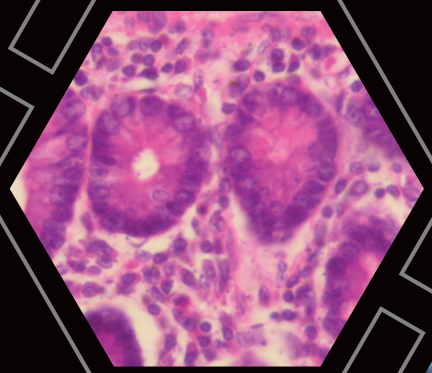
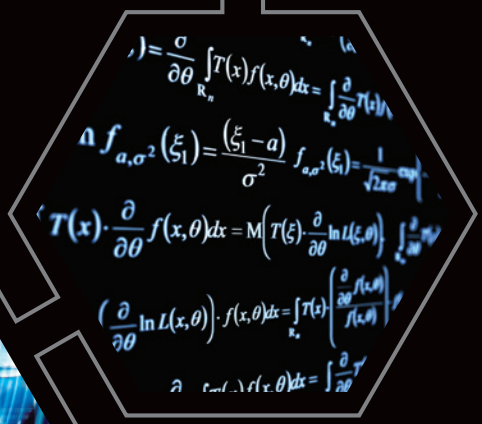
RYERSON UNIVERSITY
FACULTY OF SCIENCE
ANNUAL REPORT 2013



CONNECTED SCIENCE



Faculty of Science

RYERSON UNIVERSITY
Everyone Makes a Mark

THE NEW FACULTY OF SCIENCE

DEPARTMENT OF CHEMISTRY AND BIOLOGY

DEPARTMENT OF COMPUTER SCIENCE

DEPARTMENT OF MATHEMATICS

DEPARTMENT OF PHYSICS

TABLE OF CONTENTS

"Science at Ryerson is science that's calibrated to the complex and changing world we live in. It's science that reaches across disciplines and it's impactful, progressive and change-oriented."

IMOGEN COE

@RySciDean

A Message From

Imogen Coe
Dean

Faculty of Science

CONNECTED SCIENCE

The Faculty of Science (FOS) at Ryerson University came into being in July 2012. As a faculty of the 21st century, we are tasked with creating new knowledge that will have an impact and help solve the problems facing us all. Research in FOS is aimed at understanding the effects of climate change in urban environments, enhancing the development and realizing the implications of new technology and social media, and uncovering fundamental aspects of living systems, whether at the cellular or eco-system level. At all levels, our research is connected—with the real world, with our partners in industry and in the community, and with other researchers locally and globally.

Connected science reflects the current state of our world and the impact of technology. Students are more connected than ever, and the speed of change seems to accelerate. The volume of information being generated through research is rapidly increasing. Our understanding of connectivity is an important component in our ability to analyze, evaluate and create new knowledge to effect change or influence policy. The FOS is committed to meaningful research that will make a difference. We are connected to our students and trainees, to our colleagues within the faculty and the university, and to colleagues at other institutions. Our researchers are also connected with a variety of partners to help translate research findings into solutions. We work hand-in-hand with industry, municipalities, not-for-profit organizations, hospitals and other institutions and organizations—locally, regionally and internationally—to take our research findings out into the community where they can have an impact.

Connected science also means being connected to our past. Born from the Faculty of Engineering and Architectural Science (as our parent faculty is now known), we have a legacy of quality research, which provides us with a solid foundation of analytical and creative roots.

The research activities in the new Faculty of Science represent connected science at every level, in three dimensions and through time (the fourth dimension). As we look to the future, I am confident that the research taking place within FOS will contribute to positive change in our world.

IMOGEN COE
Dean, Faculty of Science

FOS AT A GLANCE

Undergraduate Programs

Biology

Biomedical Sciences

Chemistry

Computer Science

Financial Mathematics

Mathematics

Medical Physics

Graduate Programs

Applied Mathematics (MSc)

Biomedical Physics (MSc, PhD)

Computer Science (MSc, PhD)

Molecular Science (MSc, PhD)

Environmental Applied Science and Management (MASc, PhD)

Canada Research Chairs

Michael Kolios
Canada Research Chair (Tier 2) in Biomedical Applications of Ultrasound

Gideon Wolfaardt
Canada Research Chair (Tier 2) in Environmental Interfaces and Biofilms

2012-2013 in Numbers

Undergraduate Students: 1,818

Graduate Students: 271

International Students: 57

Faculty Members: 82

Post-doctoral Fellows: 29

Staff: 41

Innovation and Entrepreneurship Statistics for 2008-2013

Number of Disclosures Filed: 22

Number of Licenses Executed: 13

Number of Patents Filed: 16

Number of Spin-off Companies Related to the Technology: 3

Number of Scientists and Engineers in Business (SEB) Fellowships: 5

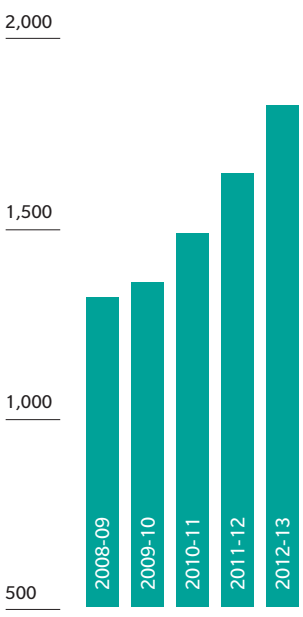
At Ryerson, we believe science should be collaborative and results-oriented. We call it "connected science."

We have a contemporary approach and are focused on strategic partnerships, experiential learning and research breakthroughs with societal impact.

This is why the Faculty of Science is becoming a top destination for more undergraduate and graduate students, and for outstanding faculty.

Undergraduate Student Enrolment

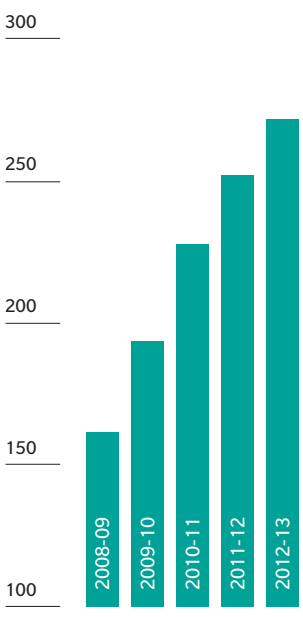
38% Growth in five years



Number of students per year

Graduate Student Enrolment

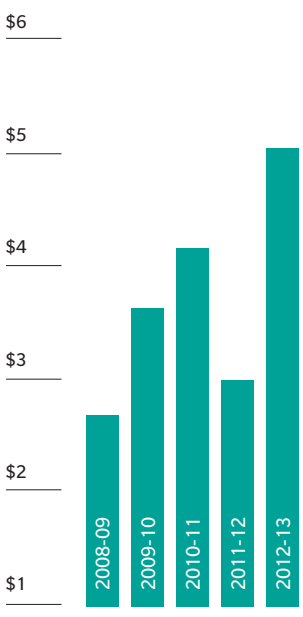
68% Growth in five years



Number of students per year

External Research Grants

87% Growth in five years



Funding per year, in millions

AWARDS AND ACCOLADES

2012-2013 Faculty Awards and Recognition

Dr. Catherine Beauchemin received the **Dean's Teaching Award.**

Dr. Anthony Bonato received the **YSGS Outstanding Contribution to Graduate Education Award.**

Dr. Roberto Botelho received the CIHR's **Maud Menten New Principal Investigator Prize.**

Dr. Alexander Ferworn was the Canadian Champion in North America in the **EURAXESS Science Slam** competition.

Dr. Robert Gossage received the **Dean's Teaching Award.**

Dr. Dzung Minh Ha received the **A Prof Who Made a Mark** award.

Dr. Eric Harley received the **Faculty Service Award.**

Dr. Darrick Heyd received the **Errol Aspevig Award for Outstanding Academic Leadership.**

Dr. Bryan Koivisto received the **A Prof Who Made A Mark** award.

Dr. Michael Kolios received the **Sarwan Sahota Ryerson Distinguished Scholar Award.**

Dr. Pawel Pralat received the **Faculty Scholarly, Research and Creative Activity Award.**

2011-2012 Faculty Awards and Recognition

Dr. Debora Foster received the **Queen Elizabeth II Diamond Jubilee Medal for the Advancement of Science.**

Dr. David Mason received the **RFA Distinguished Service Award.**

Dr. David Mason received the **President's Blue & Gold Award of Excellence** as part of the Email and Collaborative Tools Team.

Dr. Lynda McCarthy received the **Dean's Teaching Award.**

2012-2013 Student Competition Winners (External)

Acoustical Society of America, International Congress on Acoustics, Biomedical Acoustics Student Paper Competition
Biomedical science PhD student Amin Jafari Sojahrood won first place.

American Oil Chemists' Society
Molecular science MSc student Tu Tran received the Honoured Student Award.

AUTO21 Inc. Connect Canada
Molecular science MSc student Devin Machin received the internship award.

Biomedical Engineering & Sciences Technology (BEST) Research Symposium, Poster and Demo Competition
Biomedical physics PhD student Eric Strohm won first place in the poster competition.

Canadian Acoustical Association
Biomedical physics MSc student Judith Weidman won the award for best paper published in the Canadian Acoustics journal.

Canadian Society for Chemistry, Canadian Chemistry Conference and Exhibition
Molecular science MSc student Khrystyna Herasymchuk was awarded the second prize in the inorganic division graduate student poster competition.

Canadian Society of Microbiologists, CSM Annual Conference, Student Award Symposium
Molecular science PhD student Tracy Lackraj was selected to present her research.

CIHR Canada Graduate Scholarship
Molecular science MSc student Monica Dayam received this scholarship.

NSERC Postgraduate Doctoral Scholarships
Biomedical physics PhD students Laura Liao and Marjan Razani, and molecular science PhD student Muhammad Ali Naqvi received this scholarship.

Ontario Trillium Scholarship
Environmental applied science and management PhD student Wendy Stone received this scholarship.

Ryerson University Gold Medal
Molecular science MSc student Jonathan Ward received this award.

Southwestern Ontario Undergraduate Student Chemistry Conference
Undergraduate student Omar Abdi won third place in the poster competition.

Vanier Canada Graduate Scholarships
Biomedical physics PhD student Amin Jafari Sojahrood received a three-year scholarship.

Water Innovation Lab
Environmental biology student Karen Quinto won the Most Innovative Pitch Award.

2012-2013 Student Competition Winners (Internal)

The Chemistry and Biology Faculty Award for Research
Undergraduate chemistry student Kaushiga Pirabaharan and biology student Laura Olejnik were the recipients of this award.

Federation of Chinese Canadian Professionals Education Award
Computer science students Alain Li Chuen Cheong and Junaid Anwar received the award.

The Fred Hainsworth Award for Medical Physics
Medical physics student Abdulkarim Muhaseen received the award.

Irving N. Arnold Award for Innovation and Invention
Computer science student Sam Seo received the award.

Toronto Agile Community Award
Computer science undergraduate student Alex Dela Cruz received the award.

Chemistry and Biology Research Symposium
MSc students Devin Machin, Zachary Teitel and Tracy Lackraj, and PhD student Amra Saric were the recipients of the 2013 Molecular Science Graduate Student Society Award Lectures.

The poster competition prize winners and runners-up in each category were as follows:

Winner, Shane Harrypersad; runner-up, Nande Wright (undergraduate, chemistry).

Winner, Rob Denning; runners-up, Khrystyna Herasymchuk and Justin Kosalka (graduate, chemistry).

Winner, Amir Tehrani; runner-up, Agnes Klimowski (undergraduate, environmental biology).

Winner, Yulia Markunas; runner-up, Borhan Uddin (graduate, environmental biology).

