QN
QUAESTIONES NATURALES

VOLUME 7, 2019

UNDERGRADUATE RESEARCH IN SCIENCE

Photo by Kevin Noble

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Lakehead UNIVERSITY

Faculty of Science and Environmental Studies

QN
QUAESTIONES NATURALES

VOLUME 7, 2019

"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 seventh 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 nine 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: Jade Ross's isotopic analyses of human remains from a Royal Naval Hospital in Antigua; Audrey Nerino's investigation of microplastic contamination ("nurdles") that resulted from a 2008 train derailment; and Anneliese Eber's exploring the dental records of fossilized species collected in the Liang Bua field site of Dr. Tocheri's in Indonesia. Several projects (Ruth Orloci-Goodison, Tyler Ripku, Khalid Yahia) demonstrate the comparative ease students and their faculty mentors have to pursue field-based projects in the boreal forest, lakes and landscapes of northwestern and central Ontario and beyond. Many of the students profiled see the value of their research beyond their project specific goals, whether it be practical, medical or industrial applications. Examples include Kimberley Christopher's use of "big data" approaches with Dr. Wely Floriano that help us better understand connections between taste receptors and disease outcomes; Victor Xiao's work on a variant of *Haemophilus influenza* bacteria within Dr. Marina Ulanov's team; and Tristen Thibault –within Dr. Alla Reznik's group – exploring material properties to improve CT detector for cancer screening. Many have been inspired to consider advanced research opportunities at graduate school. These

Todd A. Randall, PhD, P.Geo.

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, our students clearly value the opportunity to be engaged in research and its associated experiential learning opportunities, applying their classroom knowledge to scientific questions that are important to them on a personal level or have broader benefits to the wider community. For several, this experience has further validated their decision to attend Lakehead. 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 nine 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
Kimberley Christopher	HBSc Applied Life Sciences	Thunder Bay ON	Wely Floriano wbfloria@lakeheadu.ca
Anneliese Eber	HBASc Anthropology	Kitchener ON	Matthew Tocheri mtocheri@lakeheadu.ca
Audrey Nerino	HBES Geography	Thunder Bay ON	Rob Stewart rob.stewart@lakeheadu.ca
Ruth Orloci-Goodison	HBSc Geology	Ayr ON	Amanda Diochon adiochon@lakeheadu.ca
Tyler Ripku	HBSc Biology	Thunder Bay ON	Michael Rennie mrennie@lakeheadu.ca
Jade Ross	HBSc Applied Life Sciences	Oshawa ON	Tamara Varney tvarney@lakeheadu.ca
Tristen Thibault	HBSc Physics	Dryden ON	Alla Reznik areznik@lakeheadu.ca
Victor Xiao	HBSc Biology and Chemistry BA Economics	Thunder Bay ON	Marina Ulanova mulanova@nosm.ca
Khalid Yahia	HBSc Geology	Fasher, Sudan	Mary Louise Hill mlhill@lakeheadu.ca

Tooth Trials

Using tooth morphology to determine rat species in fossil sites

Even as a young child, the mystery of ancient Egypt held a special sway over Anneliese Eber. "Anything to do with mummies or the pyramids was mysterious: things we didn't know and we didn't know how to find out about them," she says. Although she didn't know the term then, she feels she was born to be an anthropologist. "Looking back at what I was interested in, I called it 'history', but really it was the background and science of historical cultures and archaeology that I was interested in, how to learn about ancient cultures and peoples, which is basically the science of anthropology." As she prepared to go to university, she looked at various university programs and was particularly drawn to the Orillia campus and its HBASc. "I visited university campuses closer to home but it was an excellent campus tour by an anthro prof at Orillia that really made me feel I belonged there," she says. "In addition, the HBASc program allowed me to combine the arts side – cultural anthropology – with the science of field work and evolutionary biology."

