QUAESTIONES NATURALES

VOLUME 6, 2018

UNDERGRADUATE RESEARCH IN SCIENCE

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Lakehead UNIVERSITY

Faculty of Science and Environmental Studies

QN
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"Quaestiones naturales" is a Latin term referring to investigations into the natural world, or today what we call scientific research, especially those studies of a multidisciplinary nature. The term was originally used by the Roman philosopher Seneca the Younger for a series of books on meteorology and other natural processes.

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Welcoming Remarks from the Dean

This is the sixth issue of *Quaestiones Naturales*, our annual publication of the research achievements of undergraduate students in the Faculty of Science and Environmental Studies. Student engagement is a top priority in our faculty and involvement of our students in exciting research projects is central to this priority. This year in *QN*, we feature ten students from across Lakehead's two campuses whose research interests cover the spectrum of field- and laboratory-based research done by our professors. Student projects profiled include: Ty Colvin's investigation of benthic (lake bottom) communities in the Environmental Lakes Area; Darren Johnston's exploration of carbon sequestration in Simcoe County; Courtney Ellis' application of physical and mathematical modeling to explain growth of nano-sized crystals on fibre-optic cables; and Ryan Swaggert's algorithms to find patterns in social media data. A trio of projects (Ty Colvin, Tim Hollinger, Max Moore) demonstrate the comparative ease students and their faculty mentors have in pursuing field-based projects in the boreal forest, lakes and landscapes of northwestern and central Ontario and beyond. Students see the value of their research beyond their project's specific goals whether it be practical or industrial applications, such as Colin St. James' contributions to biofuels research in Dr. Qin's lab or Alison Marchand's work on the medical uses of radioisotope fluorine-18. These are just a sampling of pure and applied research projects undertaken by students in our 10 academic departments each year. We take pride in being able to offer motivated students meaningful opportunities to work with leading scientists and technology. As you will note in this year's articles,

Todd A. Randall, PhD, P.Geo.

our students clearly value the opportunity to get engaged in the research enterprise, applying their classroom knowledge to scientific questions that are important to them on a personal level or have broader benefits to the wider community. Research inspires learning and this magazine allows us to showcase just a fraction of the great work being done by some of the future generation of science alumni at Lakehead University.
Enjoy!

Todd Randall, PhD, P.Geo.

Dean of Science and Environmental Studies

Quaestiones Naturales
Undergraduate Research in Science

Featuring research performed by undergraduate students in the Faculty of Science and Environmental Studies at Lakehead University.

Ideally, science is a method by which information is gathered using evidence and physical models. It may then also extend to developing that knowledge for beneficial purposes. Part of the mandate of every university is the creation of new knowledge, and part of the educational experience for science students is the study of new knowledge and how it is gained. As part of this training, many students have the opportunity to take part in research projects under the direct supervision of a professor. As you will see, these projects are truly scientific – the students are creating new knowledge while they learn the skills to become researchers themselves.

In this magazine, we profile ten students and their projects. They performed the research when they were undergraduate students; you will see they made interesting and significant contributions to their areas of research.

Researcher	Program	Hometown	Supervisor
Ty Colvin	Biology with Concentration in Biodiversity and Conservation	Atikokan ON	Michael Rennie mrennie@lakeheadu.ca
Courtney Ellis	Physics	Grimsby ON	Gautam Das gautam.das@lakeheadu.ca
Timothy Hollinger	Environmental Science (Geography Major)	Thunder Bay ON	Rob Stewart rob.stewart@lakeheadu.ca
Darren Johnston	Environmental Sustainability	Vegreville AB	Florin Pendea ifpendea@lakeheadu.ca
Alison Marchand	Biology-Chemistry	Brandon MB	Michael Campbell mgcampbe@lakeheadu.ca
Maxwell Moore	Biology	Stevensville ON	Doug Morris dmorris@lakeheadu.ca
Colin St. James	Environmental Science (Biology Major)	Thunder Bay ON	Wensheng Qin wqin@lakeheadu.ca
April Scholz	Environmental Sustainability	Waterdown ON	Chris Murray cmurray1@lakeheadu.ca
Ryan Swaggert	Computer Science	Thunder Bay ON	Vijay Mago vmago@lakeheadu.ca
Curtis Towle	Geography	Thunder Bay ON	Adam Cornwell acornwel@lakeheadu.ca

