RYERSON UNIVERSITY FACULTY OF SCIENCE ANNUAL REPORT 2014

CONNECTED SCIENCE



RYERSON UNIVERSIT

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IMOGEN COE CONNECTED SCIENCE

At Ryerson University's Faculty of Science (FOS), we see our faculty continuing to gain independence and build its profile and reputation, both within Ryerson and in the broader community.



Since forming in 2012, the FOS has established a brand, Connected Science, and guiding principles to inform and guide faculty activities. Our principles include promoting humanity in science, social innovation, scientists and leaders, quality and agility, access and impact. Our faculty's ambitions closely reflect Ryerson's institutional academic plan – called Our Time to Lead – which highlights enhanced scholarly research and creative activities.

Over the last two years, we have formed strong connections with our students at the undergraduate and graduate level and will continue to do so. Applications to FOS undergraduate programs have climbed 20 per cent since 2012, ever strengthening our pool of incoming students. Our two new undergraduate programs, in Biomedical Sciences and Financial Mathematics, have received many applications and demonstrated our programs' appeal to young people. Building on the success of Ryerson's "Zone Learning," we are now launching new Zone initiatives at the undergraduate level in Computer Science. We are also completing a suite of doctoral graduate programs via the launch of a Mathematical Modelling & Methods program. As part of our outreach effort, we have worked closely with colleagues in media and communications to develop marketing strong tools and inform our community.

Our connections with neighbours and partners also continue to grow. We look forward to a highly active and productive partnership in teaching and research with Sunnybrook Health Sciences Centre, particularly in Medical Physics. In addition, we have strong and growing biomedical research connections with St. Michael's Hospital (SMH). A number of our researchers are now affiliate scientists at SMH; and a number of SMH researchers are adjunct professors in the faculty. Our growing connectedness with SMH will be realized in physical form with the completion and occupancy of the new shared research space on the seventh floor of the Li Ka Shing Knowledge Institute, and the formation of the new Institute for Biomedical Engineering and Science Technology (iBEST). Updates on the project can be found here. Ryerson will also sign a long-term agreement with MaRS for more than 20,000 square feet of space in the institute's Phase 2 tower. Several FOS faculty members will move their research to this new facility where leading academic and industrial organizations have laboratories.

The faculty now provides a home base for two new and growing research collectives: the Ryerson Urban Water Centre, and the Privacy and Big Data Institute. Both RUW and the PBD Institute are multidisciplinary, pan-university centres aiming to bring together thought leaders, leading-edge researchers and partners from industry, business, the not-forprofit sector, and government to develop solutions to current real-world problems.

As the world around us seems ever more fastpaced and complex, some problems can seem insurmountable. Ryerson's Faculty of Science is well-positioned to study and understand the complexities and connections and, through networking and collaboration, to find solutions to these problems. Our dynamic approach will create new knowledge. And, our research and teaching will have real impact on people in our local, national and international communities.

Lauger R. Coe

IMOGEN COE Dean, Faculty of Science

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5 FACULTY

FOS AT A GLANCE

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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)*

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*Interdisciplinary program administered by the YSGS.

Canada Research Chair

Michael Kolios

Canada Research Chair (Tier 2) in Biomedical Applications of Ultrasound (until September 30, 2014)

Gideon Wolfaardt

Canada Research Chair (Tier 2) in Environmental Interfaces and Biofilms (until March 31, 2014)

Roberto Botelho

Canada Research Chair (Tier 2) in Biomedical Sciences and Technologies (starting September 2014)



Research Centres Housed in FOS Ryerson Urban Water Centre Privacy and Big Data Institute

2013-2014 IN NUMBERS			
			Innovation and Entrepreneurship Statistics for 2009-2014
undergraduate students 2,096	graduate students 277	INTERNATIONAL STUDENTS 55	NUMBER OF DISCLOSURES FILED 29 NUMBER OF LICENCES EXECUTED 13
			NUMBER OF PATENTS FILED 19 NUMBER OF SPINOFF COMPANIES RELATED TO THE TECHNOLOGY 4
FACULTY MEMBERS	postdoctoral fellows 33	staff 41	NUMBER OF SCIENTISTS AND ENGINEERS IN BUSINESS (SEB) FELLOWSHIPS 5

FOS AT A GLANCE



GROWTH IN 5 YEARS

UNDERGRADUATE STUDENT ENROLEMT

STUDENT ENROLEMT

FOS PUBLICATIONS

TRI-COUNCIL FUNDS*

* Ryerson's fiscal year is May 1 to April 30.



2009-2010





FOS **Publications**

250

200

150

100

50

0

● 2010-2011 ● 2011-2012 ● 2012-2013



Tri-Council Funds*

- Tri-Council Operating Funds
- Non-Tri-Council Funds







2013-2014

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COMPUTER SCIENCE **MATHEMATICS**

PHYSICS

CONNECTED RESEARCH

Case Studies

- **5** Promoting Healthy Aquatic Environments
- **9** Seeing Digitally: From Disaster-Zone Rescue to Online Surveillance and Searching
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CHEMISTRY

AND BIOLOGY



CASE STUDY: Environmental Health

PROMOTING HEALTHY AQUATIC ENVIRONMENTS

Oceans, lakes, rivers, streams and even humble creeks: the impact of human-induced change – wrought by industrial production, agriculture, urbanization and other activities – is real and growing in these and other watery environments. New scientific approaches and models are needed to interpret, manage and generate solutions for the aquatic ecosystems that support life across the planet. 2 FOS AT A GLANCE

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CASE STUDY: Environmental Health PROMOTING HEALTHY AQUATIC ENVIRONMENTS

While their research focuses on what is going on *in* the water, faculty members in Ryerson's Department of Chemistry and Biology also consider changes happening on land as vitally important for explaining the health of aquatic environments and the creatures inhabiting them.



A spatial ecologist, **Dr. Stephanie Melles** focuses on species distribution patterns and ecosystem diversity to address some of the most salient problems in global change ecology. Her work begins from the premise that nothing occurs in isolation: all things are connected in space and time, and these connections make it possible for humans to detect patterns. "Our survival as a species depends," Melles contends, "on our ability to recognize patterns – suitable or threatening, repeatable or exceptional."

One of Melles's main areas of research is cross-scale drivers of species diversity, especially the factors that make some locations or samples "species rich" and others "species poor." Melles's work involves developing and using models that predict how different processes lead to diversity. She then evaluates those models (e.g. aquatic ecosystem classification models) in the field to validate or check predictions about species diversity and ecosystem services.

"Furthering our understanding of the basic drivers of diversity," Melles says, "will lead to solutions to questions such as 'How can we better manage individual ecosystem types that are susceptible to specific humancaused changes?' and 'Are there any novel remedial actions (e.g. erecting barriers, imposing fish consumption limits) that could be targeted at specific ecosystem types to manage multiple stressors such as climate warming, invasive species, land-use change and development?'"

With support from the Invasive Species Centre, Melles, with several colleagues from the NSERC Canadian Network of Aquatic Ecosystem Services, recently took this approach. They investigated how watershed network configurations, climate change and proposed hydroelectric power development could influence the risk of non-native species invasion in the Great Lakes basin. Not only did the researchers' evaluation of "mean invasion risk" provide a broad-scale comparative tool for managing invasive species control options; but their investigation led to the conclusion that dams could partially mediate risk by reducing connectivity and access to potentially suitable habitats

Dr. Michael T. Arts is an aquatic ecologist whose recent work has also concentrated on life in temperate freshwater lakes. Focusing on the health and vitality of aquatic organisms, Arts's research – which is supported by NSERC and Ryerson grants – also addresses global environmental processes such as climate change, invasive species and contaminants.