"The process, not the product, is the real learning experience"

She was sold on undergraduate research during her first field school experience, at Lac Seul First Nation in northwestern Ontario. An instructor had told her about Anthropology professor Matthew Tocheri's work on the extinct species *Homo floresiensis*, a close relative of modern humans. "I took a course with Dr. Tocheri, where we presented research papers in class," Anneliese explains. "I found fossil teeth fascinating, which he noticed and told me about a project he was planning." Intrigued, Anneliese moved to the Thunder Bay campus for her project on geometric morphometrics – mathematically describing shape – on teeth to determine rat species from the Liang Bua site where *H. floresiensis* was found. During the project, using simply 2D pictures from the dig site, she has discovered landmarks on the fossilized teeth that allow differentiation by species.

Anneliese Eber

"I had a lot of independence on the project," Anneliese says. "It was a few months of poor results, but then I found a literature paper that pointed the way and suddenly we had a great result that clearly shows the variation we were looking for." She is proud of her specific accomplishment, but points out that the skills she learned are universal. "The process of the project, rather than the result, is the real learning experience. Now I have the skills to tackle any problem!"

Soil Science

What happens to carbon nutrient when a forest is disturbed?

Growing up in a family of university-educated parents and grandparents meant that Ruth Orloci-Goodison's childhood was training for a career in science. "My grandfather, who has a PhD in ecology, would say, 'there's always a question to be asked'," says Ruth. "Everything was a teaching moment, and an encouragement to ask 'why'?" There was no question young Ruth was university-bound, only a question of where. She chose Lakehead for its combination of small class sizes, proximity to the natural world, and generous scholarship scale. "High-performing students get great scholarship offers from Lakehead," Ruth explains, "And, of course, a geologist or biologist has such easy access to the 'natural laboratory' of Thunder Bay."

After taking the first-year geology course, Ruth fell in love with the subject. Because it happens in the "real world", Geology can be messy and subjective at times. Therefore, the process of learning is the important part, as well as getting a wide variety of experience. "After all, 'science' is a process, not a result," Ruth says. "It's an exploration method, and the more tools you have to aid the problem the better."

"Everything is a teaching moment"

As a result, Ruth has sought research experiences across the spectrum of Geology, including recently with Prof. Amanda Diochon. Together they are examining change in soil carbon levels when a forest undergoes a disturbance, such as wildfire, whole tree harvest, or salvage logging. "Soil is so important: it's the interface between the planet and life!" Ruth explains. Specifically, the carbon can be bound in the soil matrix many different ways, which she examines through successively washing samples taken from the disturbance site with certain reagents. "Each reagent disrupts a certain binding method," says Ruth. "We're noticing a significant loss of carbon related to certain binding methods after these major disturbances, which goes against what everyone thought." Especially in locations where forest regeneration is slow, like in Northwestern Ontario, this new knowledge will be vital for better managing forest resources.

Ruth Orloci-Goodison

Fish Story

Determining the impact of a common antibacterial agent on a lake ecosystem

Tyler Ripku

Nanoparticles of silver are common antibacterial agents, but the full effect of releasing this emerging contaminant into the environment is poorly characterized. A multi-year experiment at the IISD Experimental Lakes Area (ELA) aims to understand this effect better. Working with Prof. Mike Rennie, Tyler Ripku is examining changes in the source of energy to fish in the presence and absence of nanosilver, which they can use to determine its effect on the lake's ecosystem. Tyler explains, "The ratio of carbon isotopes in a fish's flesh will change depending on where it feeds. We discovered a change in the isotope ratios indicating that two species of fish, yellow perch and pike, were getting more of their energy from the open water versus the benthic region of the lake after the addition of nanosilver to their environment." The fish changed from feeding primarily in the littoral (shoreline) zone and moved to the pelagic zone in the middle of the lake. As Tyler explains, this change likely arises from the impact of the antibiotic agent: "This antimicrobial likely reduces production in the littoral benthic region of the lake, resulting in less food there. This likely caused them to include more zooplankton from the pelagic zone in their diets."