Winner, Monica Dayam; runner-up, Anna Sorensen (undergraduate, molecular/cell biology and biochemistry).

Winner, Camilo Garay; runner-up, Shannon Ho (graduate, molecular/cell biology and biochemistry).

Student Competition Winners 2011-2012 (External)

FedDev Scientists and Engineers in Business (SEB) Commercialization Fellowships Awards
Biomedical physics PhD student Eric Strohm; chemistry and biology post-doctoral fellow Hassan Firoozmand; computer science PhD student Jimmy Tran; computer science post-doctoral fellow Behzad Malek; and environmental applied science and management MSc graduate Christopher Bentley received this fellowship.

International Conference for Upcoming Engineers
Biology student Monica Dayam won second place for her presentation in the undergraduate research section.

Laurence Becker Symposium, Hospital for Sick Children, Poster Competition
MSc student Crystal Gadishaw-Lue received the Best Poster Award, in the undergraduate and master category.

NSERC Canada Graduate Scholarships
Biomedical physics PhD students Eric Da Silva and Eric Strohm and MSc student Eno Hysi received the award.

Southern Ontario Undergraduate Student Chemistry Conference
Undergraduate chemistry student Maja Chojnacka won the first place in the organic and organometallic chemistry session.

2011-2012 Student Competition Winners (Internal)

Chemistry and Biology Research Award
Undergraduate biology student Patryk Skowron received the award.

Chemistry and Biology Research Symposium
The poster competition prize winners in each category were as follows:

Winner, Khrystyna Herasymchuk; honourable mention, Maja Chojnacka (undergraduate, chemistry).

Winner, Crystal Gadishaw-Lue; honorable mentions, Ahmad Sidiqi and Chloe Rapp (undergraduate, biology).

Winner, Bashar Alkhouri; honourable mention, Aman Khan (graduate, chemistry).

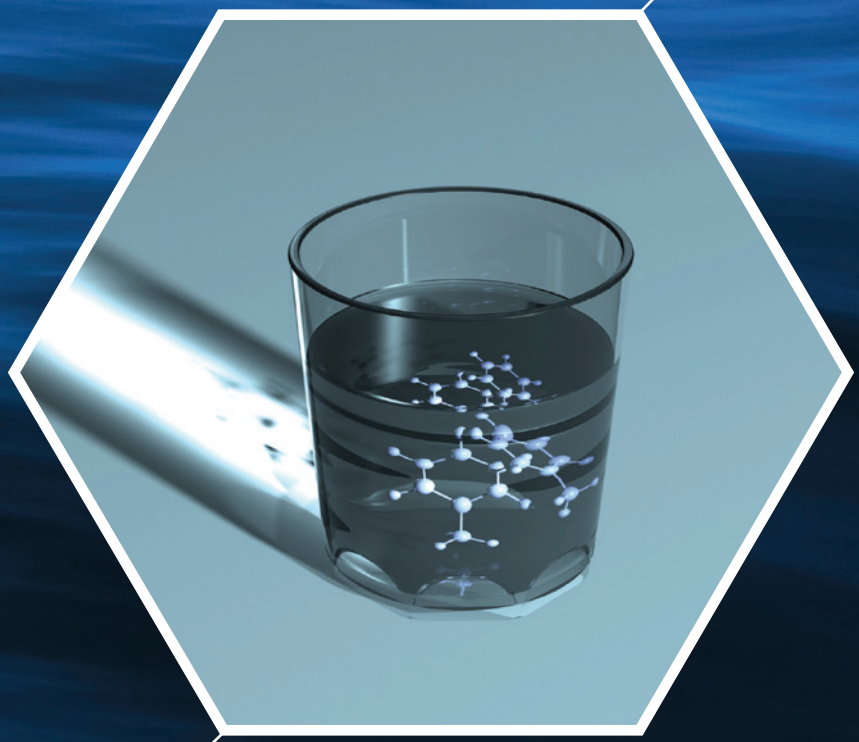
Winner, Jamie Dufresne; honourable mentions, Lindsay Jackson and Hannah Tollman (graduate, biology).

CONNECTED RESEARCH

CASE STUDIES

Case Study

Health of Freshwater Systems



TACKLING OUR WATER CRISIS

Increasingly, the health of freshwater systems is becoming compromised around the world. Stressors such as bacteria and chemicals affect our water reserves. For example, E. coli not only shuts down beaches; when it gets into our water supply it can kill. Yet we lack a full understanding of, and public concern for, the impact on lake and river ecosystems.

TACKLING OUR WATER CRISIS

Case Study

Health of Freshwater Systems

Ryerson University is taking a multi-disciplinary approach to ensuring the health of freshwater systems. Researchers are looking for more effective ways to test for the impact of toxins, particularly with regard to urban water runoff—a challenge given the number of chemicals in our environment (more than 10,000), the countless potential combinations, and the fact that we keep introducing new ones. Input from fields such as chemistry, engineering and urban planning is essential to tackle questions of source, impact and response.

The Faculty of Science is playing a central role, particularly through its Department of Chemistry and Biology, in finding biological approaches to contaminant detection.

Dr. Lynda McCarthy is convinced that the key measure of environmental impact is via the study of living organisms. She uses the metaphor of a canary in the coal mine to justify her approach. "Digital instruments can test for toxins that we know about," she explains. "But they can't alert us to the unknown." A canary, like any organism, reacts to the whole environment. When the air grows too toxic—whether or not we understand why—the canary dies. At Ryerson, the canary might be an aquatic invertebrate called "Daphnia magna".

McCarthy did much of her early work at the Canada Centre for Inland Waters. At Ryerson, she works with a team of researchers who are investigating the use of aquatic organisms as an early warning system. "The key is their behaviour," she says. "We study their reactions to contaminated water." Cameras and probes at strategic locations (along a river or canal that feeds into a drinking water source, for example) can detect changes in the organism's movement or oxygen output, depending on the species.

This real-time information can trigger the shutdown of a treatment plant or factory until the contaminant is isolated and dealt with. It is a cheaper, faster and more comprehensive method than chemical analysis. "I see great potential in our more remote regions," McCarthy says, "such as First Nations communities that are struggling to keep their water safe."

A related area is the land application of biosolids, or treated sewage sludge. All communities face the question of what to do with biosolids. Burn them? Bury them in a landfill site? Or use them as fertilizer? McCarthy acknowledges public controversy regarding the last option—and not surprisingly, less than one per cent of Canada's farmland uses human waste as fertilizer. But McCarthy argues that such reluctance lacks a scientific basis. "Research to-date has mostly overlooked the impact of biosolids on the whole ecosystem." Again, she and her team are looking at the behaviour of organisms. "We already know that humans can tolerate chemicals such as ibuprofen that remain in biosolids." She argues that we need finer instruments, such as earthworms, plants and springtails, to capture the full impact.

Ecosystem contamination, like any science, benefits from models. Researchers in the Department of Chemistry and Biology are trying to refine and promote the model of biomonitoring technology.

Dr. Vadim Bostan, a member of the Ryerson Urban Water Group, has studied the impact on freshwater systems of a range of factors, from pulp mill sludge to municipal biosolids to zebra mussels.

PHOTOS:

p.14 Members of a multidisciplinary Ryerson team—Dr. Ronald Pushchak, Dr. Mehrab Mehrvar, Dr. Vadim Bostan, Dr. Lynda McCarthy, Dr. Andrew Laursen (left to right)—work on finding organic approaches to contaminant detection.

p.15 Graduate student working on water samples in the lab led by Dr. Lynda McCarthy.

"I SEE GREAT POTENTIAL IN OUR MORE REMOTE REGIONS," MCCARTHY SAYS, "SUCH AS FIRST NATIONS COMMUNITIES THAT ARE STRUGGLING TO KEEP THEIR WATER SAFE."

Currently he is looking at phosphorus, specifically, the transfer of phosphorus from watersheds to freshwater systems. Phosphorus is a vital nutrient, and often converted into fertilizer. But it has a limiting effect on water systems, and when added to a lake can cause unusual algae growth (sometimes referred to as "toxic bloom") that can choke other species.

"My long-term goal," Bostan says, "is to enhance the understanding of nutrient transfers from watersheds to receiving lakes." While the role played by phosphorus in lake eutrophication (where an excess of nutrients causes a surge in plant growth and decay) is well accepted—and dominates our nutrient management practice—"more and more studies are debating this paradigm." Other growth limiting factors are now being scrutinized.

Biogeochemistry is the study of processes—physical, chemical, biological and geological—that govern ecosystems. Like his colleagues, biology professor **Dr. Andrew Laursen** is focusing on water: "How do aquatic environments respond to disturbance? What are their vulnerabilities? What role do they play in greenhouse gas emissions?"

Here, Laursen refers to carbon dioxide, nitrous oxide and methane—gases that are emitted from lakes and rivers. Processes that produce greenhouse gases are natural, but human activities can accelerate production, and the data can tell us something of human impact. "Countries have access to methods for keeping an inventory of gas emissions," Laursen says. "But even if we commit to using them, our models need to be refined. We know that when we disturb ecosystems, we alter the production of greenhouse gases." His own research into biogenic gases in rivers and lakes is adding another piece to our knowledge of biomonitors and their value to ecosystem sustainability.

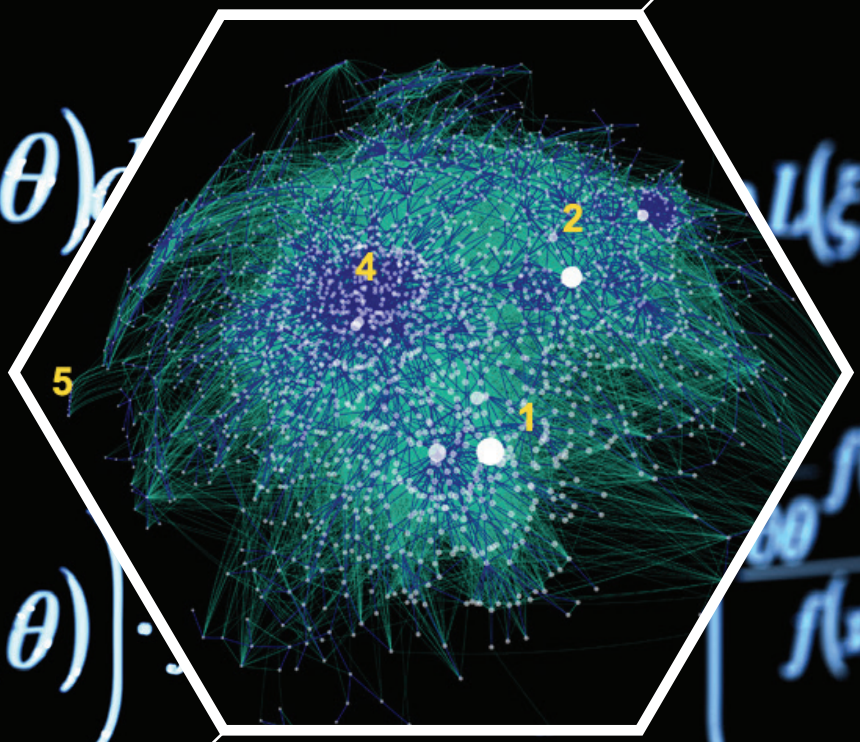
Dr. Kim Gilbride is the director of the Biology program at Ryerson and leads the Molecular Microbiology Lab (or "Gilbride's Group"). Her research mainly focuses on microbial community structure and function in complex samples such as biological wastewater treatment systems (WWTS)—in other words, the bacteria, fungi and protozoa that are part of municipal or industrial systems that clean up wastewater before it is pumped back into lakes or streams.