Recently, researchers including Arts conducted a study in Daisy Lake near Sudbury and their findings, upon publication in Nature Communications, have received worldwide media attention. Notably, Arts and his colleagues demonstrated that land use has direct consequences for fish growth in boreal lakes. "Our findings showed a clear link between watershed protection and healthy freshwater yellow perch populations," says Arts. "More specifically, trees and their leaves provide fuel for the

CASE STUDY: Environmental Health **PROMOTING HEALTHY AQUATIC ENVIRONMENTS**

microbes living in the lake, which then feed the plankton and which in turn are eaten by fish. When young fish are fueled with energy that ultimately came from the forest, they grow larger and this has a direct influence on their likelihood of reaching maturity."

In densely forested areas, fish like yellow perch derive upwards of 66 per cent of their biomass from forest matter. But with rampant deforestation in so many parts of the world, there is significant concern about dwindling fish health and stocks. And, Arts explains, that is not only a problem for fish: "Approximately seven per cent of global protein consumption is from fish; and fish are far and away the main source of dietary long-chain omega-3 fatty acids (like EPA and DHA) that reduce the risk of diseases in humans. By removing plant biomass from our forests through logging, fires and other human-related changes, we're threatening fish and the health of the people who depend on them for sustenance."

Arts's temperate-lake research has involved him in a quest to understand another dimension of human-induced environmental change: the "jellification" of Canadian lakes by a tiny jelly-clad organism called Holopedium. When present in large quantities, this planktonic organism clusters together to create masses of jelly.

In a study of lakes in Ontario and Nova Scotia, Arts and his co-investigators (from five Ontario universities and the Ministry of the Environment and Climate Change) were the first to discover a connection between decreased calcium levels in lake water and increased concentrations of Holopedium. "The main culprit in the disappearance of calcium is acid rain," explains Arts. "While acid levels in rain have fallen sharply since the 1980s, historic deposits of acid in the soil are still at work "

One of the consequences of steady calcium depletion - known by some biologists as "aquatic osteoporosis" - has been a decrease in water fleas (known as Daphnia), which require higher calcium levels in order to survive. Like Holopedium, these crustacean water fleas feed on algae; however, when their population falls, Holopedium increase in numbers to fill the ecological gap. "Unfortunately," Arts says, "Compared to water fleas, Holopedium don't provide the same quality and quantity of essential nutrients to the fish that eat them. Many experts also predict that, in addition to disrupting the food chain, before long these gelatinous plankton will begin to clog drinking-water systems."



"The main culprit in the disappearance of calcium is acid rain," explains Arts. "While acid levels in rain have fallen sharply since the 1980s, historic deposits of acid in the soil are still at work"

CASE STUDY: Environmental Health PROMOTING HEALTHY AQUATIC ENVIRONMENTS

The health of aquatic ecosystems is likewise at the centre of **Dr. Janet Koprivnikar's** research on wildlife parasites, their hosts and the environment. "My laboratory team and I are interested in the effects of environmental stressors on patterns of parasitism. By deepening our understanding of these issues, we will be better able to predict which organisms are most at risk and help prevent outbreaks."

The context in which Koprivnikar operates is the ecology and evolution of infectious diseases, which are a major concern for



health (human and non-human) and have been linked to environmental factors including climate change, urbanization and pollution. "Effectively managing such diseases," Koprivnikar observes, "requires more extensive knowledge of how hosts resist and tolerate infections, including how these abilities are affected by their environments."

With her own research supported by grants from NSERC and Environment Canada, Koprivnikar also supervises the work of two graduate students who are investigating the effects of particular aquatic contaminants on larval amphibian (tadpole) susceptibility to parasite infection. One of her students is examining the impact of runoff containing road salt, while another is looking at toxic by-product caused by massive algal blooms like the ones that have afflicted Lake Erie over the last few years. These studies are designed to give scientists a better sense of whether aquatic organisms are more prone to infectious diseases when such contaminants are present.

"This is a pressing question for any freshwater fishery such as the Great Lakes, which receive a lot of runoff," Koprivnikar says, "because effects on amphibians which we can think of as aquatic canaries in a coal mine - are often more sensitive than other organisms. That means it's often easier to detect environmental impacts on their health." By determining which human activities have the most impact on parasitism, Koprivnikar hopes that the work she and her students are carrying out will help policy makers and others implement solutions that promote healthy aquatic communities. In turn, "by investigating host-parasite dynamics in wildlife we can also learn much about the factors and processes that contribute to our own health"

"My laboratory team and I are interested in the effects of environmental stressors on patterns of parasitism. By deepening our understanding of these issues, we will be better able to predict which organisms are most at risk and help prevent outbreaks."



CASE STUDY: Vision(ary) Machines

SEEING DIGITALLY: FROM DISASTER-ZONE RESCUE TO ONLINE SURVEILLANCE AND SEARCHING

For humans (and other animals) who possess sight, the eyes transmit to the brain a vast and diverse array of visual stimuli – the faces of friends, the route to work, the varieties of flowers growing in a garden – for transformation into meaningful information. But what kinds of new insights and knowledge might be possible if computers could process visual images? What if computers could see? 2 FOS AT A GLANCE

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CASE STUDY: Vision(ary) Machines SEEING DIGITALLY: FROM DISASTER-ZONE RESCUE TO ONLINE SURVEILLANCE AND SEARCHING

Researchers in Ryerson's Department of Computer Science are leveraging the immense data processing power of computers to enrich and expand the sense of sight. Their work promises to radically alter everything from how search-and-rescue operations are conducted in urban disaster zones, to how we search for information online.



Computational public safety (CPS) involves the application of computational resources, theory and practice to support and improve public safety processes. A leader in this growing field, **Dr. Alexander Ferworn** applies his expertise in robotics and CPS within the larger scope of urban search and rescue (USAR). USAR entails locating, extricating and providing initial medical stabilization to victims trapped in confined spaces – for example, collapsed buildings – in the wake of natural disasters such as earthquakes, or human-made events such as bomb explosions.

The director of Ryerson's Network-Centric Applied Research Team (N-CART), Ferworn began working with emergency first responders in 2005 by assisting an Ontario Provincial Police specialty response team in the areas of USAR and chemical, biological, radiological and nuclear explosives (CBRNe). This experience led to collaborations with a wide range of emergency response organizations in Canada and the United States, including the U.S. Department of Homeland Security and the Federal Emergency Management Agency (FEMA).

Today, Ferworn is heavily engaged in devising strategies for locating "access holes" in rubble: portals that give access to voids where people may be hidden. Ferworn explains that "when buildings collapse with people inside, some of those individuals may become trapped and hidden inside the rubble. Their survival depends on emergency first responders finding and extricating them." Detecting and rescuing survivors are time-sensitive tasks, and the broad estimate Ferworn and his team members work with is that a person can last for about two days within rubble. "If we can develop techniques and algorithms that speed up the search and reduce the likelihood of creating a secondary collapse, we consider our work successful."

A rubble field has many holes but not all of them afford stable and sufficiently wide access. "Our overarching goal is to devise an automated means for seeing and identifying high-probability holes," says Ferworn. "We have therefore developed techniques including the use of six-rotor unmanned aerial vehicles (UAVs), or drones - and algorithms that winnow out features that are actually potentially useful access holes, from openings that are less likely to lead to people trapped within." In addition to investigations and experiments carried out in N-CART's Ryerson lab, Ferworn has made several research trips to TEEX Disaster City, in College Station, Texas. Disaster City is a 52acre, rubble-strewn training facility operated by Texas A&M University's Engineering Extension Service. It allows first responders to train for real disasters, while for Ferworn it is an ideal testing ground for his CPS theories and methods

Ferworn and his colleagues' work is in the early stages. However, to the best of their knowledge, no other research group has examined the problem of the "automatic identification" of potential access holes for first responders searching for survivors. The team, which has established wider collaborations with researchers at other institutions, will soon publish results of this work in the Journal of Field Robotics.