Carbon Cycle Study

Determining the capacity for wetlands to take in carbon

Looking at his apartment, one could be forgiven for thinking that Darren Johnston's research project is being conducted at home. "I've always loved working with plants," he explains as he shows off various aquaria filled with greenery, "In many ways my research work is just an extension of the hobbies I am already interested in." Working on a joint project with input from multiple professors in the Department of Sustainability Sciences, Darren is investigating how wetlands take up carbon. The first step involves removing cores, which are tested for amounts of carbon and lead (the latter for dating layers). The cores are replaced in the wetland with an inert medium. "It's basically the same as the soil but devoid of all carbon," Darren describes, "We then leave them in the ground for a set amount of time before taking them back out. Any carbon that has come into the inert medium, say in the form of root shoots, is new carbon that has been taken up by the wetland ecosystem."

> "People are curious and are always happy to help."

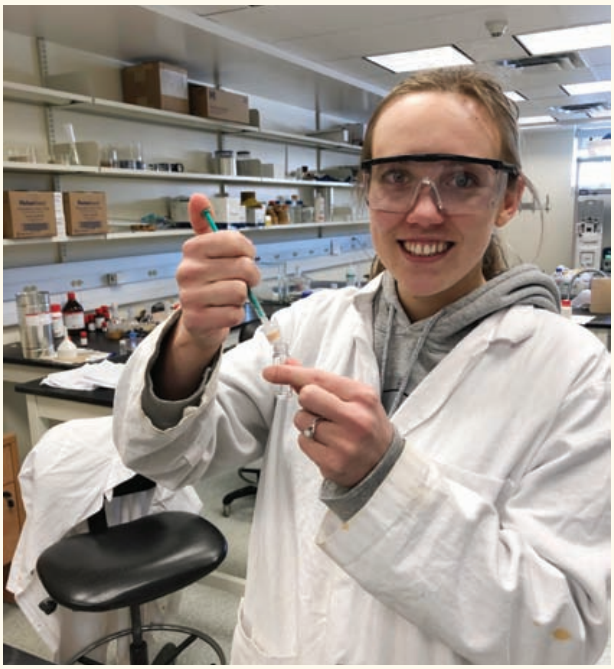
As a mature student, Darren had a number of jobs between his high school and undergraduate studies. Non-traditional pathways to university like his are becoming much more common. "I've worked with toxic chemicals phosphating steel in a machine shop, I've worked in a genetic engineering lab and as a bus driver," he says, "But now I'm at the point where I have the chance to go back to school, and the Orillia campus is an ideal location for me." He likes the fact that he can bring his life experience to bear on his research project, for example, using corrosive acids and bases when treating samples. At the same time, he takes the opportunity to learn from his professors. "People are curious, they like to hear about what you're doing, and are always happy to help with whatever project you're working on, even if it's not directly related to the research project."

Darren Johnston

Time Trials

Increasing synthetic efficiency for radiopharmaceuticals

Time is always on her mind when Alison Marchand is in the laboratory. Radiopharmaceutical chemists like Alison work with short-lived isotopes for use in medical imaging. Specifically, she is studying fluorine-18, used in positron emission tomography (PET), which has a half-life just under two hours. The combination of short lifetime and high radioactivity are advantageous for medical uses, making dosages tiny and not leaving the patient radioactive when they next try to board an airplane or cross a border. However, it makes synthesis of radiopharmaceutical agents challenging. "A typical organic synthesis would take several steps, usually requiring purification in between each step," Alison explains. "Each step takes time, during which your radioisotope is decaying. Any increase in efficiency will result in more radioactivity at the end of the synthesis and consequently a lower required dosage for the patient." Using a solid-phase reaction methodology being developed by herself and Chemistry professor Michael Campbell, she hopes to cut down the reaction times. She continues, "This method combines the reaction with a purification step, so you immediately double the efficiency of that step in the reaction." With an application to better understanding of traumatic brain injury, Alison can see the importance of her work. "The clinical purpose of the chemistry gives me the motivation to drive the project forward."



Alison Marchand

> "The clinical purpose gives me motivation to drive the project forward."