"Since microorganisms are hard to see, I've employed molecular analysis (like methods used in the TV series *CSI: Crime Scene Investigation*) to discover which microbes are doing the work, how efficient they are at doing the work, and whether there are ways to improve their methods," Gilbride explains. She and her team use DNA sequencing techniques and "clone libraries" to identify species that, however small, may potentially change the whole system.

Gilbride is currently looking at pollutants in waste streams that may negatively impact the work of microbes—in particular, pharmaceutical products such as ibuprofen and antibiotics. "Many people never think about what they flush down the toilet or pour down the drain," she says. "But our urban communities are growing, and increasing amounts of drugs and man-made compounds find their way into wastewater streams. The effect of these pollutants on the bacterial and protozoan community has not yet been determined. By looking at their impact on the bacterial and protozoan community in municipal secondary treatment processes, we can better manage our wastewater systems and protect our drinking water for future generations."

Case Study

Complex Networks and Big Data



COMPLEX NETWORKS IN THE BIG DATA ERA

Our world is awash in data. It's a fact of economic and public life. The term "big data" refers to sets of data (not all of them digital) that have grown too large to handle effectively in traditional ways. Some involve large-scale networks of data points (or nodes) that keep evolving. Facebook is one example; other big data networks may serve finance, health or retail interests. These networks are self-organizing and so vast that it takes increasingly sophisticated tools—models or algorithms—to analyze the data in a form we can use.

COMPLEX NETWORKS IN THE BIG DATA ERA

Case Study

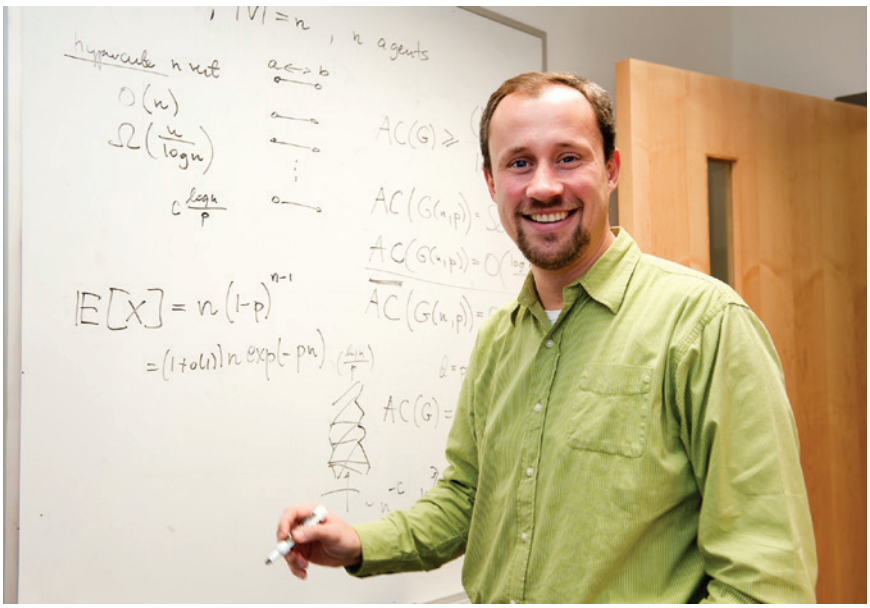
Complex Networks and Big Data

All major sectors of our society depend on these models. So does our understanding of traffic patterns and terrorist attacks. Researchers at Ryerson's Faculty of Science are working to build high-quality models using pure mathematics and tools from other disciplines, from business to the social sciences.

Dr. Pawel Pralat focuses on graph theory with real-world applications: on the modelling and searching of complex networks (such as web graph, social networks and terrorism networks) with emphasis on big data research questions. Through pure mathematics (e.g., solving open problems in random graph theory and graph searching theory) he has developed the rigorous proofs, rather than simulations, that are needed to better understand the dynamic of these networks and, as a result, enable the design of efficient algorithms. He also collaborates with social scientists to understand the emergence of community structure in networks characterized by the co-evolution of nodal attributes and link structures.

Pralat is a member of the Graphs at Ryerson (G@R) group. G@R is comprised of a dozen faculty, post-doctoral and graduate students whose work is supported by Ryerson and funding bodies such as NSERC and Mitacs. G@R is becoming a Canadian leader in graph theory related to big data research.

"Data is the new fossil fuel," Pralat claims. "In any self-organizing network (such as Facebook), nodes not only contain useful information, they are also internally connected to other nodes." Big data can help make this information visible and available for use in a timely way—not just in social media, but in biomedicine and public transportation. "Data mining," he concludes, "is an extremely promising field of research."



Since his arrival at Ryerson in 2011, Pralat has secured an NSERC Discovery Grant, three NSERC Engage Grants, an Mprime Grant and various internal grants. His Engage Grants refer to three projects: one with Winston Inc., where he is using aggregated data to improve demand predictions for a taxi service; another with Mako Invent, where he is developing a series of formulas and algorithms to map a new artificial intelligence rating system online; and a third with BlackBerry, to create a series of recommended algorithms to enhance the mobile user experience.

Dr. Anthony Bonato, Associate Dean, Students and Programs at the Yeates School of Graduate Studies, has been a professor in the Department of Mathematics at Ryerson since 2008. His field is graph theory with applications to complex, real-world networks such as the web graph and social networks like Facebook. Bonato also works on a variety of topics in graph theory such as graph searching, graph homomorphisms, infinite graphs and random graphs. He founded G@R in 2010, and is a member of the Ryerson Applied Mathematics Laboratory (RAMLab).

Bonato describes typical graph searching as "a two-player game where a set of agents are trying to capture an intruder." In fact, one of his books is titled *The Game of Cops and Robbers on Graphs* (2011). Applications include artificial intelligence and counterterrorism. "Insights into social networks can help us better predict the flow of information," Bonato explains. He and his colleagues have built a model that offers insight into terrorism hierarchies and their communication pathways.

In 2013, Bonato and Pralat co-wrote a paper (with Dr. Dieter Mitsche) in which they refer to hierarchical social networks—where information flows downward from a source—as "directed acyclic graphs." Their first example is Twitter. But they claim that knowledge of such networks gives us the ability to disrupt the flow, to halt the spread of news or gossip, and to intercept "a message sent in a terrorist network."

Nor is the potential of their work limited to blockage. "Understanding the web and other informational networks can lead to improved web searching," says Bonato. Moreover, the model goes beyond human behaviour, such as "mapping the protein networks in living cells," with potential for the treatment of disease.

By definition, such networks are self-organizing and decentralized. As such, they are forever changing, often in ways or degrees that we can't entirely predict. This makes it all the more important to involve other disciplines, and to keep refining the models.

PHOTOS:

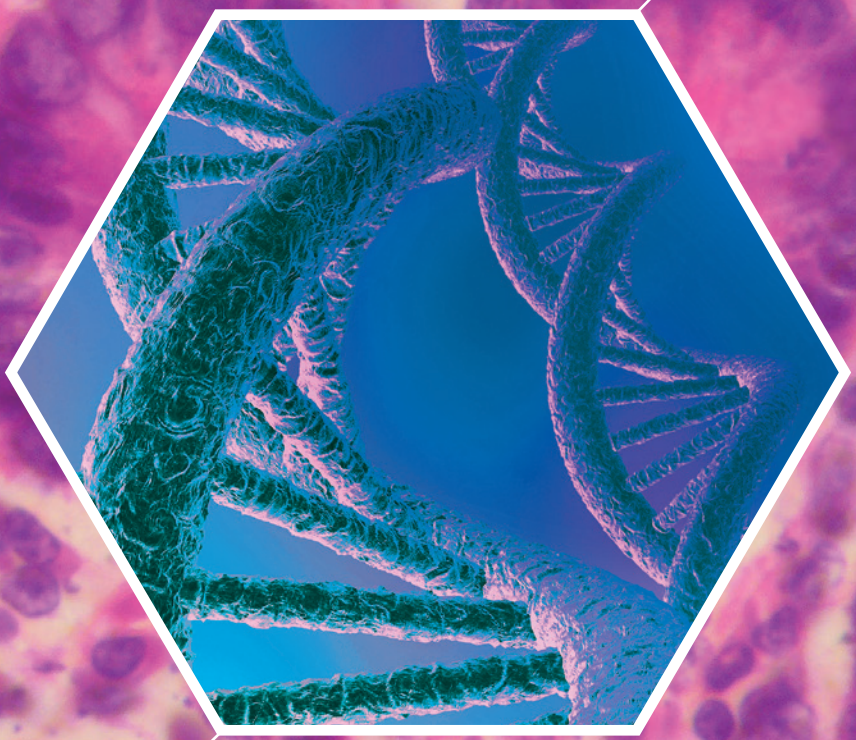
p. 18 Dr. Pawel Pralat partners with collaborators from all over the world to make breakthroughs in the area of big data.

p. 19 Dr. Anthony Bonato does research in the field of graph theory with applications to complex, real-world networks such as the web graph and social networks such as Facebook.

"DATA IS THE NEW FOSSIL FUEL," PRALAT CLAIMS. "IN ANY SELF-ORGANIZING NETWORK (SUCH AS FACEBOOK), NODES NOT ONLY CONTAIN USEFUL INFORMATION, THEY ARE ALSO INTERNALLY CONNECTED TO OTHER NODES."

Case Study

Probing Cell Function



ADVANCES IN BIOMEDICINE

Our bodies are made up of 50 trillion to 100 trillion cells. These are not static. They work together and communicate in highly organized ways. Proteins found on the cell surface for example, ensure nutrient uptake from the blood, yet are also implicated in cancer. Scientists all over the world are trying to understand the mechanisms involved. The "holy grail" of drug therapy is the identification of a specific protein structure—and the understanding of how it determines our body's response to disease. With this knowledge, we can more intelligently design drugs that target proteins of interest.

ADVANCES IN BIOMEDICINE

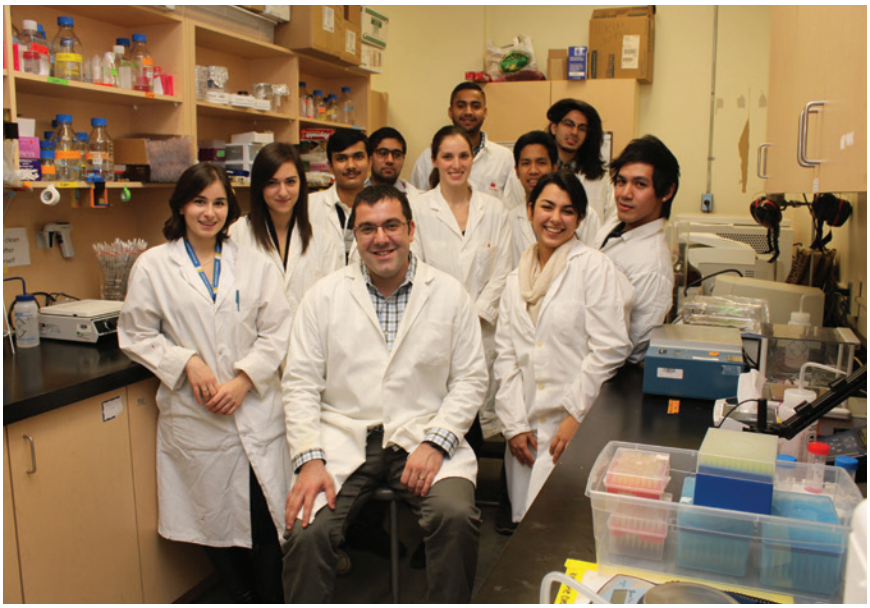
Case Study

Probing Cell Function

At Ryerson, some of our top researchers are committed to finding out how cells function, and to building our knowledge of the basic science of cellular function while investigating diseases and the potential for new therapies and diagnostics. They are supported by funds from the Canadian Institutes of Health Research (CIHR), the Natural Sciences and Engineering Research Council of Canada (NSERC) and by a growing network of partnerships with clinical laboratories in Toronto.

