it.”

Dean compares the fight against cyber-crime to warfare, with defenders and attackers. “The advantage goes back and forth,” he says. “We’re trying to stay ahead of the attackers.”

The members of the Network Security Student Team are the good guys, or “white hat hackers”. In a controlled environment in Walter Light Hall, they learn to test computer security and build defences against “black hat hackers” or “crackers” – the covert criminals who break into computer systems for illegal purposes.

“We look at proven attacks and we develop the software ourselves, so we can see how it works,” explains team leader Sean Alexander, a fourth-year ECE student.

So far, team members have written code for various attacks including a unique, brute-force password cracker. Now they’re turning their attention to PlayStation 3 attacks, WiFi signal enhancement, Blackbox security analysis and smart-phone security.

Working on these projects gives the students a whole new perspective and is a great supplement to book-reading, says Alexander. “It lets them explore technologies that are now heading towards a big intersection with security.”

The success of the team will be gauged by the students’ skills and, incidentally, by the software vulnerabilities they discover. Already, says Dean, two members have found vulnerabilities, including one that allowed access to private information on a commercial website.

“Another measure [of success] will be where the team members end up after they finish their degree, whether in grad school or in the security field. That will enhance the marketability of students in that discipline and raise the visibility of Queen’s.”

Less tangible, but just as important for Alexander and Dean, is the bond between the team members and the pride that comes from building software to counter cyber crime.

“There are a lot of bad guys out there now,” Alexander says. “It’s amazing how vulnerable systems are. That’s where we come in.”

sportsmanship, of being able to take part in something that has been going on for decades.”

Khallaghi filled out an application to be an RBC Olympic Torchbearer while he was waiting to open a bank account last year. By the time he received an email informing him that he had been selected as one of 4,500 torchbearers chosen from across Canada, he had almost forgotten about the application.

“It came totally out of the blue,” he said of the email. “I read it twice and then I asked my lab mate, who is Canadian, to read it for me. He told me it was real!”

A proud moment: Khallaghi carries the torch

“I was so excited – I felt like I was almost famous! I had never won anything through luck in my life. It made me feel lucky.”

Initially, Khallaghi had wanted to wear Queen’s colours for his leg of the relay, as well as green wristbands in support of freedom and democracy in Iran, but that was before he learned that the honour of carrying the Olympic torch comes with an official Olympic torchbearer uniform of white jacket, pants and toque, and red mittens.

In addition to keeping the uniform, the torchbearer may purchase the Olympic torch that he or she has carried, but Khallaghi extended the opportunity to Queen’s ECE. “I could have bought the torch for myself,” he says, “but I felt that it belonged here. This was my chance to give something back to Queen’s.”

“It’s more the memory that counts,” he adds. “Maybe someday my child will come to study at Queen’s and they will see the torch that I carried. How cool would that be?”

The Olympic torch, purchased by Queen’s ECE on behalf of Khallaghi, will be permanently displayed in the department.
Growing up on rocky Dalhousie Lake, northwest of Perth, Ontario, Matthew Perras always had a passion for rocks. But it wasn’t until being exposed to geological engineering after his first year at Queen’s that it occurred to him to turn his passion into a vocation. Originally he’d set his sights on becoming an aeronautical engineer. Today Perras is a Queen’s doctoral student and an expert on the behavior of sedimentary rocks. His knowledge has made him a valued participant in a number of significant Canadian projects including the Niagara Tunnel, a major clean-energy project run by Ontario Power Generation.

“Major” is no exaggeration. The project uses the world’s largest hard-rock Tunnel Boring Machine (TBM) to drill a 14.4-metre wide, 10.2-kilometre-long tunnel deep beneath the city of Niagara Falls. As Perras’ PhD advisor, Dr. Mark Diederichs of the Department of Geological Sciences and Geological Engineering, puts it, “My house would probably fit sideways in the tunnel!”

Perras first heard about the Niagara tunnel while working for Hatch Energy, following completion of his undergraduate degree in 2005. The scale of the project fascinated him, so he found full-time work in the tunnel and began a part-time Masters degree connected to his research. The job entailed long days underground, which he acknowledges might seem unappetizing to some. But the TBM is actually about four stories high “and there’s lots of light,” says Perras. “It’s not a dark cramped space like people imagine.”

Perras and his fellow tunnel geologists worked in sweltering 30-degree C temperatures while wearing long coveralls and ear protection to muffle the extreme noise. Challenging subterranean conditions aside, Perras calls it the experience of a lifetime and a tremendous opportunity. It certainly furthered his interest in specializing in geotechnical engineering.

“It was fascinating from a geological point of view to observe the rock formations we’d pass through,” he says. “It’s sedimentary rock that can be found elsewhere in Southern Ontario and the northern U.S, but not at the depths and stresses we were at – 140 metres below the surface.”

Perras was tracking those rock formations – which included dolomites, limestones, sandstones and shales – to gain a better understanding of their geotechnical behaviour. Through a new approach using computer-generated numerical analysis of the tunnel rock – as opposed to relying on more traditional forms of analysis based on average material strengths – Perras and his colleagues were able to more accurately reflect the rocks’ “anisotropic” behaviour.