Alison finds that her research neatly overlaps with her double major in Biology and Chemistry, as well as her professional and personal interests. "Ever since we started learning about life systems in high school, I've liked learning about human biochemistry," she says. "This degree also opens lots of options for professional schools like medicine or pharmacy." Alison liked doing the research project because it doesn't just follow a recipe like typical laboratory student experiments. "When it's a recipe, it doesn't stretch your brain, but to be successful in a research project you need to bring all those learned skills to troubleshoot and improve."

The Out-in-the-Fielders

Research in many disciplines requires data collection in the field

Because Lakehead University has two campuses located with easy access to Canada's northern forests, undergraduate field courses in subjects ranging from Geography to Biology to Environmental Science and Sustainability take advantage of the location by training students in sampling techniques, mapping, and other research skills, preparing them to do field-related work as part of their education. Three such field researchers are Ty Colvin, Timothy Hollinger, and Maxwell Moore.

"Growing up, I was always interested in plants and nature generally," says Ty, whose research takes place at the IISD-Experimental Lakes Area under the supervision of Biology Professor Mike Rennie. Ty first learned about his research through LABS - the Lakehead Association of Biology Students club. "They sponsor a research symposium, which was a great way to hear about research opportunities in the Department," he says, "This research pulled together my personal interest in nature with course work in ecology, and with data management and statistics courses." Acid rain can destroy certain life forms in lakes, like the freshwater shrimp

"Field work really makes you appreciate quality equipment, like a good pair of rubber boots!"

Mysis diluviana, a major food source for sport fish like Lake Trout. As a part of Dr. Rennie's research on ecosystem restoration, Ty is interested in seeing how benthic (bottom) communities have changed in a lake where they were lost to acidification. Ty explains, "We're looking at crayfish and slimy

Ty Colvin

sculpin populations using a remotely-operated vehicle that follows a transect across the lake floor. The ROV films a metre-wide transect and you count the number of crayfish and sculpin to get a population estimate in the lake." Ty is currently spending his time at the IISD-Experimental Lakes Area laying ropes to mark off the transects for the ROV.

Timothy Hollinger is also looking at local waters. His supervisor, Professor Rob Stewart from the Department of Geography and the Environment, is contracted by the U.S. Fish and Wildlife Service to inventory dams in the Lake Superior watershed. Lakehead's small class sizes worked to Timothy's benefit: "I knew Dr. Stewart well enough that when this project came along, he told me about it knowing that it was something I would be very interested in," he says. His natural organizing abilities were also recognized, having been involved

Maxwell Moore

Timothy Hollinger

in high school and university in various student groups. Some of the dams are remote, have restricted access, or require advance permission. In addition, Timothy explains, “Field work can be difficult due to unexpected variables arising. You need to be able to adapt and overcome challenges that Mother Nature presents.” Once Timothy gets to a site, by car or canoe, he does an evaluation of the condition of the dam and how it affects the local environment. “Dams can change the course of a river, act as a barrier to fish mobility, and alter the temperature and sediment levels downstream of the dam,” he says, “We need to evaluate these affects, to determine the best course of action when dealing with abandoned or decaying dams.”

Max Moore went further afield than Ty or Timothy in his work with Biology Professor Doug Morris, to an Arctic research site in Nunavut where they tests ecological and evolutionary theory. “Lemmings define the Arctic, just about every other animal in the tundra eats them,” Max explains. “They are ‘furry popcorn’ for bears and the first lemming I saw was being carried by a raven.” They are also studying voles closer to home, at a research arena (a fenced-in area with feeding stations) near Thunder Bay. The voles in the arena have two foraging choices – safe patches where food is quickly depleted by competitors and exposed spots where only brave voles dare to forage. “We can classify them into personality types that correlate with the risk they are willing to take,” Max says, “In this way we learn about how populations react to environmental changes and then use that knowledge to minimize the likelihood of extinction.” He credits Lakehead’s dedication to involving undergraduates in research for his opportunity to do field work, learning about the research assistant position when Dr. Morris advertised it in his ecology class. “When I was a kid, I’d go fishing and it was fascinating to see how the area would grow and change from year-to-year. This project is a natural extension of that childhood interest.”