Dr. Costin Antonescu looks at how cell surface proteins are regulated. "One of our main goals," he says, referring to his Ryerson lab group, "is to understand how this regulation is disrupted in tumours. Hormones instruct cells on what to do by binding to a type of protein on a target cell's surface-termed hormone receptors, which act as molecular conduits of hormone action. When the proteins become disrupted, it can lead to many different diseases. A critical component of human cancer is a change in the organization and function of proteins found at the cell surface."

Antonescu is studying the epidermal growth factor (EGF), a hormone essential to many functions of the body—from healing wounds to normal heart function—but that in high levels can trigger cancerous growth. "It's not just the presence of [epidermal growth factor receptor] EGFR that interests me," says Antonescu. "We are beginning to look at the spatial dimensions of hormone receptors. How do cells use protein scaffolds to create *spatial* organization?" Protein scaffolds help connect a hormone, using a hormone receptor like EGFR, to the other molecules within a cell that enact the changes instructed by the hormone (leading to cell growth). It is a new and exciting approach, offering potential insight into cell mechanisms and signalling pathways. This may in turn suggest new treatments for diseases in which hormone receptors are disrupted, like cancer.



The Antonescu research group also studies how other types of proteins at the cell surface are regulated. One such group of proteins, called "integrins", is used by cells to attach to the correct location within specific organs. Antonescu's group is examining how cell stress—such as the stress a cell experiences when it does not have enough fuel (e.g., glucose)—signals to integrin proteins at the cell surface to change how a cell attaches to other cells and tissues.

Several types of molecules inside cells impact how these cell surface proteins are able to function. One such type is a family of lipids called "phosphoinositides". Antonescu's group studies how new properties of these phosphoinositide lipids control the function of proteins at the cell surface. This research may provide additional new methods to treat tumours, since many of the proteins at the cell surface (e.g., EGFR) are required for cancer cells to grow and spread.

Molecular cell biologist **Dr. Roberto Botelho** is also looking for answers. His own focus is on intracellular signalling and membrane trafficking, and the function of organelles. Botelho's Organelle Identity and Function Lab investigates how organelles—the "organs" of a cell—are formed, maintained or changed.

PHOTOS:

p. 22 Dr. Costin Antonescu and his group are focusing on reciprocal membrane traffic regulation and cellular signaling in order to better understand diseases such as cancer and diabetes.

p. 23 Dr. Roberto Botelho studies the molecular mechanisms driving organelle identity and function.

"WE ARE BEGINNING TO LOOK AT THE SPATIAL DIMENSIONS OF HORMONE RECEPTORS. HOW DO CELLS USE PROTEIN SCAFFOLDS TO CREATE SPATIAL ORGANIZATION?"

"When organelles malfunction," he explains, "it has a very negative impact on the cell's health, which translates into disease." By studying the molecular mechanisms of organelles, he hopes to improve knowledge of how some diseases develop, and how the immune system responds. "My laboratory is especially interested in understanding how lysosomes and lysosome-related organelles—which serve to degrade molecules and pathogens—acquire their properties and function in immunity."

Normal lysosomes (and the lysosome-related MHC class II compartment) are small and globular, like tiny dots. When you expose them to bacterial products however, they can change shape and become a network of tubules. No one knows how or why. When Botelho learned of this phenomenon, he saw potential for immune-specific research. He began to ask if tubulation is somehow essential to the process of immunity.

He and his team have since pioneered the molecular characterization of tubular lysosomes. By discovering the first molecular regulators, they can now interfere with this process—genetically or with drugs—in order to access the role of this process in immune responses, including antigen presentation.

"This knowledge," says Botelho, "may provide the basis to develop new therapies and diagnostics to mitigate certain diseases like infectious agents and inflammatory diseases."

Dr. Warren Wakarchuk heads the Glycobiology Lab in the Department of Chemistry and Biology. He too is interested in proteins—particularly, proteins that build up and degrade "glycans" which are sophisticated structures on the surface of our cells. Glycans are used for cellular recognition, cellular communication, recognition by pathogens, and short-term storage of various growth factors.

It has been difficult to decode the information found in glycans, as these structures are very diverse in size, shape and chemical composition. Wakarchuk has been studying the proteins involved in order to make "pure" glycans—which can then be used to decode their function. With such proteins, his team has been able to make glycans that can help keep therapeutic proteins in the body for longer. "We are now working with neurobiologists to figure out how to use the same kind of glycan to help cells function in the repair of damaged tissue like the spinal cord, and perhaps even neurons in the brain."

"When I started work on the proteins that build glycans," relates Wakarchuk, "it was in the context of their role in bacteria that cause human disease. Many of these bacterial glycans mimic human ones, and so our idea to use the bacterial proteins to make therapeutic glycans started there. Now we know that the scope of our work can be much broader, and that application of these bacterial proteins for synthesis of glycans—for improvements to human health—is becoming a reality. It is very satisfying to see something come from fundamental biochemistry that has a very real-world application."

Case Study

Data Security

DATA SECURITY: BALANCING RISKS AND BENEFITS

Whether it's called an information leakage or a data breach, the "loss" of data—passwords, health records, account IDs—represents a significant concern of governments, businesses and citizens. We can't hold our cards close to our chests anymore; at least some of our data will move digitally beyond us. Data security affects us all.

DATA SECURITY: BALANCING RISKS AND BENEFITS

Case Study

Data Security

Acknowledging the risks and benefits of digital identity, faculty members in the Department of Computer Science at Ryerson are working to make our data more secure—to enable more digital innovation and growth.

The associate chair of the department, **Dr. Ali Miri**, has been working in the areas of applied cryptography and computer and network security for more than 20 years. "We're living in a new computing paradigm," Miri says, "where information can be gathered from a large number of sources—from smartphones and tablets to sensors and tags." It is often stored on massive, distributed "cloud" databases. Online social networks have added a new dimension to how users interact and share information. For experts and the public, "privacy and security represent a major challenge."

Miri is the founding Director of Ryerson's Information and Computer Security Laboratory (iCaSL). He closely collaborates with industry on security-related projects, and has raised more than $6 million in research grants to support his work so far. Two of his recent industry-funded projects have focused on mobile platform security and on cost-effective and scalable solutions for securing cloud services. He is the general chair for the 12th International Conference on Privacy, Security and Trust (PST2014) which will be held at Ryerson in July 2014.

As multi-purpose mobile platforms grow in power and popularity, they are attracting a growing number of malicious attacks. The online security firm Kaspersky Lab, which had reported 6,000 new mobile malware samples in 2011, reported more than 30,000 samples in 2012. In their mobile security platform project, Miri and his team have worked to identify the key software and hardware features used, and to classify similarities and differences in the effectiveness and impact of these attacks on different operating systems. They have also been working on isolating the most common methods of malware propagation in mobile networks, on the current monitoring schemes used, and their shortcomings.

"Cloud computing is one of the fastest growing computing paradigms, with Software as a Service (SaaS) as one of its key tenants," says Miri. SaaS promises improved performance and reduction in costs in the support and maintenance of industrial software. However, the use of SaaS tools can also expose business details—including sensitive data about ongoing projects and other business intelligence. Miri and his industrial partner are working closely to design and implement cryptographic solutions that enable effective use of these tools, while ensuring strong security and privacy guarantees.

Dr. Isaac Woungang is the director of Ryerson's Distributed Applications and Broadband NEtworks Laboratory

(DABNEL). The main goal of DABNEL is to address some of the challenges found in telecommunication networks and mobile systems—using algorithms and software development frameworks. A big problem is data security. "Our contribution to the field of networks security," claims Woungang, "will be the provision of methods and guidelines for controlling and protecting networks from any miscreant."

Woungang has done groundbreaking work on wireless ad hoc networks. Such decentralized networks have their strengths, but can pose particular challenges. Routing, for example, is unpredictable in an unstable environment prone to disconnection; and ad hoc networks can be vulnerable to attack. By creating new protocols, such networks can be made sturdier and more efficient.

Wireless sensor networks (WSNs) are another focus for Woungang. WSNs consist of sensors, or nodes, that are distributed in an environment to send back data to a main unit. Applications include the monitoring of water or air quality, routine testing of machinery, and forest fire detection in remote areas. Energy consumption is a major factor in the WSN's value—often, sensors must rely on limited power sources. Woungang uses algorithmic approaches to develop protocols that conserve energy through the network and enhanced resolution.

Data security presents computer scientists with many challenges. What makes the work compelling, from social networks to the latest in RFID technology, is the knowledge that our society has so much to gain.

PHOTOS:

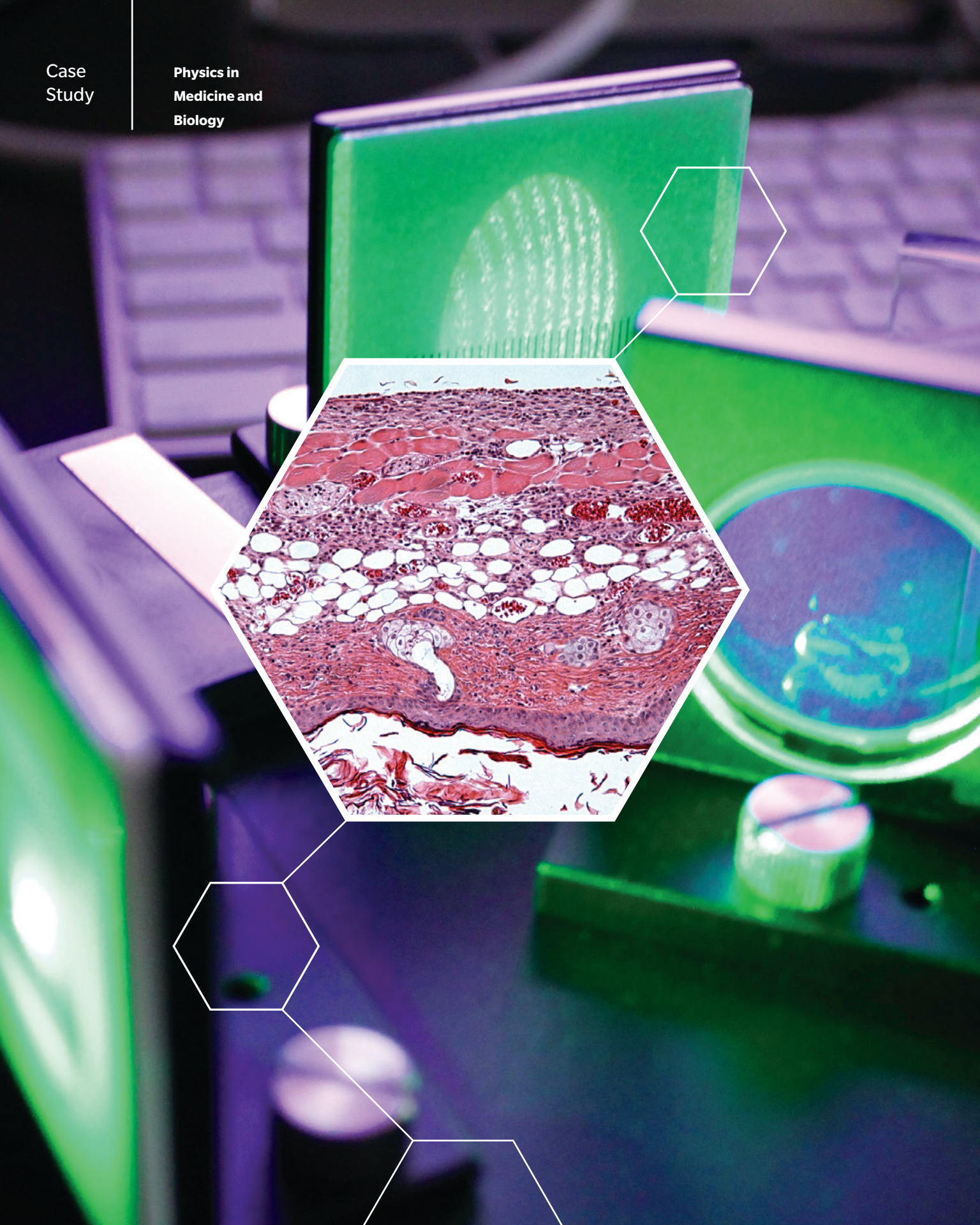
p. 26 Dr. Ali Miri collaborates with industry on computer and network security-related projects.

p. 27 Dr. Isaac Woungang's work focuses on addressing some of the challenges found in telecommunications networks and mobile systems—using algorithms and software development frameworks.