After two years balancing full-time work and his Masters, Perras headed back to Queen’s to complete his degree. As a next step, Diederichs suggested Perras embark on a doctorate whose thesis explored, in collaboration with the Nuclear Waste Management Organization, safe storage of nuclear waste. (Established in 2002 under the Nuclear Fuel Waste Act, the organization’s purpose is to “investigate approaches for managing Canada’s used nuclear fuel.”)

“I felt it was the perfect opportunity for him,” recalls Diederichs. “He knew geology and engineering. He understands the behaviors of rocks and the engineering issues related to them, based on his experience in the tunnel. Other students are working on this project too, but Matt is the hub. His thesis is very vital.”

Perras felt the opportunity “was just too interesting to pass up.” He also knows his study of safe nuclear waste storage will take him around the world.

“It’s such a global issue,” he says. “Although we’re focused on Canadian storage, we’re working with international researchers. I’ll be going to France, Switzerland and Sweden to see storage and related research facilities there.”

Perras’ own research is focused on the “excavation damage zone” – the damaged rock immediately adjacent to an excavation. Understanding rock behaviors under any circumstance is key to being able to seal a waste repository off and prevent potential contamination to the surroundings.

Diederichs believes that, in Ontario, low- and intermediate-level nuclear waste – typically items such as tools, mop heads and machines – is likely to be safely stored underground within the next couple of decades. Underground storage of high-level waste, such as spent fuel, is closer to 40 years away, says Diederichs.

Whatever the timeline, the work of Queen’s Geomechanics Group will be integral to the project, which will ultimately focus on the construction of safe nuclear-waste storage facilities and ensuring their long-term stability. Given that nuclear waste storage is a complicated and hot button issue, the responsibility associated with the project is foremost in Diederichs’ mind.

“It’s a huge challenge,” says Diederichs. “It’s the only human activity that the public demands remain absolutely safe for millions of years. The bar is set very high, and it should be. It will require a lot of study and analysis to reach that bar.”

Study, it should be noted, that both Diederichs and Matthew Perras are uniquely qualified to undertake.
Michelle Thompson, Space Dust

Michelle Thompson is “hooked on rocks from space.” That made her the perfect person – and one of only two Canadians – to do an internship last summer at the National Aeronautics and Space Administration (NASA).

The fourth-year Queen’s student, who is working on a dual degree in geological engineering and biology, traces her love of planetary sciences back to her second year at Queen’s. That’s when one of her professors, geologist Dr. Ron Peterson, inspired her through his discovery of meridianiite, a new mineral thought to exist on the surface of Mars and on the moons of Jupiter.

Peterson enlisted Thompson’s help in a collaborative project with the Royal Ontario Museum, (ROM), which focused on a meteorite that had been collected in North West Africa and donated to the Toronto museum.

Next she landed a coveted internship at NASA and found herself in Houston paired with a researcher at the Johnson Space centre – the place we think of, Thompson points out, when we hear the phrase ‘Houston, do you read me?’

The thrill of being near the astronauts was “surreal and amazing.” She met fellow Canadian Julie Payette, among others, but was equally thrilled by the internship itself: investigating “space dust,” the tiny particles of lunar soil that cling to astronauts returning to their landing craft. The samples were taken from Neil Armstrong’s Apollo 11 Mission, and the purpose of the initial research was to determine their composition and ultimately to assess their effects on the astronauts’ respiratory systems.

For Michelle Thompson, exploring space rocks is a journey that is just taking off – since, as she notes, her chosen field is filled with the “spirit of international cooperation.”

Geological Sciences and Geological Engineering: A CULTURE OF TEAMWORK

When Dr. Jean Hutchinson joined the Department of Geological Sciences and Geological Engineering at Queen’s in 2001, enrollment on the engineering side was a mere 15 students.

Today enrollment has more than doubled and Hutchinson, who is now Department Head, attributes much of the increase to the department’s ability to maintain fieldwork in a climate of declining resources. She says alumni support has been key to ensuring that the program’s crucial fieldwork component continues. High-school curriculum has been moving away from geology, and, as Hutchinson notes, convincing high school kids and their parents to consider geology and geo-engineering as a major never stops being a challenge. Being able to offer this kind of experience is vital.

To this end, the department’s annual orientation nights put a strong emphasis on the field’s career potential. Numerous industries recognize the quality of the department’s graduates, says Hutchinson, noting that former students now work across Canada and in Australia, New Zealand, Chile and Europe.

Those students all started the same way, she points out. “All engineers need to understand the earth as a system,” she says, “and they all benefit from taking The Earth’s Physical Environment, taught by Dr. John ‘Hockey Stick’ Hanes,” whose nickname comes from his habit of using a hockey stick as a pointer. He is also famed for engaging students, an ability that earned him the 2008 Alumni Award for Excellence in Teaching – Queen’s most prestigious teaching award.

The cross-discipline emphasis in the program – science and engineering students are strongly encouraged to collaborate – creates a culture of teamwork. That’s part of an overall emphasis on imparting skills that also include, for example, how to deliver professional-level reports and presentations.

The results?

Hutchinson says that companies have told her that Queen’s students can be out “in front of clients immediately” – no mean feat in today’s demanding workplace.
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