CASE STUDY: Vision(ary) Machines SEEING DIGITALLY: FROM DISASTER-ZONE RESCUE TO ONLINE SURVEILLANCE AND SEARCHING

One of Ferworn's close collaborators on the access holes project is fellow Ryerson professor **Dr. Konstantinos Derpanis**, an expert in "computer vision": using computer technology to recover useful information from images. Derpanis is the director of the Ryerson Vision Lab (RVL), and his research program is centred on advancing the fundamental understanding of video as it relates to the surrounding world (i.e. "What information about the surrounding world is available in video?") and applying that knowledge to a range of practical visual tasks.

"We have witnessed a deluge of video content due to advances in computing power and networking technologies," says Derpanis. "YouTube, for instance, reports that 65 hours of video are uploaded to their service every minute. Yet most current solutions rely on humans visually inspecting videos to extract meaning."

To address this big data challenge, Derpanis pursues two types of questions in his research on automated solutions to mining videos for information. The first, geometric, concerns the recovery of the three-dimensional layout of a surrounding environment. The second, semantic, is about interpreting what people are doing in such an environment. The potential applications of his work include video indexing and browsing, intelligent surveillance and human-computer interfaces.

Currently, Derpanis – whose investigations are supported by NSERC Discovery and Engage grants - is also invested in modelling and understanding human actions in videos. "Humans are ubiquitous in many video types," Derpanis notes, "and their actions represent a prime source of information for scene understanding." Derpanis is therefore working on automated solutions for both spotting actions in videos (identifying where and when a particular action is being performed) as well as classifying those actions. Derpanis sees his research as a critical precursor to the development of an online video-searching system. Potentially, video retrieval (e.g. "Find me all videos that contain a tennis swing.") could be based on the automatic translation of video signals rather than traditional methods using textual metadata laboriously provided by a human each time a video is uploaded.

To date, Derpanis has presented findings from his research at leading international conferences (e.g. IEEE Conference on Computer Vision and Pattern Recognition; IEEE International Conference on Computer Vision). Results of his investigations have also been published in IEEE Transactions on Pattern Analysis and Machine Intelligence.



"YouTube, for instance, reports that 65 hours of video are uploaded to their service every minute. Yet most current solutions rely on humans visually inspecting videos to extract meaning."



CASE STUDY: Financial Mathematics

RISKY FUTURES: GETTING A GRIP ON MONEY AND MARKETS

The desire to predict the rise and decline of stocks, bonds and other financial products is as ancient as investing itself. Most recently, the 2008 global financial meltdown – which caught many industry experts as well as private investors off guard – sparked heightened awareness of the acute challenges facing accurate economic forecasting. Until someone invents a time machine that can whisk us into the future, an element of risk will likely always be associated with investing. Meanwhile, the well-established field of financial mathematics is focused on mitigating risk and analyzing markets through the development and application of sophisticated models. 2 FOS AT A GLANCE

CASE STUDY: Financial Mathematics RISKY FUTURES: GETTING A GRIP ON MONEY AND MARKETS

Research on mathematical models for financial transactions is well underway in Ryerson's Department of Mathematics. The topics being explored range from theoretical approaches, to applications sought by financial sector professionals, as well as individuals interested in maximizing their returns. This innovative work feeds directly into the curriculum of Ryerson's undergraduate Financial Mathematics programs. Launched in 2013, there are only a handful of programs of this kind in Canada:



One department member active in this field is **Dr. Sebastian Ferrando**, who combines knowledge of pure and applied mathematics with principles of theoretical physics. "The financial market is an observable phenomenon for which we have enormous amounts of information," Ferrando says. "These abundant data can be analyzed and modelled in several different ways that continue to evolve as the market's characteristics change."

Financial mathematics proposes formal models for the future value of stocks and associated financial products. But the financial market is inherently unpredictable, even, as Ferrando explains, double-sided. "Value can correspond to physical goods such as a company's assets; yet value is also created through humans' non-objective perceptions and expectations as well as the flow of information – not all of which is fully reliable."

Calculating the Unpredictable

A major mathematical tool for studying the market is stochastic calculus. Derived from the foundational work of Robert Brown, Louis Bachelier and Kiyoshi Ito, stochastic calculus is today widely used to interpret and modelinherently unpredictable, random systems. For Ferrando and his co-researchers, this involves deploying stochastic models in pursuit of goals such as estimating the accuracy of various models associated with multivariable hedge fund data, and optimizing investment portfolios in the context of realistic market assumptions and conditions.

"Despite its explanatory power," Ferrando cautions, "the stochastic model – even when it includes abundant details – suffers from the limitations imposed by the large number of hypotheses needed for it to apply." In order to address this problem, Ferrando has collaborated on the development of an approach that requires fewer hypotheses. "In particular," he notes, "our trajectory-based model avoids probabilistic assumptions about a future set of possible scenarios."

Ferrando unpacks this concept by analogy to a homeowner who wants to save money for future home-maintenance expenses (e.g. to cover the cost of roof repairs or to replace a defunct furnace). "A person who took a probabilistic point of view," Ferrando explains, "would set aside an amount based on the cost of the item most likely to break down (or on an average cost). An alternative point of view – one that aligns with our work in financial mathematics – instead involves budgeting for the worst case scenario; in other words, the disaster that would cause either the most serious damage or annoyance."

Dynamic Portfolio Optimization

A good deal of Ferrando's research is carried out with **Dr. Marcos Escobar**, whose expertise in applied statistics complements his colleague's more theory-driven orientation. For example, together with their postdoctoral fellow Dr. Alexey Rubtsov, Ferrando and Escobar have been working on a project that focuses on performing "dynamic portfolio optimization" under realistic conditions.

As Escobar explains, "One of these conditions is 'unobservability,' which occurs when we are unable to observe a piece of the model associated with a given stock. It's possible, for example, to observe the value of a stock; however, while we can estimate the value of its financial trend, it's impossible to observe its true value."

CASE STUDY: Financial Mathematics RISKY FUTURES: GETTING A GRIP ON MONEY AND MARKETS

A second condition is "ambiguity," a term that entered the financial mathematics lexicon from the realm of behavioural finance. "We encounter ambiguity," Escobar says, "when there is uncertainty about the probabilities of certain events taking place. In practical terms, one can tell that a stock's price will fall more than 10 per cent, but it is impossible to know whether the probability of such an event is five per cent or 20 percent. So, the issue driving our project is how to optimize a portfolio taking into account the 'unobservability' of certain underlying processes as well as the ambiguity of risk-related probabilities."

Multi-dimensional Modelling

An additional line of Escobar's research concerns stochastic modelling in multiple dimensions. Whereas most research has been limited to one-dimensional models (e.g. treating a single stock or bond), Escobar focuses on the modelling of "joint behaviour."

The critical importance of a multi-dimensional perspective was underscored, Escobar points out, by the 2008 financial crisis and "the naïveté of industry-leading models used to explain dynamic co-movements among stocks. Models in 2008 ascribed a near-zero chance of more than three stocks falling significantly. The reality however, was that hundreds of stocks plummeted in a short period of time, and no one was prepared for, or had the right model, to face this scenario. Knowing what every single stock does or might do separately does not tell you what they will do simultaneously."

Industry Relations

Direct collaboration with the financial industry is a pivotal component of Escobar and Ferrando's work. "This line of work is a conscious decision of ours to keep on track with the latest developments and needs of the financial sector," says Escobar. Some of the projects he has led with industry partners include statistical arbitrage detection using accounting information supplied by investment firms; the development of financial, accounting and statistical metrics to improve understanding of hedge fund portfolios; and the discrete-time modelling of hedge funds' clusters of other funds using multivariate models.