"WE'RE LIVING IN A NEW COMPUTING PARADIGM," MIRI SAYS, "WHERE INFORMATION CAN BE GATHERED FROM A LARGE NUMBER OF SOURCES—FROM SMARTPHONES AND TABLETS TO SENSORS AND TAGS."

Case Study

Physics in Medicine and Biology



THE ROLE OF PHYSICS IN MEDICINE

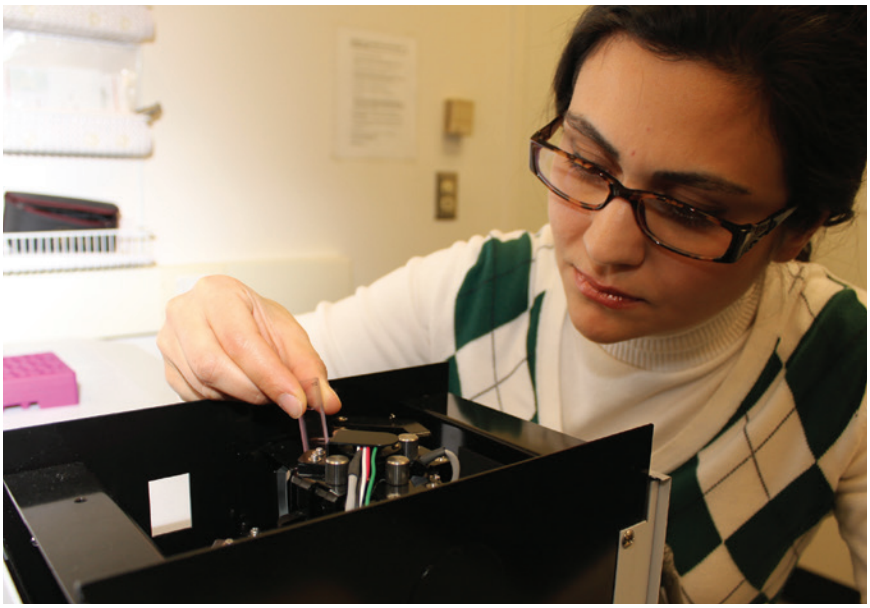
Hospitals are sites of technology. And no wonder. They give us compelling reasons to try to extend our senses in order to detect and diagnose disease. Our goal is to prevent illness in the first place; and if that fails, to find the best therapy. At Ryerson, faculty in the Department of Physics are developing innovative ways to connect with disease—from many approaches—using sound, light and algorithms.

THE ROLE OF PHYSICS IN MEDICINE

Case Study

Physics in Medicine and Biology

In 2013, the department's teaching program got a boost, while research projects got new and significant funding from government. Full accreditation was awarded to Ryerson's graduate program in Biomedical Physics, with an option in Medical Physics, by the Commission on Accreditation of Medical Physics Educational Programs (CAMPEP). Collaboration between Ryerson and St. Michael's Hospital resulted in an agreement to create the Institute for Biomedical Engineering and Science Technology (iBEST) for launch in 2015.



Efforts by researchers are also helping to bridge the gaps between basic science, clinical trials and the market for new technologies. **Dr. Alexandre (Sasha) Douplik** is a physics professor at Ryerson, specializing in medical photonics and biooptics. He is also an affiliate scientist at the Keenan Research Centre of the LKS Knowledge Institute at St. Michael's Hospital. Finally, he is a guest professor at Friedrich-Alexander-University Erlangen-Nuremberg (FAU) in Germany, and has initiated a double degree program for PhD students between FAU and Ryerson.

Douplik is interested in applications in laser surgery and nanobiophotonics. Last year, he won a grant from the Banting Research Foundation for his efforts to develop surface-enhanced Raman spectroscopy fiber probes. His aim is to improve clinical diagnostics, to make the early detection of tumour-related biomolecules a practical reality.

"We are also looking for cost-effective solutions," Douplik says. "This is a hallmark of light-based techniques." Biophotonics is the study and application of a relationship between biology and photons. It can refer, more specifically, to the use of optical methods and technologies to study human cells and tissues. It is a growing market. Douplik cites the EPIC Biophotonics report which anticipates a global biophotonics-related market size of $36 billion by 2017.

"We are following the market trends," he says. "My group (Ryerson's Medical Photonics and BioOptics Lab) develops new generations of light surgery scalpels based on nanotechnologies, reducing the laser power for ablation and cutting up to 100-fold. We are working on microendoscopes that are able to penetrate to the spot of pathology inside the human body without causing bleeding or pain—rather like an acupuncture needle." Douplik is also developing gadget applications, such as a non-invasive blood cell counter based on a smartphone and compact devices for remote diagnostics. "Another domain of my activity," he adds, "is the design of methods linking psychological aspects of education and training with optics to significantly reduce training and learning curves."

Dr. Carl Kumaradas is the department's graduate program director. He also heads Ryerson's Computational Biomedical Physics Lab, and does groundbreaking work on the computational modelling of gold nanoparticles in diagnostics and therapy.

"Gold nanoparticles (GNPs) are strong absorbers of light," states Kumaradas. "The wavelength (colour) at which they absorb light, called the absorption peak, is easily tuned by changing the size and/or shape of the GNPs. The absorption peak can

PHOTOS:

p. 30 Biomedical physics PhD student Homa Assadi working in Dr. Alexandre (Sasha) Douplik's lab.

p. 31 Dr. Alexandre (Sasha) Douplik and his group aim to improve clinical diagnostics, to make the early detection of tumour-related biomolecules a practical reality.

"ONCE THE UPTAKE IS DETECTED," KUMARADAS EXPLAINS, "AND IF FURTHER TESTING CONFIRMS A MALIGNANCY, THE TUMOUR CAN BE DESTROYED USING LONG-DURATION LASER EXPOSURE AIMED AT THE EXACT AREA."

range from red wavelengths (500 nm) to the infrared region (1000 nm). Light has deep penetration into tissue (up to 5 cm) at this range. A focal concentration of GNPs in tissue can be detected and imaged by photoacoustic methods."

Cancer tumours have leaky vasculature. Thus, they absorb GNPs (once intravenously injected) more readily than surrounding areas. Kumaradas is investigating the potential of using this preferential uptake to develop a modality that can provide early detection, tailored treatment and treatment monitoring.

"Once the uptake is detected," he explains, "and if further testing confirms a malignancy, the tumour can be destroyed using long-duration laser exposure aimed at the exact area." In other words, the GNPs—through their absorption of light—cause heat, which can destroy cancer cells.

Kumaradas emphasizes the range of physical phenomena involved. "We are utilizing COMSOL Multiphysics modelling software and SHARCNET high performance computing infrastructure for this research—in collaboration with labs at Ryerson, the University of Toronto and Université Lyon 1 in France." His goal is to revolutionize the detection and treatment of some types of cancer.

Dr. Michael Kolios has an equally bold vision. Recently appointed Associate Dean, Research and Graduate Studies for the Faculty of Science, Kolios also holds a Tier 2 Canada Research Chair in Biomedical Applications of Ultrasound at Ryerson. He is working on the development of ultrasound techniques to detect structural tissue changes associated with cell death in cancer patients—research that is being clinically tested at Sunnybrook Hospital. "My team is advancing biomedicine," he states.

For more than 13 years, Kolios has led efforts to build a facility for the analysis of tumours at a cellular level. His lab is one of the few in the world with capability for ultrasound imaging and spectroscopy that can span a frequency range from kilohertz (kHz) to gigahertz (GHz). "Our 2013 funding ($1.2 million from the federal and provincial governments) will help us take biomedical imaging to a new level." Machines will be upgraded; and his team will be able to develop the newer fields of optical coherence tomography (OCT) and photoacoustic imaging. They will be able to study—and collect new data for—the two most important tissue elements in cancer imaging and therapy monitoring: cells and blood vessels.

Kolios's team was the first in the world to show how OCT "speckle decorrelation" can detect cell death both in vitro and in vivo. Under the new project, an OCT instrument will be developed with a much higher frame rate acquisition to better detect cell death. The technology will also improve the analysis of cell death and vascular collapse.

Cancer research needs more methods to track how cancer cells in a particular tumour respond to treatment. New instrumentation will allow Kolios's team to map cellular death and vascular flow. The ability to map change has major clinical potential. Kolios's team will be one of the first in the world to use photoacoustic data to monitor changes in tumour vascularity and oxygenation status—in the process of cell death—to improve treatment.

Such efforts are on the cutting edge of biomedicine. Ryerson is working with labs in Toronto hospitals and foreign universities to find new approaches to disease. New technologies, interdisciplinary teams, and academic and clinical collaboration offer an exciting potential for breakthrough.

CONNECTED DEPARTMENTS

CHEMISTRY AND BIOLOGY

FINDING ANSWERS FOR A CHANGING WORLD

The Department of Chemistry and Biology brings together researchers in biomedical sciences, environmental science, and chemistry to tackle real-world problems of health and our environment using an interdisciplinary and collaborative approach. The department offers three undergraduate science programs (Biology, Biomedical Sciences and Chemistry) to more than 800 students; and Master's and PhD programs in Molecular Science and in Environmental Applied Science and Management. Faculty members have developed a strong research focus, with expertise bridging diverse areas such as: synthetic organic, bioorganic and medicinal chemistry, ecotoxicology, ecology, evolution, water and wastewater treatment, biochemistry, molecular biology, microbiology and polymer science.

Disease is a natural part of any ecosystem, but environmental stress can alter the balance, impacting how host organisms resist parasites and their ability to tolerate infections. **Dr. Janet Koprivnikar** addresses this issue in her disease ecology research program. "I'm particularly interested in how habitat quality relates to patterns of parasitism, such as the influences of biodiversity, contaminants, and landscape elements," says Koprivnikar. "This is critical in understanding how environmental features, and any subsequent changes, may be expected to impact both diseases and host populations." Parasites can also influence how hosts function and interact with their environment, likely playing a significant role in the structure of natural communities. When organisms interact with their environment, they often respond by changing their behaviour. Plants can be especially sensitive, changing the places they live, the way they grow, and their sex lives.

Dr. Lesley Campbell explores how plant populations respond to environmental pressures and how they might thrive in the altered environments humans are creating. "I'm interested in how humans alter plant evolution, genetic diversity and demography in rare and weedy plants," says Campbell. "Understanding how human activity affects plants can improve our ability to produce food in urban gardens, control weed invasions, and find rare plant populations." Campbell studies both

PHOTO: Dr. Bryan Koivisto and his group are using organic dyes to develop next-generation solar power.

agricultural and natural settings. She is fascinated by the similarity in population sizes—and contrasts in population demography—between invading weedy and rare native plant populations.

Energy production is one of the most intensive generators of greenhouse gas emissions, a potent driver of anthropogenic climate change. In order to meet our energy demands with a minimal carbon footprint, **Dr. Bryan Koivisto's** research focuses on the development of next-generation photovoltaic (PV) devices. The most efficient next-generation PV device is the dye-sensitized solar cell (DSSC). "Unlike silicon-based PVs, the plant-inspired DSSC is optically transparent; therefore it could be employed in windows and coatings," says Koivisto. "The powerhouse of this photovoltaic device is the dye molecule, and our research program seeks to prepare new bio-inspired organic dyes and fabrication techniques to improve the performance and long term stability in order to facilitate the commercialization of this emerging technology."