> "The fish were changing their feeding patterns after addition of nanosilver"

Tyler is currently immersed in preparation of tissue samples for isotopic analysis, which have been collected over the last seven years. "We take muscle tissue form the perch and pike and I prepare the samples for isotopic analysis," he explains. "Although I'm looking at the carbon, we also do nitrogen and mercury, which tells us other things, such as contaminant biomagnification of the fish."

Looking back on his pre-university days, Tyler says he's always been a biologist, even before he knew what the term meant. "I was a documentary addict!" he says. "*Crocodile Hunter* was a favorite. I eventually gravitated to aquatic and marine biology, and luckily Lakehead has a world-class expert in Dr. Rennie. [a Canada Research Chair in Freshwater Ecology and Fisheries]. I loved every minute of the class he taught me, and now I'm getting to do practical research that I love as well."

Nurdle Hurdles

Remediation and recommendations following a train derailment

In 2008, a train derailment on the north shore of Lake Superior dumped a carload of nurdles onto the shore and into the water. Over the next ten years, a coalition of partners from the rail carrier to Parks Canada have been trying to clean up this microplastic contamination. Unfortunately, Audrey Nerino points out, "On the surface it seems like a simple problem, but it's actually very complicated. How do you clean up something so small? How do you know when to stop and declare the site 'remediated' when a beach can be clean one day and then a storm blows in and two inches of nurdles pile up the next day?"

"Now I have the confidence to work on complex real-world problems"

Working with Prof. Rob Stewart in the Department of Geography and the Environment, Audrey is looking at the extent of the problem and working with the stakeholders to make recommendations moving forward. "Prevention and inventory are key," Audrey concludes. "Microplastics are so small that a spill like this is almost impossible to clean up." The detrimental effects of microplastics on aquatic organisms, not to mention the effect on property values of unsightly nurdles washing up onto the beach, are well-known. "They fill fish stomachs without nutritional value and they concentrate other pollutants, so they can really cause harm to the environment."

Audrey was especially attracted to this project because it combined her long-standing interest

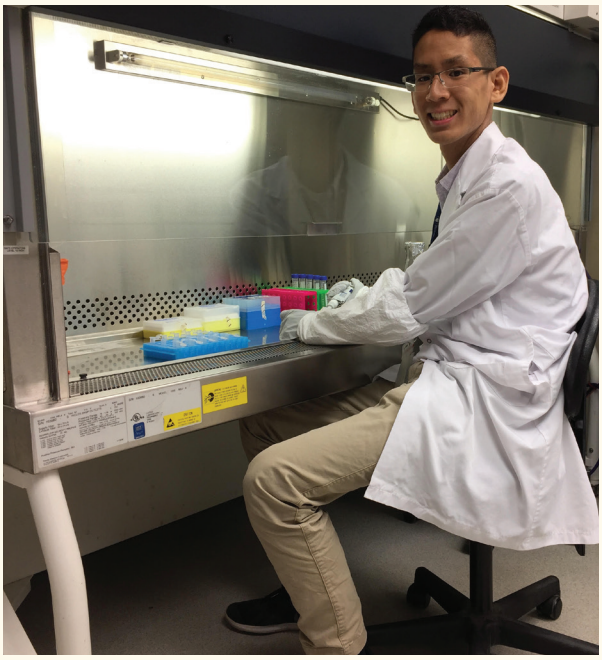
Audrey Nerino

in the environment with a practical study close to home. "This accident occurred close to where I grew up, so it really emphasizes the project's importance to me," she says. She's also happy to study at Lakehead where she gets real-world opportunities like this and, for example, a field-school experience in South America. "We were looking for microplastics in the fjords at the south end of Chile," she explains. "Luckily from an environmental standpoint, we didn't find any in this remote area, but unfortunately there was still a lot of plastic pollution from buoys and fishing activities from the local villages." These experiences have emphasized for Audrey the importance of research. "Before doing these projects I wasn't sure how well I would do, but now I have the confidence to use my education to work on complex real-world problems."

