Lakehead
UNIVERSITY

RESEARCH & INNOVATION

BIOTECHNOLOGY & MATERIALS SCIENCE

Dr. Heidi Schraft | Dr. Lionel Catalan

New PhD programs in Biotechnology and in Chemistry & Materials Science showcase Lakehead's high-impact research profile, partnerships, and infrastructure.

CREATING THE FUTURE NOW

Through collaborative, multidisciplinary research and strong relationships with industry and regional research initiatives, Lakehead University experts in biotechnology, chemistry, and materials science are developing ever keener understandings of the properties and interactions of our bodies and the world around us — contributing to breakthroughs in health care, the environment, and industry.

For example, Dr. Aicheng Chen, Canada Research Chair in Materials and Environmental Chemistry, is a world-renowned leader in the field of nanotechnology. Bioinformatician and SHARCNET Research Chair Dr. Wely Floriano, a pioneer in the field of computer-assisted molecular design techniques, is working with northern biomass materials to create modern medical breakthroughs in diagnostics and screening. Three Ontario Research Chairs and two Lakehead University Research Chairs enhance the University's strengths in materials science and biotechnology.

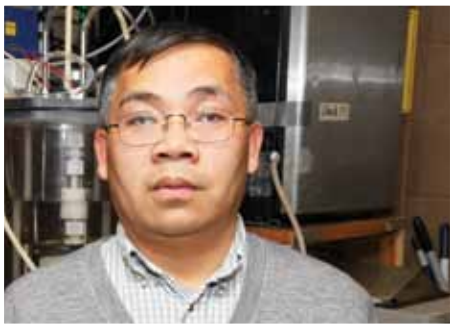
Lakehead's impressive research infrastructure is augmented by a strong culture of interdisciplinary research and close partnerships with the Thunder Bay Regional Research Institute, the Northern Ontario School of Medicine, and the Biorefining Research Initiative. These facilities and relationships provide extraordinary opportunities for both undergraduate and graduate students as well as faculty and postdoctoral fellows, and contribute to faculty's high-impact research, strong publication and funding records, and active participation in international meetings. Two new PhD programs, in Biotechnology and Chemistry & Materials Science, plus MSc programs in Biology, Chemistry, and Environmental Engineering build on these considerable strengths.

IMPROVING **wastewater management**

At Lakehead University, situated at the top of the Great Lakes Basin, Dr. Baoqiang Liao is developing improved systems for treating wastewater. His current research targets both municipal water systems and the industrial waste that comes from pulp and paper processing and petroleum refining plants so common to Northern Ontario industry.

In particular, Dr. Liao, a former Lakehead University Research Chair in Chemical Engineering, is working toward developing the next generation of membrane bioreactors, promising technology to treat wastewater.

Membrane bioreactors have many advantages over more traditional wastewater treatment methods and are widely used for municipal and industrial wastewater treatment. But, says Dr. Liao, an associate professor of chemical engineering, they could be better. He is working on developing anaerobic, or oxygen-free, membrane bioreactors. These new systems have a smaller footprint and create less waste "sludge." What's more, by converting organics to methane, he says, they can actually generate net energy.



Dr. Liao's research is supported by the Natural Sciences and Engineering Research Council of Canada (NSERC), the Canadian Foundation for Innovation (CFI), the Ontario Research Foundation, and the Northern Ontario Heritage Fund Corporation (NOHFC), as well as by industry partners Abitibi-Bowater, GE Water and Process Technologies, and the City of Thunder Bay.

Dr. Baoqiang Liao
Department of Chemical Engineering

LAKEHEAD UNIVERSITY IS BUILDING THE NEXT GENERATION OF RESEARCH AND UNDERSTANDING IN MOLECULAR IMAGING AND BIOTECHNOLOGY

— LAKEHEAD IS LEADING THE WAY

FROM BIOMASS **to biomarkers**

For thousands of years, humans have harnessed the medicinal properties of the natural world. Today, Dr. Wely Floriano is combining the traditional use of biomass materials with cutting-edge, high-performance computing technology to create modern medical breakthroughs.

A pioneer in the field of computer-assisted molecular design, Dr. Floriano is a chemistry professor who holds the Molecular Simulations Research Chair at Lakehead's Biorefining Research Initiative (BRI), in association with the Thunder Bay Regional Research Institute and SHARCNET (Shared Hierarchical Academic Research Computing Network).

One of her projects is to develop a noninvasive, optical imaging probe that could help identify women at higher risk for developing cervical cancer. Her computational model searches for chemical compounds that can effectively bind to — and therefore detect — certain variants of a protein produced by the high-risk HPV 16 virus, which can lead to the disease. She's also part of a team collaborating across universities to identify chemical compounds that can bind to a protein involved in breast cancer, thereby inhibiting the growth of breast cancer tumours.