The department anticipates growth—as it implements the Biomedical Sciences undergraduate program, hires more faculty, continues to build research capacity, and expands its collaborative projects. "We will continue to support researchers in launching programs and sustaining research funding," says **Dr. Stephen Wylie**, the department chair. "Ryerson is carving out a reputation for relevant, collaborative research and our department is a part of that."

Research Areas

Biomedicine and Biomolecular Interactions

Synthetic and Medicinal Chemistry

Surfaces and Interfaces

Pathogens and Infection

Cells, Genes, Molecules

Water, Energy and Environmental Change

Materials and Food Chemistry

Pedagogy, Science Education and Outreach

Research Facilities

Advanced Microscopy Facility consisting of a two-photon confocal laser scanning microscope (CLSM), a Raman confocal microscope (RCM) and an atomic force microscope (AFM)

Inverted laser-confocal microscope suitable for live-cell imaging, epiflourescence microscope and 400-MHz Bruker multi-probe NMR instrument

Level 2 Biohazard Facility licensed for work with eukaryotes and prokaryotes

Ryerson University Analytical Centre which offers a suite of analytical equipment including high performance liquid chromatography (HPLC) with UV, refractive index, conductance and fluorescence detection; gas chromatography-mass spectrometry (GC-MS) with autosampler; GC with headspace and purge-and-trap autosamplers; molecular luminescence, UV-visible spectroscopy and FTIR spectrometers

COMPUTER SCIENCE

ON THE VIRTUAL FRONTIERS OF ARTIFICIAL INTELLIGENCE, CLOUD AND PERVASIVE COMPUTING

Computer technology has become an integral part of every field of human endeavour—from science to engineering, art, education, law and medicine. Our everyday lives, professional and personal, increasingly rely on computation science in general and software technology in particular. The technological advances and breakthroughs in the 21st century will be very closely dependent on the scientific achievements in computer science. During the past decade, leading-edge research areas such as cloud computing, augmented reality, context-aware software applications, big data analytics and the "Internet of things" have all come to fruition. And artificial intelligence is no longer a dream but a reachable reality. The Department of Computer Science provides exceptional learning and research environments in all these major areas.

The department offers two strong and accredited undergraduate programs, and two graduate programs in computer science. The undergraduate programs are (1) a campus-based four-year program and (2) a five-year co-operative program that provides students with paid work experiences in top software companies, banks, insurance companies, government, etc. The graduate programs lead to an MSc and a PhD in Computer Science. With approximately 700 undergraduate students and 80 graduate students, the department has one of the largest computer science programs in the province of Ontario. "Learning and teaching continue to be high priority," says **Dr. Alireza Sadeghian**, department chair. "We are regularly investing in state-of-the-art teaching labs and developing online testing facilities." Department growth plans include initiation of an undergraduate program in game development.

Faculty members are active in a wide range of research topics. For example, **Dr. Alex Ferworn** and his graduate students, the Network-Centric Applied Research Team (N-CART), are working in the field of computational public safety. Their Disaster Scene Reconstruction (DSR) project seeks to take data gathered from a complex optical sensor carried by an unmanned aerial vehicle, then transform and enhance the data for use within a game engine with physics models applied to artifacts

PHOTO: Dr. Jelena Misic's research focuses on network security, cloud computing, networking for big data and wireless networks.

within the model. The goal is to provide emergency first responders with a tool for modelling a disaster as it unfolds, in order to develop a strategy without expending resources or incurring risk. They have also started work on automatically detecting "holes" within disaster rubble where survivors might be found, which could assist first responders in prioritizing how they search rubble for survivors.

Advancements in computer and communication technologies are rapidly changing how users and computers interact. **Dr. Ali Miri** and his students in the Information and Computer Security Laboratory (iCaSL) are engaged in projects that address various privacy and security challenges in this new computing paradigm. In one project, they are building tools that will allow delivery of a cloud-based service for project planning and resource management, which will enable (among other features) the secure sharing of files. In another project, their team is identifying, analyzing and building countermeasures to malicious attacks on multi-purpose mobile platforms.

Drs. Jelena Misic and **Vojislav Misic** are currently working on various research projects related to networks in general, and particularly on: vehicular ad hoc networks, machine type communications, communications and security in Smart Grid, body area networks, performance evaluation of cloud computing centers, cognitive personal area networks and dynamic spectrum allocation.

The department is active in community projects through the Office of Science Outreach and Enrichment (OSOE), where high school classes are invited to visit the university and to participate in workshops on robotics and mobile "app" development.

Research Areas

Computational Intelligence

Network-Centric Applied Research

Information and Computer Security

Wireless and Sensor Networks

Ubiquitous and Pervasive Computing

Artificial Intelligence: Knowledge Representation and Reasoning

Interactive Visual Exploration, Manipulation and Analysis of 2D and 3D Data

Social Computing, Data Analytics and Behavior Informatics

Research Facilities

Network-Centric Applied Research Team (N-CART) Laboratory

Information and Computer Security Laboratory (iCaSL)

Computational Intelligence Initiative Lab (CI2)

Distributed Applications and Broadband NEtworks Laboratory (DABNEL)

Distributed Systems and Multimedia Processing (DSMP) Laboratory

Ubiquitous and Pervasive Computing Lab (UPCL)

EXPLORING THE WORLD THROUGH NUMBERS, MODELS AND COMPLEX NETWORKS

MATHEMATICS

Fluctuations in the stock market. The spread of a pandemic. The flow of blood in arteries and veins. The Facebook phenomenon. Competition between species. The nature of the Internet itself. Those are just a few of the real-world issues that mathematicians at Ryerson are exploring. "Most of us have very direct applications to our research," says **Dr. Dejan Delic**, interim chair of the Department of Mathematics. "That gives us an edge, not only in research but also in our teaching programs." The department's 21 faculty members and five post-doctoral fellows have expertise in areas such as mathematical finance, graph theory, complex networks, big data, mathematical biology, fluid dynamics, stochastic calculus and quantum mechanics. The department consists of three research groups.

Graphs at Ryerson (G@R) is a group of researchers and students working in pure and applied graph theory, with a special focus on large-scale networks in the real world, such as Facebook and Twitter, and with emphasis on connections to big data research questions. The group is involved in a number of applied research projects, including three NSERC Engage Grants with industry partners, namely: Intelligent Rating System, dynamic clustering and prediction of taxi service demand, and Personalized Mobile Recommender System.

The second group, Financial Mathematics, is working to understand risk and to model financial transactions. "This is a really hot topic right now," says Delic. "Our group is very active in developing new models for stocks and hedge funds and other financial transactions, with the goal of maximizing returns. There is a lot of interest from banks and smaller companies." The group recently renewed their Collaborative Research and Development Grant from NSERC to model hedge funds, with support from Sigma Analysis & Management Ltd., a Toronto-based investment firm.

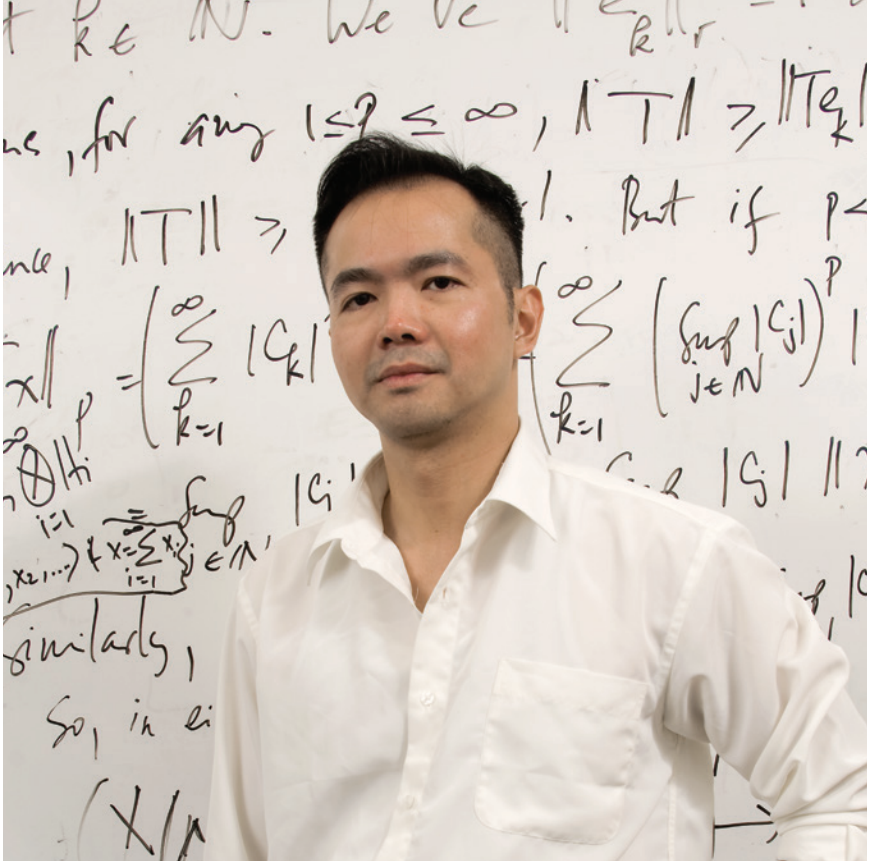


PHOTO: Dr. Dzung Minh Ha's research interests are in ergodic and operator theory.

The third group, Biomathematics and Fluids, explores the application of mathematics to biology. Researchers use mathematical models to explore everything from genomics and proteomics, to the fluid dynamics of blood flow. "People said that the 20th century was all about math applied to physics," says Delic, "and the 21st century will be about math applied to biology, including big data. We are a part of that exciting development."

From its early role in "service teaching" at Ryerson, the Department of Mathematics has moved forward quickly. In 2008, it launched a BSc in Mathematics and its Applications, and in 2009, a Master's in Applied Mathematics. A BSc in Financial Mathematics was introduced in 2013. "We are the only applied mathematics program in the GTA," says Delic. "Because of our roots, we have a keen understanding of pedagogy and provide a great environment for students to learn and achieve their goals." The department plans to add a PhD program shortly, and is committed to its strategy of attracting top researchers and external research grants, while developing its research intensive profile.

The department is actively involved in organizing international events such as the 2nd Graph Searching Workshop (GRASCan) held at Ryerson in May 2013, and the 10th Workshop on Algorithms and Models for the Web Graph (Harvard University, December 2013). Academic exchange is further encouraged by grants such as the Emerging Leaders in the Americas Program, which is enabling PhD student Ivan Degano, from the National University of Mar del Plata in Argentina, to visit the Department of Mathematics at Ryerson in 2014 and work under the supervision of **Dr. Sebastian Ferrando**.

Research Areas

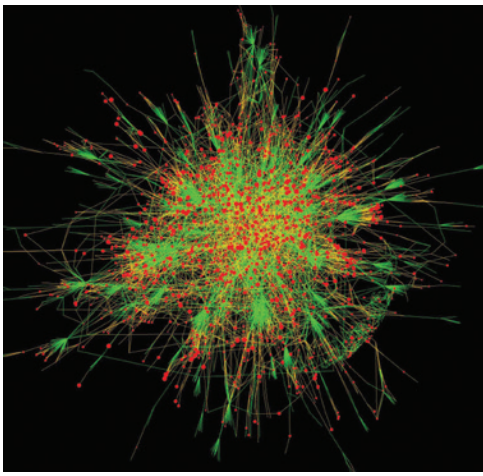
Biomathematics and Fluids

Financial Mathematics

Graph Theory

Research Facilities

Ryerson Applied Mathematics Laboratory (RAMLab)



EARLIER DIAGNOSIS AND EFFECTIVE THERAPY: MEDICAL PHYSICS IN THE SERVICE OF HEALTH

PHYSICS

Ryerson's Department of Physics has a unique focus on physics in the context of human health and health care, with research collaborations with: St. Michael's Hospital, Princess Margaret Hospital, Sunnybrook Health Sciences Centre and Hamilton Health Sciences, McMaster University Medical Centre. Diagnosis and treatment have benefited from principles of physics discovered and applied in biophysics and medicine. Our vision is to establish fruitful collaborations with clinicians and industry in order to address critical and relevant questions for medical care in Canada. The department is dedicated to improving physics education using innovative teaching methods with emphasis on conceptual understanding and problem-solving skills.