Immunological Investigations

Studying host-pathogen interactions

Opportunities for research in the Faculty of Science and Environmental Studies are not just limited to full-time faculty of Lakehead University. Scientific researchers in government, industry, and other institutions like the Northern Ontario School of Medicine have affiliations with the University and have undergraduate students working with them. Victor Xiao is working with one such researcher, Dr. Marina Ulanova, whose research program he learned about through a list of researchers on the University website. "I've always been interested in immunology," Victor says. "It's not always obvious, but many health conditions have an immunological component, from cardiovascular diseases to cancer to asthma. Even gluten sensitivity can have an immunological component!"



Victor Xiao

"So many conditions have an immunological component"

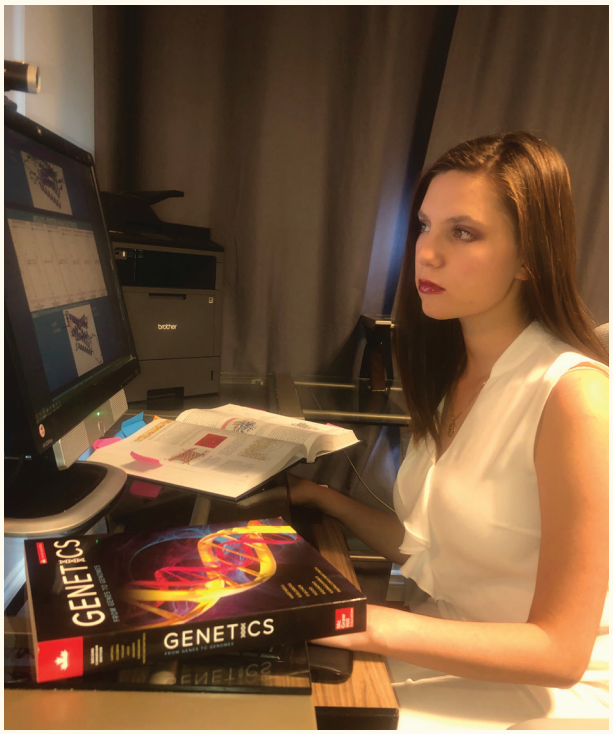
Victor's work is on the bacterium *Haemophilus influenzae*. "There are many variants, called serotypes," explains Victor, "There is a vaccine for type b, which has led to a significant decrease in its incidence rate." Unfortunately, that vaccine does not confer protection against the other serotypes. The Ulanova lab has now started to study the type a variant (Hia) because it has a higher prevalence in Northwestern Ontario. Specifically, Victor is studying how the outer polysaccharide capsule of Hia interacts with the innate immune system by infecting monocytes – a type of white blood cell – with Hia. "We have two strains: a wildtype with the polysaccharide capsule and a mutant type that is capsule-deficient. We then determine the difference in immune response of the monocytes." By studying how Hia interacts with the host immune system, it is hoped that the research can help development of an effective vaccine.

Math and science have always appealed to Victor. "I participated in a number of science fairs and math contests in high school," he says. In addition to his HBSc in Chemistry and Biology, Victor is also graduating with a BA in Economics. "Having this kind of liberal arts-based background has definitely given me a well-rounded and balanced education."

In Good Taste

Studying the evolution of human taste receptors

Two of the tastes that humans can detect on the tongue are sweet and umami, the latter a Japanese word for "savory". Both receptors are protein heterodimers, meaning two different proteins combine in the receptor, one of which is common for these two tastes. Because of the complex nature of the receptor, tastes are not "on/off" but scaled, which might explain why different populations prefer different tastes. Kimberley Christopher is using bioinformatics to study these receptors with Dr. Wely Floriano of the Department of Chemistry. "Taste perception is a major food choice, and poor long-term eating habits can lead to metabolic diseases like Type II diabetes, obesity, and certain liver diseases," Kimberley explains. "We are using 'big data' methods to look at a set of 2500 human genomes to investigate the diversity of these proteins, and, by extension, to determine if there is a link between metabolic diseases and various populations."