As part of the BRI, Dr. Floriano is building a computer library of primary chemical compounds from the northern boreal forest, including waste and byproducts from biorefining processes. "By finding novel biomedical applications for these compounds," she explains, "we hope to increase the economic viability of biorefineries — while at the same time furthering medical goals."

Funding for Dr. Floriano's work is provided by the Thunder Bay Regional Research Institute, SHARCNET, and its vendor partners, HP, and SGI.

Dr. Wely B. Floriano
Department of Chemistry

TINY MATERIALS, **enormous potential**

Line up a million nanometers in a row and you get a line about the size of a pinhead. And yet, in the hands of Dr. Aicheng Chen's research team, these microscopic materials can yield enormous benefits for the mining and pulp and paper industries, and to the sustainable development of Canadian natural resources.

For example, Dr. Chen, a full professor in Lakehead's chemistry department and the Canada Research Chair in Materials and Environmental Chemistry, is researching ways to develop the hydrogen-based economy. He and his team have developed novel, titanium dioxide–based nanomaterials that hold promising results for solar hydrogen production, as well as palladium-based nanomaterials that can store hydrogen using much less energy than the traditional methods. Another research project involves using platinum-based nanochemicals in the development of fuel cells, a clean energy source.

Dr. Chen's team has recently filed a patent for the use of nanotechnology to develop efficient electrochemical sensors that can be used to detect glucose, ethanol, or even carbon monoxide — the technology could have an important impact on the diabetes-supply industry.

Beyond nanotechnology, Dr. Chen has developed a water treatment technology that combines two advanced methods in a cost-effective and more efficient way to remove hard-to-clean contaminants from drinking and wastewater. The technology was featured in MIT's *Technology Review*, highlighted by *The New York Times Syndicate*, and profiled by the *Industrial Wastewater Newsletter*. It was awarded an Natural Sciences and Engineering Research Council of Canada (NSERC) I2I grant to help bring it to market.

Dr. Chen's research is also funded by FedNor, the Northern Ontario Heritage Fund Corporation (NOHFC), the Canadian Foundation for Innovation (CFI), and the Ontario Ministry of Research and Innovation (MRI).

Dr. Aicheng Chen
Department of Chemistry, Canada Research Chair in Materials and Environmental Chemistry

CONCRETE **results**

The global construction industry has an insatiable appetite for concrete and, by extension, one of its main ingredients: cement. In the past 50 years, per capita consumption of concrete has tripled, with the global concrete industry consuming nearly 2,300 million metric tonnes of cement in 2005.

As consumption of cement rises, however, so do carbon dioxide emissions. "Cement production is responsible for approximately 7 to 10% of global CO_2 emissions," says Dr. Lionel Catalan, a professor and chair of Lakehead's Department of Chemical Engineering, as well as the Canada Research Chair in Industrial Waste Management and Site Remediation. "Producing a tonne of cement releases about a tonne of CO_2 into the atmosphere," says his colleague, inorganic and physical chemistry professor Dr. Stephen Kinrade. "So, limiting the amount of cement used in concrete would make a large dent in greenhouse gas emissions."

Drs. Catalan and Kinrade's work focuses on doing just that. The two have invented special admixtures for concrete that promise to reduce the amount of cement by as much as 50% while maintaining its strength and durability. Given that cement is one of the most expensive components of concrete, this development holds economic as well as environmental benefits, "particularly for poorer countries, where the economic costs of development are an issue," says Dr. Catalan. The technology has recently been licensed by GreenCentre Canada for further development.

Drs. Catalan and Kinrade are also developing geopolymers — or "green cements" — out of the fly ash and slag that are waste byproducts of power generation. These cheaper, carbon-neutral alternatives to traditional cement have the potential to help create a more sustainable, more affordable future for the construction industry.

Drs. Catalan and Kinrade's research is supported by the Natural Sciences and Engineering Research Council of Canada (NSERC) and GreenCentre Canada.

Dr. Lionel Catalan
Department of Chemical Engineering, Canada Research Chair in Industrial Waste Management and Site Remediation

Dr. Stephen Kinrade
Department of Chemistry

LIGHTENING **energy use**

It's estimated that 20% of the world's energy is used for lighting. Adopting more efficient lighting — in particular light-emitting diodes, or LEDs — could cut that energy use in half.

At Lakehead University, Dr. Dimiter Alexandrov is developing technology to create a more energy-efficient LED lightbulb, among other green technologies. A world expert in the field of nitride semiconductors, he is using these advanced materials, along with a new technology, called MEAGlow (migration-enhanced afterglow), to develop a range of environmentally friendly applications.