The department offers a BSc in Medical Physics, and an MSc and PhD in Biomedical Physics. As of 2013, the graduate program offers a CAMPEP accreditation option in biomedical physics. This exciting new development allows graduates of biomedical physics to complete a residency program and become licensed clinical medical physicists. Furthermore, the department now offers a "cotutelle" doctoral program. Martin Hohmann was the first student to enter the joint PhD program through Ryerson and Friedrich-Alexander-University Erlangen-Nuremberg (FAU) in Germany, to work simultaneously on two PhDs: one in biomedical physics, the other in engineering.

Faculty members in the department develop new knowledge in research areas, including (1) medical imaging, (2) cancer therapy, (3) computational and mathematical physics, (4) trace element detection in human and biological samples and (5) physics education.

Early detection and targeted therapy is critical in our fight against cancer and other diseases. Diseases induce changes at the tissue and cellular level that can be detected using photoacoustic imaging, functional magnetic resonance imaging (fMRI), contrast-enhanced ultrasound imaging, electro-kinetic response imaging, optical coherence tomography and optical spectroscopy. Photoacoustic microscopy can characterize the shape of individual blood cells, effectively creating a new tool potentially capable of identifying blood-borne diseases at early stages (as featured in Scientific American, July 2013). Targeted therapy of cancerous tissues is based on ultrasonically stimulated microbubbles and gold nanoparticles with the aim to improve treatment outcome of radiotherapy,

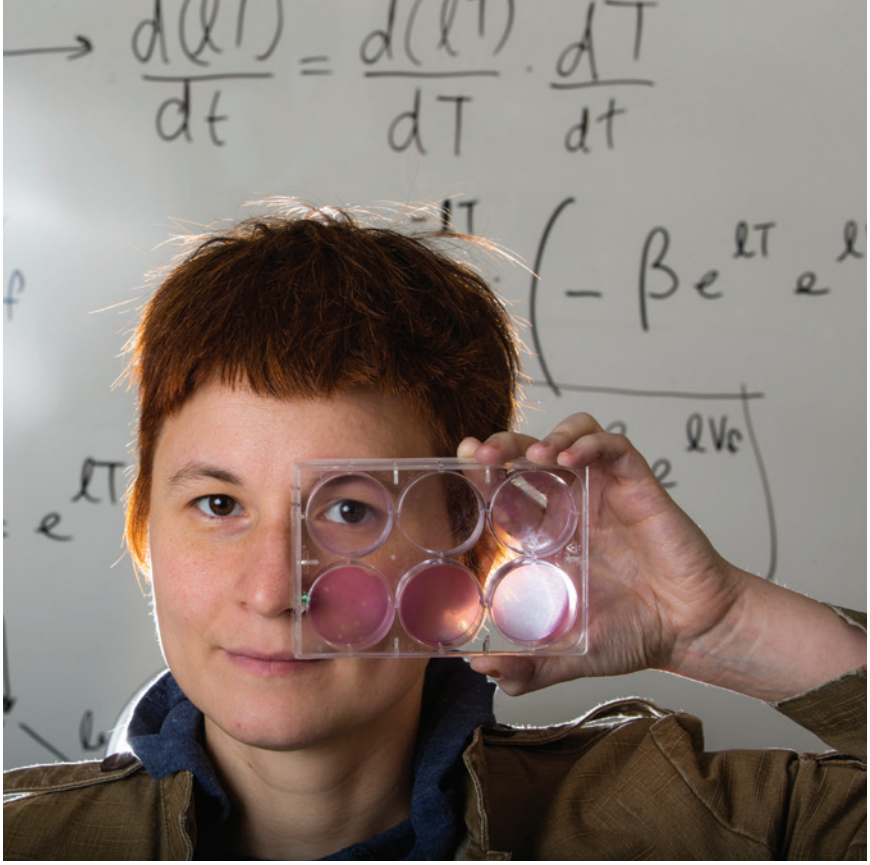


PHOTO: Dr. Catherine Beauchemin uses mathematics and computers to model how viruses replicate and spread cell to cell.

chemotherapy, laser therapy and high-intensity focused ultrasound (HIFU).

In addition, non-destructive and multi-elemental analytical tools using X-ray fluorescence spectrometry are being developed by **Dr. Ana Pejović-Milić** , the chair of the department.

Dr. Catherine Beauchemin builds mathematical and computer models to better understand the interaction among biological factors and antiviral drugs that affect the spread and the severity of flu in an individual. Dr. Beauchemin's work is supported in part by pharmaceutical companies who produce antiviral medications. A team led by **Dr. Tetyana Antimirova**, teaching chair of the Faculty of Science, focuses on developing innovative teaching methods in physics to improve conceptual understanding and problem-solving skills among students in introductory physics courses.

Research Areas

Medical Imaging and Treatment Modalities:
Optoacoustic imaging; ultrasound biomicroscopy; advanced biomedical ultrasound imaging and therapy; ultrasound and microbubble therapeutics and imaging in cancer; ultrasound mediated imaging; magnetic resonance imaging and near infrared spectroscopy; nanoparticles for improved therapeutics and imaging in cancer therapy; minimally invasive thermal therapy; robust treatment planning; clinical feedback for laser surgery; and treatment optimization for radiation therapy and image reconstruction

Computational and Mathematical Physics:
Physical modelling in biology, immunology and ecology (phymbie); Computational Biomedical Physics Laboratory; and simulated treatment courses using Monte Carlo techniques

Trace Element Detection in Human and Biological Samples:
Human trace element detection; X-ray fluorescence

Physics Education:
Technologies include interactive peer response systems (or clickers) and computer-based laboratory equipment such as Logger Pro

Research Facilities

Advanced Biomedical Ultrasound Imaging and Therapy Laboratory

Clinical Feedback for Laser Surgery Laboratory

Computational Biomedical Physics Laboratory

Magnetic Resonance Imaging and Near Infrared Spectroscopy Laboratory

Minimally Invasive Thermal Therapy Laboratory

Nanoparticles for Improved Therapeutics and Imaging in Cancer Therapy Laboratory

Optoacoustic Imaging Laboratory

Physical Modelling in Biology, Immunology, and Ecology (Phymbie) Laboratory

Robust Treatment Planning Laboratory

Simulation of Radiation Therapy Delivery Using Monte Carlo Techniques Laboratory

Treatment Optimization for Radiation Therapy and Image Reconstruction Laboratory

Trace Element Detection in Human and Biological Samples Laboratory

Ultrasound Biomicroscopy Laboratory

Ultrasound and Microbubble Mediated Therapeutic Applications Laboratory

CONNECTED FACULTY

PROFILES

CHEMISTRY AND BIOLOGY

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Research Areas: Cell biology, in particular molecular mechanisms that control membrane traffic and hormone signaling related to human health and disease

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Research Areas: Phosphorus transfer from watersheds to freshwater systems; the impact of specific particulate phosphorus fractions on the phytoplankton community; ecotoxicological aspects of nanoparticles as vectors for hydrophobic contamination

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Research Areas: Cell biology, biochemistry, organelle identity, phosphoinositides, membrane trafficking, phagosome, endolysosomes

Lesley Campbell, PhD
Assistant Professor

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Research Areas: Agro-evolutionary biology, conservation, evolution, global climate change consequences, invasive species

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Professor and Dean,
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Research Areas: Structure, function, regulation of transporters and other membrane proteins

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Research Areas: Development of novel HIV/AIDS therapeutics exploiting the MCEF protein, structure/function analysis of MCEF, HIV-1 transcription, protein transduction

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Research Areas: The nature and uses of host-guest complexes, binding models for cyclodextrins, applications of polymer-immobilized cyclodextrins, development of molecular imprinted hydrogel polymers

Jeffrey Fillingham, PhD
Assistant Professor

jeffrey.fillingham@ryerson.ca
416-979-5000, ext. 2123

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Research Areas: Molecular biology, biochemistry, genetics, protein-protein interactions, chromatin

Debora Foster, PhD
Professor and Director, Graduate Program in Molecular Science

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Research Areas: Pathogenesis of diarrheagenic E. coli, impact of stress on virulence of pathogenic E. coli

Daniel Foucher, PhD
Associate Professor

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Research Areas: Novel inorganic and organometallic polymers

PROFILES

CHEMISTRY AND BIOLOGY

Noel George, PhD
Associate Professor

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Research Areas: Chemical education

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Research Areas: Molecular microbiology, bacterial diversity, surface waters, wastewater treatment process, bacterial pathogens

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Robert A. Gossage, PhD
Associate Professor

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416-979-5000, ext. 2056

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Research Areas: Inorganic and organic chemistry, synthesis, chemotherapy, medicinal chemistry

Martina Hausner, Dr. rer. nat.
Associate Professor

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416-979-5000, ext. 6553

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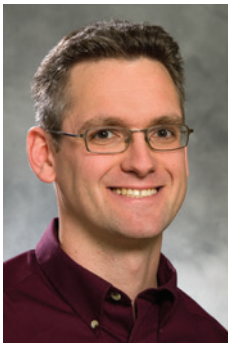
Research Areas: Environmental microbiology, molecular microbial ecology, biofilms, environmental biotechnology



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Associate Professor and Associate Dean, Undergraduate Science Program and Student Affairs

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Research Areas: Physical/analytical chemistry, surfaces and interfaces, photochemistry, raman microscopy, thin films

Anne E. Johnson, PhD
Associate Professor and Undergraduate Program Director (Chemistry)

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Research Areas: Chemical education research, case studies, bioorganic chemistry, spatial ability

Bryan Koivisto, PhD
Assistant Professor

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416-979-5000, ext. 4625

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Research Areas: Sustainable energy, advanced solar design, next-generation photovoltaics

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Associate Professor

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Research Areas: Ecology and evolution of infectious diseases

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Associate Professor and Academic Coordinator, First Year and Common Science Office

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Research Areas: Aquatic ecology, nitrogen carbon and sulfur biogeochemistry, ecosystem science

Julia Lu, PhD
Professor

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416-979-5000, ext. 7481

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Research Areas: Analytical chemistry, biogeochemistry of persistent toxic pollutants, chemical speciation, air and water quality

PROFILES

CHEMISTRY AND BIOLOGY

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John G. Marshall, PhD
Associate Professor

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Research Areas: Mass spectrometry of receptors complexed with their circulating ligands, innate immune response, phagocytosis, free radicals from NAPDH oxidase, protein biochemistry, analytical biochemistry, analytical cell biology

Lynda H. McCarthy, PhD
Professor

l3mccart@ryerson.ca
416-979-5000, ext. 6378

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Research Areas: Great Lakes pollution, industrial and municipal wastewater ecotoxicology, land-application of biosolids

Andrew McWilliams, PhD
Associate Professor

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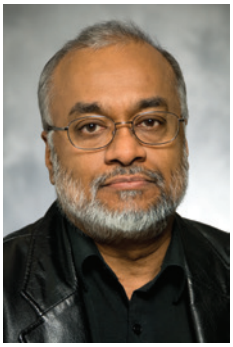
Research Areas: Inorganic chemistry, polymer synthesis, main group chemistry, organometallic chemistry, inverse crowns