Taking the third of those examples, Escobar (the principal investigator) and Ferrando (coinvestigator) are working with a Toronto-based hedge fund that wants to measure how well it is performing. With support from an NSERC Collaborative Research and Development grant, Escobar and Ferrando manage a team of researchers and meet with the company on a regular basis to deliver software, documents and analysis to the firm.

"These relationships with industry provide our students with excellent applied learning opportunities," Ferrando notes. "They also offer the possibility of industry contacts that can be useful when our graduates are seeking employment in the field. In fact, extensive interaction with industry distinguishes our Financial Mathematics program and significantly enhances its value and scope."



"This line of work is a conscious decision of ours to keep on track with the latest developments and needs of the financial sector," says Escobar. CASE STUDY: Physics Education and Biophysics

> EDUCATIONAL INNOVATION AND VIROPHYSICS: OPTIMIZING HOW WE TEACH STUDENTS AND COMBAT VIRUSES

> What are the tiniest particles observed and theorized? What forces govern weather, cellular growth and decay, the generation and transmission of energy? For millennia, physics has been the domain of people who want to understand how our bodies, world and universe function. Physicists seek to enhance the quality of life and to address the challenges threatening its very survival.

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CASE STUDY: Physics Education and Biophysics EDUCATIONAL INNOVATION AND VIROPHYSICS: OPTIMIZING HOW WE TEACH STUDENTS AND COMBAT VIRUSES

Faculty members in Ryerson's Department of Physics are pushing the frontiers of knowledge in several areas. In this case study, we highlight the work of two such individuals. One is an expert in the field of physics education. The other is breaking new ground in the fight against viral infections.



Excellence and Innovation in Science Education

An associate professor in the Department of Physics, Dr. Tetyana Antimirova also serves as the inaugural teaching chair for the entire Faculty of Science. In this role, Antimirova conducts research on effective student engagement strategies for teaching and learning in the sciences. She also explores emerging educational technology tools and spearheads a number of initiatives including collaborative workshops that highlight effective research-informed teaching methods. These workshops provide her colleagues with forums to exchange ideas on teaching innovations and discuss their experiences using educational technology. Antimirova's overarching goal is to cultivate evidenceinformed approaches to teaching and learning throughout the faculty.

"I cannot overemphasize the foundational importance of excellence and innovation in teaching in the sciences," Antimirova says. Historically, she points out, her own branch of science –physics – has been taught predominantly in an instructor-centred, didactic manner via lectures with students mostly in a passive-learner role. Now, that well-worn model is being challenged by physics education research (PER), a swiftly growing field at the intersection of pedagogical research and discipline-specific knowledge.

Active Learning

"Physics offers students not just disciplinespecific knowledge, but also unparalleled opportunities to experience the thrill of scientific discovery," comments Antimirova. Antimirova, who received the inaugural Desire2Learn Innovation Award in 2012 from the Society for Teaching and Learning in Higher Education (STLHE), and the Provost's Innovative Teaching Award in 2010 from Ryerson, says: "[Physics] also has great potential for developing transferable skills such as problem-solving, critical thinking and logical reasoning."

To maximize the experiences that can produce such results, Antimirova and others involved in PER emphasize opportunities for students not only to attend lectures but to actively participate in them and become engaged in guided, enquiry-based "active learning" (also known as iterative engagement). For Antimirova, investing in this type of learning is especially important due to proven benefits for students from groups that are underrepresented in science, technology, engineering and mathematics (STEM) education—this includes women and cultural minorities.

Teaching Innovations

Antimirova is currently exploring teaching and learning in technology-rich environments using tools such as clickers, tablets, video analysis, real-data acquisition systems for undergraduate laboratories, simulations and online education tools. She is piloting the use of social media for educational purposes. And her inquiries also encompass curriculum development, the impact of activity-based student-centred pedagogies, as well as gender (and other demographic) factors in science education, and how to facilitate the transition from high school to post-secondary education.

CASE STUDY: Physics Education and Biophysics FDUCATIONAL INNOVATION AND VIROPHYSICS: OPTIMIZING HOW WE TEACH STUDENTS AND COMBAT VIRUSES



"Vaccines against a new flu strain take six months to develop," Beauchemin says, "and that's usually too long to wait. Therefore antiviral drugs will be our first line of defence." In Antimirova's view, "Sustainable and lasting change in the way physics (and other natural sciences) is taught requires the buy-in and cooperation of the majority of teaching faculty. It's therefore so important that we continue compiling new research-based evidence demonstrating the advantages of interactive engagement strategies and, as I strive to do through my teaching chair, to promote the best approaches to science teaching."

Understanding and Controlling Virus Infections

While teaching and supervising Ryerson physics students is a big part of her work, Dr. Catherine Beauchemin also uses physics "to teach viruses new tricks." Beauchemin describes her research field as "virophysics," which focuses on applying the tools of physics to understand and control virus infections.

The influenza (flu) virus is a major cause of ill health each year and is especially dangerous for young people and seniors. About 90 per cent of Canada's and Ontario's antiviral stockpiles consist of a single drug – oseltamivir (Tamiflu). But emerging resistance to that drug as well as the appearance of bird-flu strains (e.g. H5N1, H7N9) highlight the need to diversify those stockpiles. "Vaccines against a new flu strain take six months to develop," Beauchemin says, "and that's usually too long to wait. Therefore antiviral drugs will be our first line of defence." The investigations Beauchemin and her team are undertaking will help public health agencies revise their antiviral stockpiles in order to be prepared for a potential flu pandemic.

Modelling Behaviour

Beauchemin and her team are developing equations that explain how viruses - flu, but also HIV, hepatitis C and the respiratory syncytial virus - behave. The mathematical and computer models (MCMs) involved in this research give unique insight into how viruses spread between cells in a cell culture or host. The first of its kind, the spatial MCM built and validated by Beauchemin and her colleagues entails parameters such as the lifespan of an infected cell and the rate at which a virus degrades after it leaves a cell.

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By adjusting these parameters (Beauchemin describes it as being "like tuning a set of dials") until the model matches the experiment, Beauchemin and her team can discover, for example, what the lifespan of an infected cell must be to account for experiment results. If they run the experiment twice, once with and once without a drug or a virus mutation, the team can measure how the drug or the mutation affects each parameter.

Towards an Anti-flu Cocktail

"Our work enables us to detect the aspects of fluvirus replication affected by an antiviral drug," says Beauchemin. "And we can also see how replication changes when a virus mutates and becomes resistant to the drug." It is specifically this new advance that Beauchemin and her team will be applying to their design of an optimal anti-flu cocktail that mixes together existing anti-flu drugs. In 2014, in support of this work, the Ontario Ministry of Research and Innovation gave Beauchemin an Early Researcher Award.

CONNECTED DEPARTMENTS





CHEMISTRY AND BIOLOGY

Connecting substances, matter, energy and life

An interdisciplinary, collaborative approach: that's how our researchers in biomedical sciences, environmental science, and chemistry address critical issues affecting human health and the world we inhabit. In the Department of Chemistry and Biology, all of our 31 tenure-track and three limited-term faculty members are committed to engaging in research that matters, and to delivering high-quality, relevant education. **3** RESEARCH

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CHEMISTRY AND BIOLOGY

Today's students are tomorrow's leaders. Over 800 students are enrolled in our three undergraduate programs: Biology, Biomedical Sciences and Chemistry. These programs offer both core education in each discipline and opportunities to explore the interface between chemistry and biology. We also have over 55 students advancing their knowledge and careers in our master's and doctoral programs in Molecular Science, and Environmental Applied Science and Management.