Recycled Tires, Revisited

Creating new paving materials from old tires

Students in disciplines that straddle the social and physical sciences often have to choose an arts or a science degree. For those who like both, the Bachelor of Arts and Science (HBASc) at Lakehead's Orillia campus is an attractive choice. Under that degree, the Environmental Sustainability major was ideal for April Scholz. "I was always the one reminding people to recycle and I like spending time outdoors" she says. "This program falls naturally into my areas of interest, spanning biology to environmental policy." First attracted to the program itself, April then embraced the collaborative nature of her small classes. That also led to her research project with Chris Murray, a professor in the Departments of Sustainabilty Sciences and Physics. "He sent me an e-mail to ask if I was interested in working with him," April explains, "because he knew me from class."

April Scholz

"My project advisor asked if I was interested because he knew me from class"

The research project involved old tires. "They fill up landfills and don't degrade easily, so they are simply incinerated" April says. "We looked at an alternative use, as a pavement construction material – that is, a replacement for cement and asphalt." Using ground-up tires, she prepared mixes with an adhesive and tested them for compressive strength, to see how well the materials bounced back after putting a load on it (modelling vehicles driving across it). In addition to diverting a waste product, another environmental bonus could be the material's hydraulic conductivity. As April explains, "Water normally washes off an asphalt pavement, carrying material into the water supply and contributing to local flooding. It would be better if the water could soak through the roadway, which is a goal of this research."

City Sizing

Using mathematical and geographical information to predict population growth

Calculations for predicting population growth often focus on large regions, such as provinces and states. Curtis Towle is interested in adapting models for use on subregional areas like cities; he'll then analyze the predictions from a geographical perspective. "Purely mathematical extrapolations of population growth are easier to do," explains Curtis, "but you get more accurate results if you include more granular information from the census such as immigration, age distribution of the current population, and rural-urban migration."

"The faculty are very supportive of students who follow an independent path"

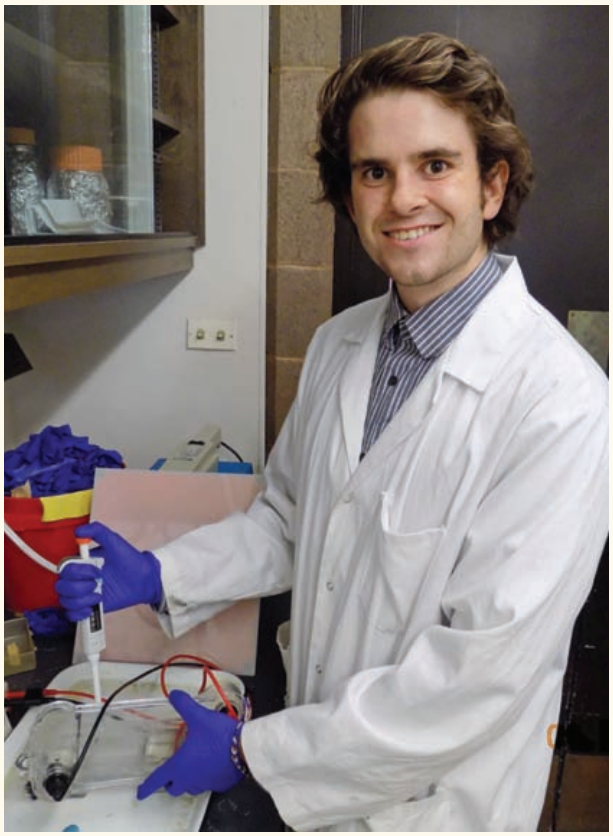
Unfortunately, even within the same country, census data is not consistent. The province of Québec collects different information than other provinces. Therefore, Curtis will test his prediction program on several Québec cities then compare them to Calgary and Thunder Bay; his initial results are very promising because his model outperforms the purely mathematical models in retroactive projection. "It's about finding the best predictive models using population geography in addition to raw statistical numbers," Curtis says.

At the start of his degree, Curtis did not really know what was involved in geography research, but he knew from his courses that he was interested in human geography rather than physical. When it came time to do a research project, he worked with Professor Adam Cornwell in the Department of Geography and the Environment. "There wasn't necessarily a lot of expertise in the Department in the area of Population Geography, so I learned self-reliance," Curtis says. "At the same time, Dr. Cornwell and the whole Department are very supportive of students who want to follow an independent path in their research."