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Professor

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Areas of interest: Analytical chemistry, spectroscopy, chromatography

Dérick Rousseau, PhD
Professor

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Research Areas: Food science and technology, lipid crystallization, controlled release, emulsions, microemulsions, chocolate

Russell D. Viirre, PhD
Associate Professor

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Research Areas: Synthetic organic chemistry, medicinal chemistry (especially with Cystic Fibrosis), stereochemistry, bioorganic chemistry

Warren W. Wakarchuk, PhD
Professor

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Research Areas: Glycobiology, glycosyltransferase and glycosylhydrolase structure and function, application of glycosyltransferases for glycan synthesis

Gideon Wolfaardt, PhD
Professor and Canada Research Chair in Environmental Interfaces and Biofilms

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Research Areas: Environmental microbiology, biofilm ecology, biofilm control, bioprocessing

R. Stephen Wylie, PhD
Associate Professor and Department Chair

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Research Areas: Inorganic chemistry, reaction thermodynamics, kinetics and mechanisms, supramolecular self-assembly

PROFILES

COMPUTER SCIENCE

Abdolreza Abhari, PhD
Associate Professor

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Research Areas: Web 2.0 social networking, web mining and information retrieval, data mining and database systems, big data analysis, sensor networks and distributed systems, soft computing and fuzzy logic, modelling and simulation

Konstantinos Derpanis, PhD
Assistant Professor

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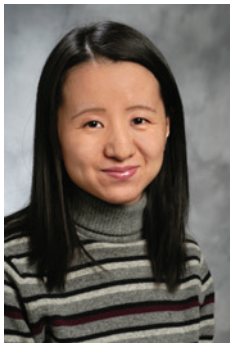
Research Areas:
Computer vision



Chen (Cherie) Ding, PhD
Associate Professor

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Research Areas: Cloud computing, software service selection and ranking, recommender systems, data analytics, social network, behaviour informatics, information retrieval

Alexander Ferworn, PhD
Professor, Associate Chair and Graduate Program Director

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Research Areas:
Computational public safety: Urban Search and Rescue (USAR) and Chemical, Biological, Radiological and Nuclear explosives (CBRNe) applications; mobile, autonomous and teleoperated robotics; artificial intelligence and network applications

Denis Hamelin, PhD
Associate Professor

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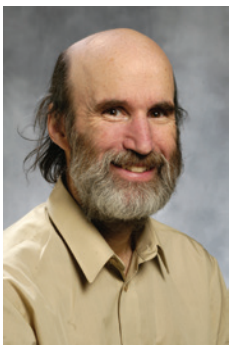
Research Areas: Computer science education, multimedia, web design, quantitative research



Eric Harley, PhD
Associate Professor

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Research Areas: E-learning, bioinformatics, natural language processing

David Mason, PhD
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Research Areas: Citizen programmers, programming languages, program analysis, software reliability, code optimization

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Research Areas: Software engineering, OS, DBMSs, distributed systems (OS and DBS), repositories (reuse), multidimensional files (tables)

Tim McInerney, PhD
Professor

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Research Areas: 3D interactive visualization, medical image analysis, 3D human-computer interaction

Ali Miri, PhD, PEng
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Research Areas: Security and privacy, computer networks, digital communication

PROFILES

COMPUTER SCIENCE

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Research Areas: Cloud computing and networking, M2M communications, body area networks, cognitive and green networking, network security, performance evaluation

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Research Areas: Wireless networks, software engineering

Joshua Panar, PhD
Professor

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Research Areas: Teaching faculty, specifically in object-oriented and mainframe education; first and second year Science and Engineering computer education

Sophie Quigley, MMath
Professor

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Research Areas: Human-computer interaction, user interface design, usability testing

Alireza Sadeghian, PhD
Associate Professor and Department Chair

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Research Areas: Computational intelligence, neural networks, fuzzy sets of higher order, knowledge-based systems, and nonlinear modeling

Marcus Santos, PhD
Associate Professor

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Research Areas: Genetic and evolutionary computation, knowledge representation and automatic reasoning

Mikhail Soutchanski, PhD
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Research Areas: Artificial intelligence knowledge representation and reasoning, computationally tractable reasoning about actions and events

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Professor

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Research Areas: Software engineering, software testing, agile software development, software reliability composition

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Research Areas:
Network security, mobile communication systems, mobile wireless networks

PROFILES

MATHEMATICS

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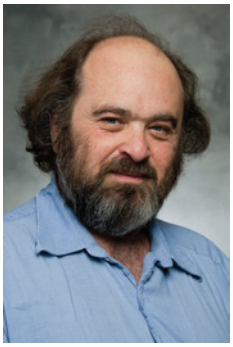
Research Areas: Networks, graph theory, web graph, social networks



Peter Danziger, PhD
Professor

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Research Areas: Discrete mathematics, design theory, graph decompositions and factorizations, covering arrays

Dejan Delic, PhD
Associate Professor and Department Interim Chair

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Research Areas: Computational complexity, model theory of relational structures, algebraic method in graph theory

Marcos Escobar-Anel, PhD
Associate Professor

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Research Areas: Multidimensional stochastic processes, dependence structures, financial mathematics, biostatistics

Sebastian Ferrando, PhD
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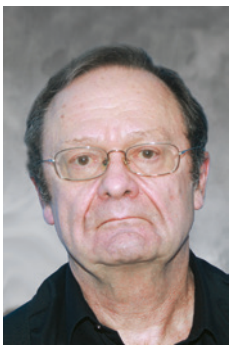
Research Areas: Mathematical finance, computational harmonic analysis and applications, ergodic theory



Chris Grandison, MSc
Professor

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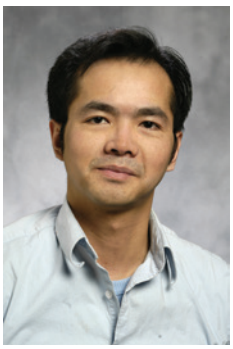
Research Areas:
Approximation theory and its software implementation



Dzung Minh Ha, PhD
Associate Professor

haminh@ryerson.ca
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Research Areas: Ergodic and operator theory

Silvana Ilie, PhD
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Research Areas:
Computational biology; development and analysis of simulation methods for biochemical systems; stochastic computation with applications to systems biology; numerical methods, analysis and computation; applications to gene regulatory networks

Chul Kim, PhD
Associate Professor

chulkim@ryerson.ca
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Research Areas:
Cryptography, cryptanalysis, information security management, computation algebra

Lawrence A. Kolasa, PhD
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Research Areas:
Harmonic analysis, signal and image processing

PROFILES

MATHEMATICS

Kunquan Lan, PhD
Professor

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Research Areas: Differential equations, partial differential inequalities, nonlinear analysis and applications to mathematical biology, ecology

Peter A. Lawrence, PhD
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Research Areas:
Computational, commutative and topological algebra

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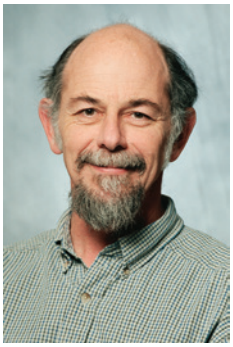
Research Areas:
Mathematical finance, asymptotic inference of stochastic processes, levy models, stochastic differential equations



Garnet Ord, PhD
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Research Areas: Exactly solvable models in statistical mechanics, foundations of quantum mechanics

Jean-Paul Pascal, PhD
Associate Professor

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Research Areas: Fluid mechanics, hydrodynamic instability, gravity-driven flows, numerical methods

Pawel Pralat, PhD
Assistant Professor and
Associate Chair for Research

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Research Areas: Modelling and searching complex networks in the big data era

Katrin Rohlf, PhD
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and Associate Chair for
Undergraduate Studies

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Research Areas: Non-Newtonian fluid dynamics, reaction diffusion equations, stochastic processes, numerical methods, particle aggregation

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Associate Professor

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Research Areas: Mechanical and electrical properties of raw and annealed metallic glasses (thin magnetic layers); statistics applied to engineering problems

PROFILES

PHYSICS

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Associate Professor and Undergraduate Program Director

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416-979-5000, ext. 7416

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Research Areas: Physics education research, curriculum development, educational technologies, science education and outreach, condensed matter physics, physical chemistry

Catherine Beauchemin, PhD
Associate Professor and Co-op Program Faculty Advisor

cbeau@ryerson.ca
416-979-5000, ext. 2508

phymbie.physics.ryerson.ca/~cbeau

Research Areas: Virophysics, or utilizing physical models to resolve the temporal dynamics of viral infections; specifically, the development of realistic mathematical and computer models to capture and explain the kinetics of viral infection spread within a cell culture (in vitro) or a host (in vivo)

NO PHOTO AVAILABLE

Margaret Buckby, PhD
Professor

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Research Areas: Nuclear astrophysics, supernovae, extraterrestrial life

Juliana Carvalho, PhD
Professor

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Research Areas: Collective motion in nuclear physics, algebraic models, Schur function formalism; MAPLE as a tool for teaching physics

Basnagge Devika Chithrani, PhD
Assistant Professor

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Research Areas: Medical physics, synthesis and characterization of nanoparticles, development of nanoparticle based systems for multimodal imaging and therapeutics, nanoparticle-based radiosensitizers, drug delivery, intracellular fate of nanoparticles

Dietmar Cordes, PhD
Associate Professor

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Research Areas: MR physics, MR imaging, echoplanar imaging and functional MRI (fMRI), fMRI data analysis and mathematical methods, ultra-short echo-time imaging (UTE)

Alexandre Douplik, PhD
Associate Professor

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Research Areas:
Clinical photonics

Pedro Goldman, PhD
Professor

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Research Areas: Radiation therapy of tumours, fast inverse dose optimizations for intensity modulated radiation therapy (IMRT) and tomotherapy, alternative methods for efficient CT image reconstruction, physics education

Emily Heath, PhD
Assistant Professor

e3heath@ryerson.ca
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Research Areas: Radiation therapy, image registration, treatment plan optimization, Monte Carlo simulation

Raffi Karshafian, PhD
Associate Professor

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Research Areas: Ultrasound and microbubble therapy, sonoporation, chemotherapy, radiotherapy, ultrasound imaging, biophysics

PROFILES

PHYSICS

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Professor, Associate Dean of Research and Graduate Studies, and Canada Research Chair in Biomedical Applications of Ultrasound
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Research Areas: Ultrasound imaging and therapy, optoacoustic imaging, optical imaging and therapy, thermal therapies

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Associate Professor and Graduate Program Director

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Research Areas: Medical physics, thermal therapy, electromagnetism, heat transfer, numerical analysis

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Research Areas: Medical physics, trace elements analysis in humans, bone strontium, aluminum, manganese and magnesium, nuclear analytical methods for medical applications, X-ray fluorescence (XRF), in vivo neutron activation analysis (IVNAA)

Jahan Tavakkoli, PhD
Associate Professor

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Research Areas: Biomedical ultrasound, image-guided ultrasound therapy, nonlinear ultrasound simulation, ultrasound signal and image processing, medical devices

Vladislav Toronov, PhD
Associate Professor

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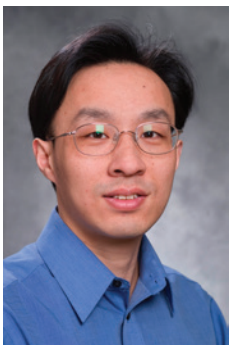
Research Areas:
Optical and magnetic resonance biomedical imaging, non-linear dynamics of the brain



Yuan Xu, PhD
Associate Professor

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Research Areas: Ultrasound imaging, novel imaging reconstruction algorithms, multi-wave imaging methods, medical imaging

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February 2014 (80371)

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