With funding from the Northern Ontario Heritage Fund Corporation (NOHFC), FedNor, the City of Thunder Bay, Lakehead University, and Meaglow Ltd. — an Ontario-based company established to help commercialize MEAGlow technology — Dr. Alexandrov is establishing a state-of-the-art semiconductor research laboratory at the University. The lab will house a Canadian-designed MEAGlow chemical film growth reactor, which can grow very thin layers of semiconductors on both micro and macro scales.

The project is creating several jobs in Thunder Bay, will train graduate and postdoctoral students in the latest semiconductor technology, and could allow master's and PhD students in the lab to find jobs without having to leave the city. It also contributes to maintaining a Canadian community of high-tech companies.

MEAGlow technology, says Dr. Alexandrov, can overcome several of the limitations of current semiconductor development, including reliance on extremely high temperatures and large flows of pure ammonia, hydrogen, and other gases. Eliminating these materials means that production costs can be cut dramatically.

"This Canadian technology provides a unique opportunity for a very wide spectrum of application in the field of electronics," says Dr. Alexandrov. "The MEAGlow reactor, with Lakehead University's new PhD program in Chemistry and Materials Science, puts Thunder Bay on the map as a leader in the semiconductor field."

Dr. Alexandrov's work is also supported by the Natural Sciences and Engineering Research Council of Canada (NSERC).

Dr. Dimiter Alexandrov
Department of Electrical Engineering

FIGHTING BACTERIA **with bacteria**

In 2008, 57 Canadians became ill and 23 died of listeriosis after the foodborne pathogen *Listeria monocytogenes* contaminated deli products at a Maple Leaf Foods plant.

At Lakehead University, Dr. Heidi Schraft's biofilm research could help prevent and control such outbreaks. Her team is examining two foodborne pathogens: *Listeria monocytogenes*, and *Campylobacter jejuni*, which is the leading cause of foodborne disease in North America. "The survival of both," says Dr. Schraft, "is enhanced by forming biofilms."

Biofilms are microbial communities that adhere to and grow on solid surfaces, such as the steel or polystyrene often found in food processing plants. In biofilm form, bacteria are more resistant to stressors like antimicrobials, oxygen, or dry conditions. In the lab, Dr. Schraft's team takes an approach relatively unique in food safety research: rather than simply applying a sanitizer to see if it works, they study bacterial changes at the genetic, molecular level. "If we know what bacteria do to form biofilms and enhance their survival, then we might be able to develop certain chemicals to prevent their formation or to remove them," she says, "with the ultimate goal of enhancing food safety."

In one study, Dr. Schraft and her graduate student Lauren Davey found that a common environmental bacterium, *Pseudomonas aeruginosa*, secreted a substance that significantly reduced the number of listeriosis-causing bacteria. In other words, the fight against "bad" bacteria may just incorporate "good" bacteria.

A former Canada Research Chair in Molecular Food Microbiology, Dr. Schraft appreciates the interdisciplinary opportunities afforded by Lakehead as a smaller university. "I work with people at the medical school, with engineers and with physicists; Lakehead makes it very easy to collaborate with people across disciplines."

Dr. Schraft's research is funded by the Natural Sciences and Engineering Research Council of Canada (NSERC).

Dr. Heidi Schraft
Department of Biology

LAKEHEAD UNIVERSITY'S **centres of excellence**

Biorefining Research Initiative (BRI)

The goal of the BRI is to create a centre of excellence dedicated to developing transformative technologies and products based upon biomass from the Boreal Forest. The vision of the BRI is not limited to fuels and forest biomass for bioenergy, but also considers the economic benefits derived from the forest ecosystem. http://lubri.lakeheadu.ca

Lakehead University Centre for Analytical Services (LUCAS)

LUCAS is a cornerstone for research and industry, and environmental and resource-based development. LUCAS labs provide researchers with access to the sophisticated equipment they need, as well as hands-on training to the University's best and brightest students early in their careers. LUCAS labs' experienced technical staff, internationally recognized researchers, and unique technology offer a wide range advanced, accredited testing services to local, national, and international clients. The following LUCAS laboratories are currently working in the areas of materials science and biotechnology:

- Instrumentation Laboratory (LUIL)
- Material Characterization Services
- Paleo-DNA Laboratory

www.lucas.lakeheadu.ca

GRADUATE PROGRAMS **related to biotechnology & materials science**

Faculty of Science and Environmental Studies

- MSc (Biology)
- MSc (Chemistry)
- PhD (Biotechnology)
- PhD (Chemistry and Materials Science)

Faculty of Engineering

- MSc Eng (Control Engineering)
- MSc Eng (Electrical and Computer Engineering)
- MSc Eng (Environmental Engineering)

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www.lakeheadu.ca

Thunder Bay
Office of Research
955 Oliver Rd., Thunder Bay, ON, P7B 5E1
(807) 343-8223, Fax (807) 346-7749

Lakehead University
Orillia Campus
500 University Avenue
Orillia, ON L3V 0B9

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