Generating New Knowledge

Our department has a strong research focus, with faculty expertise bridging diverse areas such as: synthetic organic, bioorganic and medicinal chemistry; ecotoxicology; ecology; evolution; water and wastewater treatment; biochemistry; molecular biology; microbiology; genetics; and polymer science. We are also major contributors to Ryerson Urban Water, a multi-disciplinary collective of experts with research and educational interests in water in urban environments. In addition to Dr. Roberto Botelho, our Canada Research Chair (Tier 2) in Biomedical Sciences and Technologies, faculty members have external funding from agencies such as NSERC and CIHR. They are also active in a wide variety of industrial and corporate interactions.

Deoxyribonucleic acid (DNA) encodes and stores all of the genetic information needed to replicate a living organism; this long, double-helical molecule requires special packaging for storage in a cell. Cells with nuclei (eukaryotic cells) have their DNA packaged with proteins into chromatin. Dr. Jeffrey Fillingham studies chromatin assembly at the molecular level, exploring how it influences events in the cell nucleus, particularly the modification of chromatin following protein synthesis. Much of our current knowledge about these processes comes from work with the budding yeast Saccharomyces cerevisiae, the same yeast species used in beer- and bread-making.

Fillingham is also investigating a quite different organism, the ciliated protozoan *Tetrahymena thermophila*, to evaluate its effectiveness as a model for identifying sets of proteins involved in dynamic events involving chromatin in the cell nucleus. "By comparing these sets of proteins with those from budding yeast," says Fillingham, "new insights should be gained into how chromatin is modified and why."

Bacterial species play diverse roles in human health and disease. Dr. Debora Foster is investigating two gastrointestinal pathogens: enterohemorrhagic Escherichia coli, which causes acute gastroenteritis (bloody diarrhea) and can sometimes become life-threatening; and enteropathogenic Escherichia coli, which causes severe infantile diarrhea and is responsible for the death up to one million infants every year, particularly in developing countries. Understanding how these pathogens infect host cells and how the host responds to these infections is critical to the development of new methods for treating and preventing these infections. "We are particularly interested in the impact of environmental stress on the pathogenicity of these organisms," says Foster. "As they pass through the gastrointestinal tract, these organisms are exposed to a variety of stresses and micro-environmental cues. We want to understand how these cues modulate expression of the pathogen's virulence factors and properties. The

results of this research can have profound implications for management of these infections as well as for food handling and processing practices, since contaminated food is often the vehicle for infection."

As the Department of Chemistry and Biology continues to implement the Biomedical Sciences undergraduate program, now in its second year, it will hire more faculty members and develop additional research capacity and 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 strong part of that." **3** RESEARCH

CHEMISTRY AND BIOLOGY



Research Areas

Biomedicine and Biomolecular Interactions Synthetic and Medicinal Chemistry Surfaces and Interfaces Pathogens and Infection Cells, Genes and 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); an atomic force microscope (AFM); and an inverted laserconfocal microscope suitable for live-cell imaging

Deconvolution Epifluorescence Microscopy Facility – for live-cell imaging

400-MHz Bruker multi-probe nuclear magnetic resonance instrument

Tritium Labelling Facility

Level 2 Biohazard Facility – licensed for work with eukaryotes and prokaryotes

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

An array of dedicated research laboratories in direct support of Chemistry and Biology faculty members' research programs

COMPUTER SCIENCE

Connecting to the virtual frontiers of artificial intelligence, the cloud and pervasive computing

Medicine, politics, engineering, the media – even human relationships: few aspects of life remain untouched by computer technology. Computer science has altered human existence in ways that would have seemed like science fiction 50 years ago. And while it's hard to imagine working without "the cloud," we also wrestle with new challenges such as keeping digital records and personal details confidential. The Department of Computer Science – one of the largest in Ontario – delivers forward-looking research and learning opportunities in augmented reality, context-aware software applications, big data and artificial intelligence, plus other areas of innovation reshaping our world.

I G G B 3 F D 7 G D 8 28 C A 07 F 25 L A 8 9 B A 6 7 2 5 G 8 0 B 0 C E D 9 0 A 9 1 D 7 2 D 8 E 8 F 8 5 E C 8 D D 7 B 2 B 3 0 8 7 D 3 8 7 B C D C 3 B C A 8 8 5 0 C A 0 B 1 8 9 B A 4 5 A 6 B 3 8 D C 1 F 2 5 B 3 0 D 9 C 0 0 A 6 8 D 7 5 A 3 4 F 4 1 2 9 F 1 D C 0 6 E 9 7 B E A 5 A 8 E 1 3 F 2 6 2 E 2 C 0 6 T D 9 E 1 3 8 C 8 9 E A 8 7 0 7 F 2 5 B D A C 7 2 C 6 E 8 7 B 1 C 2 A B 2 A 1 B 2 B 4 4 9 0 A A 1 D 4 7 9 C 9 A A 1 E 3 F 0 2 1 D A D C 1 A D C B 3 0 8 7 D 3 8 A 2 7 8 E 6 1 3 7 A 1 C 3 8 9 F C E 1 0 F F 7 B 8 C 8 7 8 9 0 6 1 9 7 B C D E A 8 E 3 F 0 2 9 0 A C 1 F 9 0 4 7 2 D A 1 F 5 F 8 E A 8 7 D 4 5 F 7 3 8 F D 2 6 D 9 8 2 8 3 4 9 B D C 6 1 3 7 A B 2 B 4 4 6 F F 9 0 7 2 5 6 E 8 0 B 1 0 C 6 H 3 5 E C A 8 8 5 C 8 9 E A 8 7 D 4 5 F F 7 B A A A 0 A 8 9 B 6 7 5 B 4 3 0 D 5 C 0 A 1 B 2 B 4 4 6 F F 9 0 4 7 2 3 8 F 1 C 6 B 4 3 0 D 9 C 0 3 F 2 6 D 2 8 F 6 D 8 C 8 9 E 8 5 E A 8 9 7 1 E A 6 A 8 E D A C 6 2 F B 0 1 0 A 6 B A 1 B 2 8 5 0 2 8 E 8 7 0 7 F 2 5 B A 4 7 8 9 C A 9 D D F 4 1 6 1 A D D 9 4 4 6 F F 9 0 4 B 2 7 A 1 C 6 E B 3 B D E A 8 1 E 8 9 B A F 8 2 Z 4 9 B 8 D B A 8 9 B 6 6 7 7 D 5 F F 8 D F 7 5 4 4 2 A D C 9 6 7 2 D 8 E 8 F 4 6 F <u>9 0 E 6 2 E 7 5 4 4 2 A D C 9 6 7 2 D 8 E 8 F 4 6 F 1 9 0 E 6 2 E 7 9 1 D C E 1 9 E A 8 7 D 4 5 B 8 2 7 4 9 6 2 C 7</u> 2 FOS AT A GLANCE

3 RESEARCH

4 DEPARTMENTS

5 FACULTY

COMPUTER SCIENCE

The department's foundation is two strong and accredited undergraduate programs (approximately 750 students are currently registered). We offer both a four-year campus-based program, and a five-year co-op program that gives students paid work experiences with government as well as topflight businesses in the financial, software, insurance and other sectors.

At the graduate level, over 70 students are pursuing master's and doctoral degrees and our growth plan includes creating a new course-based master's program. "Learning and teaching are a major priority for us," says the department chair **Dr. Alireza Sadeghian**. "We therefore continue to invest in teaching labs that give students access to the best equipment, and we are developing a suite of online testing facilities that will enhance the student experience."

Generating New Knowledge

In their research, faculty members address the breadth of the computer science field itself. **Dr. Ali Miri** and his students in the Information and Computer Security Laboratory (iCaSL) for example, are addressing computing-related privacy and security challenges. In one project, they are creating tools for a cloud-based project planning and resource management service that will enable secure file sharing (among other features). In other research, the team is building a data-analytics engine into its existing cloud-management platform. This is designed to enable advanced, automated resource orchestration and data centre placement based on real-time demand and usage-data sizing.