Curtis Towle

Fuel Formation

Using microbiology to develop renewable fuel sources



Colin St. James

Microbiology is a fast-growing field that is rapidly progressing due to improvements in techniques, understanding, and instrumentation. "There is so much potential for progress in the field," comments Colin St. James, "It feels like we've merely discovered the tip of the iceburg." He is working with Professor of Biology Wensheng Qin and Biotechnology PhD student Chris Choi on renewable biofuels. Colin explains how this is done on a microbiological level: "Cellulose is a polysaccharide common in plant cell walls. By overexpressing a gene in *Bacillus* that can break it down, the polysaccharide can be efficiently converted to monosaccharides in order to produce ethanol, which can be used as a fuel." The primary issue with naturally occurring *Bacillus* is that the reaction is slow and unsuitable for industrial applications, so they need to be genetically modified to become more stable and produce products faster. This can be done by making bacteria overexpress the desired genes for products. "We transform the genes in plasmid into an expression host, *E. coli*, using the heat shock method in order to over-produce the genes," says Colin.

> "There's so much potential for progress in this field"

While the concept is straightforward, there are many steps involved, and specific techniques to be learned to do the work correctly and safely. There is also the fact that there are many enzymes that could serve this function, so Colin needs to track down the best ones. "If you're going to use it for fuel production, you need the process to be as cheap and efficient as possible," he says.

Colin is enjoying research so much that he now plans to continue with advanced studies in graduate school. "Scientific research can really help move the world forward," he explains. "At the same time, it's personally satisfying to be able to understand the world around me using science."

Fibre-optic Physics

Using fundamental physics to model an experimental observation

Many research projects start with an observation that can't be easily explained. Such was the origin for Courtney Ellis's research project. She is working with Professor Gautam Das from the Department of Physics, attempting to explain the growth of nano-sized crystals on a fibre-optic cable. "There are specific patterns and locations of growth when laser light is beamed through a tapered cable," Courtney explains. "The patterns are consistent but not easily explained, so we're working to try and explain it." For Courtney, this involved running

"I went back to my textbooks for fundamental equations to use in my computer program"

computer simulations to compare the results to the real world. Her complication: the programs that were available were not good enough. "I had to heavily modify the program," she says. "That meant going back to my textbooks for the fundamental physics equations and writing the necessary pieces from those equations into the program. Not only that, the nanoparticles are non-spherical in shape, which complicates the calculation."

This kind of mathematical approach to solving a physical problem especially appeals to Courtney. "I always liked math, but not so much pure math," she says. "I find the physical application of the mathematics to be the interesting part." Growing up in southwestern Ontario, she initially did not consider Lakehead if not for her uncle who attended the University years before. "He encouraged me to apply, so I came up to Thunder Bay for a campus tour and fell in love with the place," Courtney says. Her choice has been justified by the opportunities

Courtney Ellis

she's had in her program. Courtney continues, "Doing this research is an entirely different experience from the largely theoretical content you get in the classroom. It explains why you're learning the textbook stuff, and it gives you a better feel for what it's like to actually be a physicist."

Posting Probes

Designing computer algorithms to intelligently identify population groups

Ryan Swaggert had a very practical reason for choosing to major in Computer Science. "I liked math in high school and I'm really interested in data analysis," he says, "so a degree in Computer Science seemed like a good match. Also, a good choice for future career prospects!" When a summer research scholarship became available to him, he decided to see what research was like, which led him to a position with Professor of Computer Science Vijay Mago.

Ryan Swaggert

In the research, Ryan is applying his interest in data analysis to social media. He is attempting to create algorithms that would use bigrams and trigrams – two- and three-word phrases – to group tweets into categories. He illustrates with a medical example: "Recovering addicts might say something like 'I'm three months sober today', a sentence that would not be used by a member of the general population. Therefore a bigram like 'months sober' could be used to identify recovering addicts using their social media postings." In this example, Ryan has determined the bigram, while the goal of his algorithm design would be to determine centrality (between phrases and a given group of people or behaviour) independent of human intervention. He goes on to explain how he would test his design: "Amazon has a service called 'Mechanical Turk' that crowdsources human analysis of data. Ultimately we would test the results generated by the algorithms against results from MTurk to determine how 'intelligent' the results are." Ryan forsees a future for this kind of analysis in various medical and data sampling fields. "It would be an anonymous way to identify at-risk populations to be investigated in a medical study."

> "It would be an anonymous way to identify at-risk populations"

“The scientist is not a person who gives the right answers, he’s one who asks the right questions.” – Claude Lévi-Strauss

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