Kimberley Christopher

"My childhood dream was 'find a cure for cancer'"

With current methods, it is even possible to compare with extinct species. Kimberley continues: "One protein is the same in all humans, including Neanderthals and Denisovans, while another has one mutation in *Homo sapiens*, a different one in *H. neanderthals*, and yet another in *H. denisovas*. Of course, we only have one Neanderthal and one Denisovan genome, so it's hard to generalize from such a small data set!"

Kimberley originally chose Lakehead because of its reputation for undergraduate research like her project. "My father is a researcher, so you might say research is a family affair!" she says. It was an easy choice since Lakehead is rated the #1 undergraduate research institution for the last several years by *Research Infosource*. She elaborates: "Health research is a great way to help people – my childhood dream was to 'find a cure for cancer' because my mother was diagnosed with a terminal cancer when I was young." She combines volunteering at the hospital with summer research and her Applied Life Sciences program to carry out her goal. "Even my electives have been helpful," says Kimberley. "I took piano from a great concert pianist professor, and now I play for patients at the hospital!"

Graveyard Story

Using bioanthropology to fill in historical gaps

The first thing Jade Ross mentions when asked about her decision to come to Lakehead University is, “Small class sizes! It really was important to me to be able to speak with my professors,” she explains. “The added advantage of proximity to nature and outdoor activities was also a big part of my decision.” Having been interested in all the science courses in high school, Jade chose the multidisciplinary Applied Life Sciences program. “You take all these courses in Biology, Chemistry, and Physics, which was great,” she says. “But it turns out that the one subject I hadn’t known about – Anthropology – is the one I liked the best.”

Jade Ross

> “Their stories need to be told to help us understand our colonial history”

Specifically, Jade has been doing archaeological research with Professor Tamara Varney, working in the area of bioanthropology, which uses biochemical and instrumental techniques to learn about people who died long ago. “We are doing stable isotope analysis on remains excavated from the Royal Naval Hospital cemetery in English Harbour, Antigua,” Jade says. The ratio of isotopes in certain elements like carbon, oxygen, and strontium can be used to estimate an individual’s location during life because isotopic abundance varies geographically. “Tooth enamel is ‘permanent’ from the time the tooth develops,” Jade explains, “while bones remodel throughout your life. Thus, a change in isotope ratio between teeth and bones can signify a change in diet and therefore a geographic move, for example an individual sold into slavery in Africa and transported to the Antilles.” At the time of the interview, Jade has not yet traveled to Antigua, although she has since then. “So far I’ve been working on data and samples collected previously, and I’m looking forward to being part of the next excavation team.”

The combination of historical context and molecular science appeals to Jade. “The history of these enslaved dockyard labourers has not been documented,” Jade says. “Their stories need to be told to help us understand colonial history.” With the analytical tools currently at their disposal, archaeologists like Jade are able to help fill in these stories.