Dr. Isaac Woungang and his students in the Distributed Applications and Broadband NEtworks Laboratory (DABNEL) employ a multi-faceted research approach, largely drawn from the fields of artificial intelligence and mathematics. In their work, they address the implementation of algorithms and software development frameworks for data security in cloud computing systems, networks and secured mobilecommunication systems and resource management in next-generation networks.

Quantifying and mitigating risks (in the broadest sense) associated with software engineering processes is the focus of research carried out by **Dr. Andriy** Miranskyy and his students. Examples of the risks they study are numerous, including improper testing of big data databases (resulting in defect escapes and unplanned outages); non-scalable algorithms for which it is impossible to determine the root cause of system failure fast enough to preclude prolonged outages and customer dissatisfaction; and spikes in the number of defects discovered by clients and that overload support and maintenance personnel.

Supporting Students – Current and Future

Computer Science faculty members actively support various activities organized by the students. This includes regular workshops held in the gaming club, student participation in programming contests and hackathon events, and the programming clinic offered to first-year students. The department also participates in community projects through the Office of Science Outreach and Enrichment (OSOE). These include visits by high school students to our classes as well as their involvement in department-organized 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

Computer Vision

Cloud Computing

Social Computing, Data Analytics and Behavior Informatics

Research Facilities

COMPUTER

SCIENCE

GRADUATE

STUDENTS

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)

Ryerson Vision Lab (RVL)



MATHEMATICS

Connecting the world through numbers, models and complex networks

Ryerson's mathematicians build bridges between theory, abstraction and the material world. In their research and teaching, they explore issues such as social media for business, artificial intelligence, global economic performance, online data mining, interspecies competition and even the ways our bodies combat invasive diseases. "Making direct connections to real-life public concerns is foundational to mathematics at Ryerson," says **Dr. Dejan Delic**, chair of the Department of Mathematics. "Our 18 tenure-track faculty members, three limited-term faculty members, 10 instructors and six postdoctoral fellows push hard at the boundaries of knowledge in graph theory, big data, mathematical biology, quantum mechanics and a host of other areas of critical theoretical and public concern." 3 RESEARCH

4 DEPARTMENTS

5 FACULTY

MATHEMATICS

The Department of Mathematics, which began as a service-teaching provider for other parts of the university, has become a highly focused department offering rigorous programs at the undergraduate and graduate levels. In 2008, the department introduced an undergraduate program in Mathematics and its Applications; in 2009, a master's program in Applied Mathematics; and in 2013, a second undergraduate program in Financial Mathematics. "We are the only applied mathematics program in the GTA," says Delic, "and we're deeply committed to teaching effectiveness. Every faculty member puts great stock in ensuring that students find a welcoming and supportive learning environment in which to achieve their goals." In the near future, there are plans to add a doctoral program.

Generating New Knowledge

The Department of Mathematics houses three dedicated research groups: Graphs at Ryerson (G@R), Financial Mathematics, and Biomathematics and Fluids.

G@R

This group of researchers and students focuses on pure and applied graph theory, with special emphases on large-scale realworld networks (e.g. Facebook and Twitter) and connections to big data. G@R members are involved in several applied research projects, including three NSERC Engage grants (awarded in 2014) linked to industry partners:

- · Exploiting big data for a customized online news-recommendation system (with The Globe and Mail).
- A self-organizing dynamic network model intended to increase the efficiency of outdoor digital billboards (with KEEN Projection Media Ltd.).
- · Utilizing big data for a business-tobusiness matching and recommendation system (with ComLinked Corp.).

In addition, the group recently obtained an OCE TalentEdge Fellowship with The Globe and Mail for a project entitled "Web Visitor Engagement Measurement and Maximization."

Financial Mathematics

Members of the Financial Mathematics group are working on what Delic identifies as a hot topic these days: understanding risk and model financial transactions. "The main thrust of our work entails developing new models for stocks, hedge funds and other financial transactions - with a goal of maximizing returns." Banks and smaller

companies have shown strong interest in the group's research and members recently renewed their Collaborative Research and Development Grant from NSERC to model hedge funds (with support from Sigma Analysis & Management Ltd., a Torontobased investment firm).

Biomathematics and Fluids

The third group, Biomathematics and Fluids, explores the application of mathematics to biology. Researchers use mathematical models to investigate everything from genomics and proteomics, to the fluid dynamics of blood flow. "The 21st century is all about math applied to biology, including big data," says Delic. "It's so exciting to be playing a critical role in this surging area."

> DR. PRAWEL PRALAT

3 RESEARCH

5 FACULTY

MATHEMATICS

Grants and Awards

The Department of Mathematics is committed to continuing to attract top researchers and external research grants, and to becoming a research-intensive department. In 2014, Dr. Andrea Burgess received the Dean's Scholarly, Research and Creative Activity Award. As well, 13 of the department's researchers hold NSERC Discovery grants. Many faculty members are involved in applied projects. For example, in recent years researchers have been awarded two NSERC Collaborative Research and Development (CRD) grants, six NSERC Engage grants and one Ontario Centres of Excellence (OCE) TalentEdge Fellowship in cooperation with companies such as Sigma Analysis and Management Ltd., The Globe and Mail, Blackberry and ComLinked Corp. In 2014, the department published 34 research papers and also received \$484,000 in external funding, the highest support in its history.

Ryerson mathematics students are also gaining recognition for the quality of their work. In 2014, undergraduate students Christopher Heggerud and Kelly Quinlan received NSERC Undergraduate Student Research Awards (USRA). At the graduate level, students Farid Gassoumov and **Jill Padgett received Ontario Graduate** Scholarship (OGS) awards, and Erin Meger received a Queen Elizabeth II award.

Knowledge Exchanges

In addition to teaching and research activities, faculty are involved in organizing knowledge-exchange events both internationally and closer to home. This includes the 11th Workshop on Algorithms and Models for the Web Graph (WAW 2014), held in Beijing last year; and a symposium on random graphs at the 5th biennial Canadian Discrete and Algorithmic Mathematics Conference (CanaDAM) to be held in Saskatoon in June, 2015. The department is also active at Ryerson campus events such as the Faculty of Science's annual Pi Day, held in March, which attracts many researchers and students.

Research Areas

Biomathematics and Fluids Financial Mathematics Graph Theory

Research Facilities

Ryerson Applied Mathematics Laboratory (RAMLab)

 $(x,\theta)dx = M T(\xi)$ $\ln L(x,\theta)$



PHYSICS

Connecting medical physics to groundbreaking diagnosis and therapy

Ryerson's physicists have a bold vision: to address critical and relevant questions for medical care in Canada and worldwide. To make this vision a reality, the Department of Physics places a unique focus on human health and health care – from fundamental discoveries to knowledge translation. Our work gains strength from dynamic collaborations with clinicians and industry partners across the health-care spectrum. And we are dedicated to first-class physics education that draws directly on our faculty members' research, uses innovative teaching methods, and emphasizes both problem-solving skills and conceptual understanding. 2 FOS AT A GLANCE

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PHYSICS

Ryerson's Department of Physics offers an undergraduate program in Medical Physics (with over 180 students currently registered), plus master's and doctoral programs in Biomedical Physics - with a CAMPEPaccreditation option allowing graduates to complete residency training and become licensed clinical medical physicists. The graduate program has awarded 83 master's of science degrees and one PhD; current enrollment includes 31 master's students and 18 doctoral students. We are especially proud of the PhD program's first graduate, Dr. Eric Strohm. Among his achievements, Strohm received the 2014 Ryerson Gold Medal for the Faculty of Science in the Yeates School of Graduate Studies: the Governor General's Academic Gold Medal; and the C. Ravi Ravindran Outstanding Doctoral Thesis Award.

Generating New Knowledge

Physics faculty members are active in several research areas focused on human health and health care. One of those areas is medical imaging, which involves detecting disease-induced changes at the tissue and cellular levels using approaches such as photoacoustic imaging, functional magnetic resonance imaging (fMRI), ultrasound imaging, electro-kinetic response, optical coherence tomography and optical spectroscopy. Several department members are also involved in cancer therapy research. For example, work is underway to improve treatment efficacy using ultrasonically stimulated microbubbles, high-intensity focused ultrasound (HIFU), gold nanoparticles, radiotherapy, chemotherapy, and laser thermal therapy. Other areas of research in the department include trace-element detection in human and biological samples using X-ray fluorescence spectrometry, as well as computational and mathematical physics.

Collaborative Approach

"To facilitate the translation of knowledge from fundamental discoveries, we have developed a number of national and international collaborations to support our researchers and students," says Dr. Ana Pejović-Milić, chair of the Department of Physics. Faculty members have research collaborations with St. Michael's Hospital, Princess Margaret Hospital, Sunnybrook Health Sciences Centre, Hamilton Health Sciences and McMaster University Medical Centre. The department also has a strong presence in the Institute for Biomedical Engineering, Science & Technology (iBEST), which is a partnership between Ryerson and St. Michael's Hospital.

Collaborations are critical to the research that **Dr. Alexandre Douplik** carries out. Douplik works both experimentally and theoretically in hyperspectral microendoscopy and laser ablation with breast surgeons from the Ontario Cancer Institute (Princess Margaret Hospital) and the University Medical Centre Utrecht in the Netherlands. He is also studying optical microcirculation diagnostics with dermatologists and plastic surgeons from St. Michael's Hospital, and Raman chemotherapy monitoring with radiologists from Sunnybrook Health Sciences Centre.



Innovative Teaching

A team led by Dr. Tetyana Antimirova,

the Faculty of Science teaching chair, focuses on developing innovative teaching methods in physics to improve conceptual understanding and problem-solving skills among students in introductory physics courses. Meanwhile, along with his PhD student Aditya Pandya, Douplik developed an augmented-reality education platform based on a voice-gesture recognition system. This platform allows course instructors to communicate more effectively with students by interactively controlling their lectures using voice and gesture commands from anywhere in the classroom. The technology is based on Microsoft's Kinect for Xbox 360, the popular controllerfree gaming device.

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5 FACULTY

PHYSICS



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

Treatment optimization for radiation therapy and image reconstruction

Computational and Mathematical Physics: Physical modelling in biology, immunology and ecology (phymbie)

Computational biomedical physics

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

CONNECTED FACULTY



CHEMISTRY AND BIOLOGY





Assistant Professor and Coordinator, Office of Science Outreach and Enrichment

Costin Antonescu, PhD Assistant Professor

Michael Arts, PhD Professor



Vadim Bostan, PhD Associate Professor



Roberto Botelho, PhD Associate Professor

eagard@ryerson.ca 416-979-5000, ext. 2057

ryerson.ca/cab/ facultyandstaff/emily-agard. html

Research Areas: Science education; developing strategies for effective largeclass teaching; community service learning; educating individuals of various ages and socioeconomic backgrounds; science outreach

cantonescu@ryerson.ca 416-979-5000, ext. 4659

ryerson.ca/cab/faculty and staff/costin-antonescu. html

ryerson.ca/cellsurfacebio

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

michael.arts@ryerson.ca 416-979-5000, ext. 3147

ryerson.ca/cab/ facultyandstaff/michael-arts

Research Areas: Essential fatty acids (EFA) and the role they play in maintaining the health of aquatic and terrestrial organisms and how climate change, geneticallymodified organisms, invasive species, and contaminants affect the production and distribution of EFA in food webs culminating in the human food chain

vbostan@ryerson.ca 416-979-5000, ext. 6546

ryerson.ca/cab/ facultyandstaff/vadim-bostan. html

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

rbotelho@ryerson.ca 416-979-5000, ext. 2059

ryerson.ca/cab/ facultyandstaff/robertobotelho.html

ryerson.ca/organelles

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

CHEMISTRY AND BIOLOGY







Charlotte de Araujo, PhD Assistant Professor



Mario C. Estable, PhD Associate Professor

cevans@ryerson.ca

416-979-5000, ext. 2356

ryerson.ca/cab/ facultyandstaff/chrisevans.html

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

lesley.g.campbell@ryerson.ca 416-979-5000, ext. 2996

Lesley Campbell, PhD

Assistant Professor

ryerson.ca/cab/ facultyandstaff/lesleycampbell.html

Research Areas: Agro-

evolutionary biology, conservation, evolution, global climate change consequences, invasive species

imogen.coe@ryerson.ca 416-979-5000, ext. 5247

Imogen Coe, PhD

Professor and Dean.

Faculty of Science

ryerson.ca/cab/ facultyandstaff/imogen-coe. html

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

cdearaujo@ryerson.ca 416-979-5000, ext. 3391

ryerson.ca/cab/ facultyandstaff/charlotte-dearaujo.html

Research Areas: Protein

structure and function, protein-protein interactions, new methods in science education, inquiry-based learning

mestable@ryerson.ca 416-979-5000, ext. 4517

ryerson.ca/cab/ facultyandstaff/marioestable.html

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



Christopher Evans, PhD

Associate Professor and

Vice-Provost Academic

CHEMISTRY AND BIOLOGY





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

dfoster@ryerson.ca

ryerson.ca/cab/ facultyandstaff/deborafoster.html

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

daniel.foucher@ryerson.ca 416-979-5000, ext. 2260

ryerson.ca/cab/ facultyandstaff/danfoucher.html

Research Areas: Novel inorganic and organometallic polymers

n3george@ryerson.ca 416-979-5000, ext. 6552

ryerson.ca/cab/ facultyandstaff/noel-george. html

Research Areas: Chemical education

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Kimberley A. Gilbride, PhD Professor. Associate Chair and Program Director (Biology)

gilbride@ryerson.ca 416-979-5000, ext. 6354

ryerson.ca/cab/ facultyandstaff/kim-gilbride. html

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

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

ryerson.ca/cab/ facultyandstaff/ Jeff-Fillingham.html

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

416-979-5000, ext. 6345



CHEMISTRY AND BIOLOGY

ΝΟ ΡΗΟΤΟ AVAILABLE







Darrick V. Heyd, PhD Associate Professor

dheyd@ryerson.ca

416-979-5000, ext. 7921

ryerson.ca/cab/ facultyandstaff/darrick-heyd. html

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



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

anne.johnson@ryerson.ca 416-979-5000, ext. 6348

ryerson.ca/cab/ facultyandstaff/anne-johnson. html

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

gossage@ryerson.ca 416-979-5000, ext. 2056

Robert A. Gossage, PhD

Associate Professor

ryerson.ca/cab/ facultyandstaff/rob-gossage. html

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

sharonna.greenberg@ryerson.ca 416-979-5000, ext. 3390

Sharonna Greenberg, PhD

Assistant Professor

ryerson.ca/cab/ facultyandstaff/sharonnagreenberg.html

Research Areas: Chemical education, online learning in chemistry, using new teaching tools in the chemistry curriculum

martina.hauser@ryerson.ca 416-979-5000, ext. 6553

Martina Hausner, Dr.