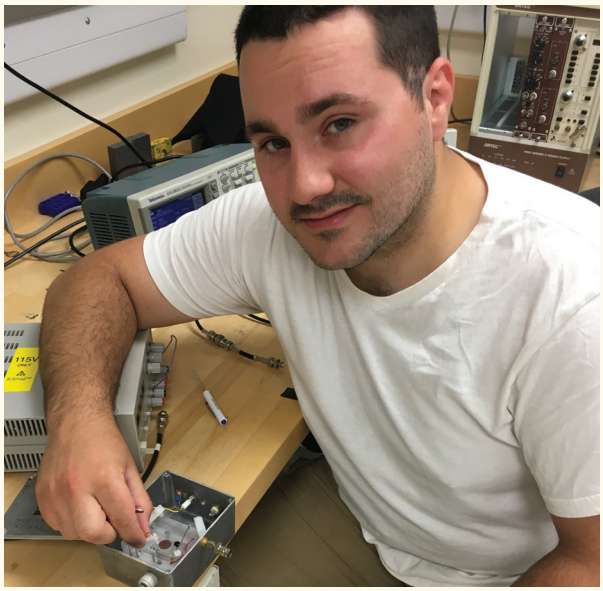
Intense Imaging

Searching for materials to improve CT detectors

Some students change majors after taking their first-year courses. Such was the case with Tristen Thibault: "When I was a teenager I read science books like Stephen Hawking's, but I didn't start as a Physics major. It was my winter semester freshman course that re-awakened my love of physics." He later learned about the research being done by members of the Department and the opportunities for summer work. "I was being encouraged to apply for a summer research scholarship, which requires a professor supervisor," he recalls. "I was walking by Dr. Reznik's office and the door was open, so I started chatting with her about research."

"The professor's office door was open, so I just started chatting with her about research"

As a result, he's working with Dr. Alla Reznik, a Canada Research Chair in Physics of Radiation Medical Imaging. "Here I can apply my classroom Physics to problems in healthcare," says Tristen. Specifically, he is studying X-ray detectors for advanced CT scanners. "Current detectors see all X-rays the same, which gives you anatomical and density information only," he explains. "If you could differentiate wavelengths, you could also learn about chemical composition." Materials that see wavelengths are overwhelmed by the number of photons produced by a CT machine. In order to overcome this limitation, Tristen is researching the physical characteristics of detector materials, which are commercially produced by a company in B.C. "The incoming X-ray generates an electron-hole pair and therefore a current – that's a semiconducting photodetector," Tristen explains. It turns out that



Tristen Thibault

the electrons move much faster than the holes (the positive charges). Tristen continues: "Holes may accumulate, causing a dynamic polarization that distorts the resulting image."

By better understanding charge transport the Reznik group and their industrial collaborators hope to design "spectral CT" detectors that can differentiate wavelength. "Take kidney stones, for example," Tristen says. "They have similar densities but there are multiple chemical types. Some can only be treated surgically but others can be treated pharmaceutically. A spectral CT would be able to differentiate them and avoid unnecessary surgery." Working with industrial collaborators comes with its own challenges, though. "It's fun to know you have a direct application," Tristen comments, "but the company won't tell us exactly what their detector is made of because it's a trade secret. It makes it challenging sometimes to understand what our results mean!"

Fracture Factors

Determining geological history in Northwestern Ontario

Although Thunder Bay's region is currently geologically stable, that hasn't always been the case. Fractures in the rock point to tectonic activity in the past, which Khalid Yahia is studying with Geology Professor Mary Louise Hill. Rock cuts made for the Trans-Canada highway exposed granite rocks, giving them the opportunity to study the geological history. "The Mid-Continental Rift (MCR) is a well-known feature in North America," explains Khalid. "We wanted to see what this looked like in the local rock." By measuring the orientation of fractures in the granite, Khalid was able to show geological activity between the local rocks consistent with the published literature for the MCR, but also a second structure with a different age. "Based on our observations, we conclude the activity occurred prior to the MCR, which no one has seen before."

"You need to keep an open mind."

Khalid's conclusions highlight another set of lessons he learned from doing an undergraduate research project. "First, you need to keep an open mind and don't have pre-conceived bias," he says. "Skills like communication and working as a team are very important. If your conclusions contradict someone else's, don't attack them! You present your conclusions respectfully and let the facts make your point."

Having already obtained a degree in petroleum geology, Khalid's undergraduate path was not typical. "I was working in Sudan, but left during the war," he says. He has left behind the petroleum industry, at least for now, and is currently doing field work in diamond exploration with Rio Tinto. "I had the opportunity to study in Canada and did this research project, which then led to this professional opportunity," he continues. "If the project goes well, it could lead to a permanent position."

Khalid Yahia

“Equipped with his five senses, man explores the universe around him and calls the adventure Science.” – Edwin Hubble

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