Associate Professor

rer. nat.

ryerson.ca/cab/ facultyandstaff/martina-

Research Areas:

hausner.html

Environmental microbiology, molecular microbial ecology, biofilms, environmental biotechnology

CHEMISTRY AND BIOLOGY





Janet Koprivnikar, PhD Associate Professor

Andrew Laursen, PhD Associate Professor and

Julia Lu, PhD Professor

julialu@ryerson.ca 416-979-5000, ext. 7481

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



John G. Marshall, PhD Associate Professor

4marshal@ryerson.ca 416-979-5000, ext. 4219

ryerson.ca/cab/ facultyandstaff/john-marshall. html

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

bryan.koivisto@ryerson.ca 416-979-5000, ext. 4625

ryerson.ca/cab/ facultyandstaff/bryankoivisto.html

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

jkoprivn@ryerson.ca 416-979-5000, ext. 3160

ryerson.ca/cab/ facultyandstaff/janetkoprivnikar.html

Research Areas: Ecology and evolution of infectious diseases

Academic Coordinator, First Year and Common Science Office

alaursen@ryerson.ca

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facultyandstaff/andrewlaursen.html

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

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CHEMISTRY AND BIOLOGY









Lynda H. McCarthy, PhD Professor Andrew McWilliams, PhD Associate Professor Stephanie Melles, PhD Assistant Professor **David Naranjit**, PhD Professor



I3mccart@ryerson.ca 416-979-5000, ext. 6378

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Research Areas: Great Lakes pollution, industrial and municipal wastewater ecotoxicology, landapplication of biosolids amcwilli@ryerson.ca 416-979-5000, ext. 4060

ryerson.ca/cab/ facultyandstaff/andrewmcwilliams.html

Research Areas: Inorganic chemistry, polymer synthesis, main group chemistry, organometallic chemistry, inverse crowns stephanie.melles@ryerson.ca 416-979-5000, ext. 3413

facultyandstaff/stephanie-

Research Areas: Spatial

of diversity, network

sampling design

ecology, cross-scale drivers

theory, aquatic ecosystem

classification, optimizing

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melles

naranjit@ryerson.ca 416-979-5000, ext. 6353

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Areas of interest: Analytical chemistry, spectroscopy, chromatography

rousseau@ryerson.ca 416-979-5000, ext. 2155

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

CHEMISTRY AND BIOLOGY





rviirre@ryerson.ca 416-979-5000, ext. 4951

ryerson.ca/cab/ facultyandstaff/russ-viirre. html

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

wwakarchuk@ryerson.ca 416-979-5000, ext. 3207

Warren W. Wakarchuk, PhD

Professor

ryerson.ca/cab/ facultyandstaff/warrenwakarchuk.html

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

gwolfaar@ryerson.ca 416-979-5000, ext. 4051

ryerson.ca/cab/ facultyandstaff/gideonwolfaardt.html

Research Areas:

Environmental microbiology, biofilm ecology, biofilm control, bioprocessing



R. Stephen Wylie, PhD Associate Professor and **Department Chair**

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ryerson.ca/cab/ facultyandstaff/steve-wylie. html

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

COMPUTER SCIENCE









Abdolreza Abhari, PhD Professor Konstantinos Derpanis, PhD Assistant Professor Chen (Cherie) Ding, PhD Associate Professor Alexander Ferworn, PhD Professor, Associate Chair and Graduate Program Director

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.

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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 kosta@scs.ryerson.ca 416-979-5000, ext. 3205 scs.ryerson.ca/~kosta

Research Areas: Computer vision cding@scs.ryerson.ca 416-979-5000, ext. 6965 scs.ryerson.ca/cding

Research Areas: Cloud computing, software service selection and ranking, recommender systems, data analytics, social network, behaviour informatics, information retrieval aferworn@scs.ryerson.ca 416-979-5000, ext. 6968

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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 dhamelin@cs.ryerson.ca 416-979-5000, ext. 4876

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

COMPUTER SCIENCE





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Research Areas: E-learning, bioinformatics, natural language processing dmason@ryerson.ca 416-979-5000, ext. 7061

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Research Areas: Citizen programmers, programming languages, program analysis, software reliability, code optimization amastora@ryerson.ca 416-979-5000, ext. 7400

Anastase Mastoras, MA

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Research Areas: Software engineering, OS, DBMSs, distributed systems (OS and DBS), repositories (reuse), multidimensional files (tables) tmcinern@ryerson.ca 416-979-5000, ext. 7245

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

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Research Areas: Quantifying and mitigating risks (in the broadest sense) associated with the software engineering process in three different areas: quality assurance, green (energy efficient) software, and requirements engineering

COMPUTER SCIENCE







Vojislav Misic, PhD



Sophie Quigley, MMath Professor

Ali Miri, PhD, PEng Professor and Associate Chair Jelena Misic, PhD Professor

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Joshua Panar, PhD Professor

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Research Areas: Security and privacy, computer networks, digital communication

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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

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

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Research Areas: Humancomputer interaction, user interface design, usability testing

COMPUTER SCIENCE



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Research Areas:

Computational intelligence, neural networks, fuzzy sets of higher order, knowledgebased systems, and nonlinear modeling

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Student Affairs

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



Mikhail Soutchanski, PhD Associate Professor

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ΝΟ ΡΗΟΤΟ

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engineering, software testing, agile software development, software reliability composition



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Research Areas:

Network security, mobile communication systems, mobile wireless networks



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intelligence knowledge representation and reasoning, computationally tractable reasoning about actions and events

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Research Areas: Software

MATHEMATICS





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Programs, Yeates uate Studies

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Research Areas: Financial mathematics, dependence modelling, pricing, arbitrage, stochastic processes abonato@ryerson.ca 416-979-5000, ext. 3012

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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



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Research Areas:

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



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Research Areas:

Multidimensional stochastic processes, dependence structures, financial mathematics, biostatistics

MATHEMATICS





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Research Areas:

Mathematical finance, computational harmonic analysis and applications, ergodic theory

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Research Areas: Approximation theory and its software implementation

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Research Areas: Ergodic and operator theory

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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

chulkim@ryerson.ca 416-979-5000, ext. 7064

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Research Areas:

Cryptography, cryptanalysis, information security management, computation algebra

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MATHEMATICS







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Research Areas:

Harmonic analysis, signal and image processing

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Research Areas: Differential equations, partial differential inequalities, nonlinear analysis and applications to mathematical biology, ecology plawrenc@ryerson.ca 416-979-5000, ext. 5293

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Research Areas: Computational, commutative and topological algebra pablo.olivares@ryerson.ca 416-979-5000, ext. 4868

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Research Areas: Mathematical finance, asymptotic inference of stochastic processes, levy models, stochastic differential equations gord@ryerson.ca 416-979-5000, ext. 6967

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Research Areas: Exactly

solvable models in statistical mechanics, foundations of quantum mechanics

MATHEMATICS



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Research Areas: Fluid

mechanics, hydrodynamic

instability, gravity-driven

flows. numerical methods

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



Katrin Rohlf, PhD Associate Professor 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



Nursel Ruzgar, PhD Assistant Professor

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Research Areas: Operations research (simulation and modelling), mathematical modelling and statistical applications



Bozena Todorow, PhD 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

PHYSICS



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ryerson.ca/physics/people/ faculty/antimirova.html

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.

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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



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Research Areas: Medical physics, synthesis and characterization of nanoparticles, development

of nanoparticle based systems for multimodal imaging and therapeutics, nanoparticlebased radiosensitizers, drug delivery, intracellular fate of nanoparticles

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PHYSICS







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Research Areas: Clinical photonics goldman@ryerson.ca 416-979-5000, ext. 7418

Pedro Goldman, PhD

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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 karshafian@ryerson.ca 416-979-5000, ext. 7536

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



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Research Areas: Ultrasound imaging and therapy, optoacoustic imaging, optical imaging and therapy, thermal therapies



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

PHYSICS









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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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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)

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

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Research Areas:

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