UNIVERSITY OF TORONTO SCARBOROUGH

APRIL 2023

DEPT. OF PHYSICAL AND ENVIRONMENTAL SCIENCES

DPES DIGEST

Photo: Chai Chen

EDITORS:

DR. SHADI DALILI

HARRY XU

“I (we) wish to acknowledge this land on which the University of Toronto operates. For thousands of years it has been the traditional land of the Huron-Wendat, the Seneca, and most recently, the Mississaugas of the Credit River. Today, this meeting place is still the home to many Indigenous people from across Turtle Island and we are grateful to have the opportunity to work on this land.”

- University of Toronto, Land Acknowledgement

Photo: Chai Chen

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EDITOR FAREWELL

Yao Yan Huang

Congratulations to Yao Yan Huang for receiving the **2023 Joan E. Foley Quality of Student Experience Award**! This $1000 prize is presented annually by the University of Toronto Alumni Association (UTAA) to a student, faculty or administrative staff member who has made a distinctive and lasting contribution to enhancing the quality of the undergraduate or graduate student experience at the University of Toronto.

Yao Yan Huang, DPES Digest Editor & Writer
July 2020 - April 2023

About me:
Hello everyone. My name is Yao Yan Huang and I've been a writer and later editor for the DPES Digest since 2020. I'm a 5th year student doing a co-op Environmental Chemistry specialist and will be graduating in June this year. I'm also Director of Partnership and Funding for the Chemistry Students' Society at UTSC and Co-President of Regenesis UTSC, an environmental and sustainability student group. I'm a big fan of science fiction and fantasy and I'm currently hosting a book club with some friends.

What has been the most enjoyable part of working on the DPES Digest?
I really enjoy the process of putting together an article, whether that is more of an interview or informational piece or highlight about a course. I like writing a lot and building that narrative thread. As an editor, I enjoyed the chance to artistically express myself as well and put forth ideas about what the department would like to read. Overall, I think I've had the most fun just getting to know people in the department and all the amazing things that students, faculty, alumni, and staff are doing.

What is your favorite piece or part that you've worked on?
It's very hard to decide. I started as a writer during the pandemic when I was looking for something to do at home so it's been a long time. I think it might have to be the piece in 2021: *Reflections on the COVID-19 Pandemic*, where I got to explore it from a health, environment, and psychology perspective. I interviewed Professor Gerald Cupchik from the psychology department and it was my first time doing an interview and writing an original article that wasn't just compiled from other sources.

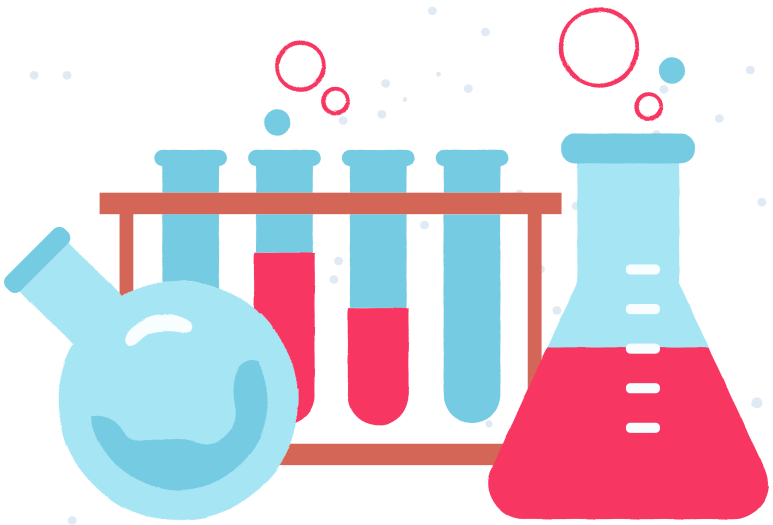
What are some of your future plans?
After exams? Take a long nap. And pack for the Costa Rica Field Camp course that I'll be going on at the end of April. Since I'm graduating in June I don't have many specific plans for summer. I will be starting a PhD in Chemistry in Fall at UTSG.

Something interesting about yourself?
I collect keychains and postcards of every place I've been. I would like to visit every continent.

Anything else you would like to share or any closing remarks?
I've really enjoyed working on the newsletter with the rest of the team and Professor Dalili. The DPES Digest to me is a celebration of the department and I hope that it can continue to be this way. I also hope that we can get a budget to print some physical copies too.

More information:
https://alumni.utoronto.ca/events-and-programs/awards/awex/joan-foley-award

THANK YOU YAO YAN FOR ALL YOUR CONTRIBUTIONS TO THE DPES DIGEST! WE APPRECIATE ALL YOUR HARD WORK THAT MAKES THE NEWSLETTER POSSIBLE!



CELEBRATIONS

HAPPY NOWRUZ!

March 20th marked Nowruz, the beginning of the Iranian/Persian New Year. Nowruz is celebrated by Persians and by many other countries such as Afghanistan, Azerbaijan, India, Kyrgyzstan, Kazakhstan, Pakistan, Turkey, Tajikistan, Turkmenistan and Uzbekistan. Nowruz is a means of reflecting on the past and creating new goals for the future. Happy belated Nowruz to everyone at UTSC!

RAMADAN AND EID MUBARAK!

March 23rd marked the beginning of Ramadan, the one month Islamic holiday where Muslims fast from sunrise to sunset. Ramadan is observed by Muslims from around the world as a holy month of worship, study of the Quran, prayer, and fasting. Ramadan occurs during the month in which Muslims believe the Quran began to be revealed to the Prophet Muhammad. The purpose of this month is to fast, pray, and reflect within the community to become closer to Islam. Eid al-Fitr, which was celebrated on April 21st, is the celebration that marks the end of Ramadan. Belated Ramadan Mubarak and Eid Mubarak to everyone at UTSC!

CHOOSING YOUR PROGRAM & WOMEN IN STEM

March was Choosing your Program Month, and UTSC hosted several in-person events to help students decide their path in future semesters. If you are having trouble choosing a program, please consider contacting the Academic Advising Centre at UTSC for next steps.

Academic Advising and Career Centre (AC213)

- Monday & Tuesday 10:00 am - 4:00 pm
- Wednesday 10:00 am - 6:45 pm
- Thursday 10:00 am - 6:45 pm
- Friday, 10:00 am - 3:00 pm
- Phone Number: 416-287-7561

In the spirit of choosing your program, three popular departmental student associations on campus hosted a Women in STEM event featuring several inspiring panellists. **EPSA, BIOSA**, and the **PNDA** invited several of UTSC's very own talented professors to discuss how women play a definitive role in the STEM field. Students received the opportunity to ask questions and network with the panelists. Check out some pictures from the event!

DPES FACULTY

RESEARCH HIGHLIGHT

In a recent UofT News article "Too comfortable in our own comfort", Professor Mandy Meriano explains why we should not waste water. Summarized from full story at: https://www.utoronto.ca/news/too-comfortable-our-own-comfort-u-t-expert-why-we-shouldn-t-waste-water

We all understand the need to reduce our carbon footprint, considering the effects of climate change. However, we need to be assessing our water footprint as well, according to Dr Meriano: "We need to ask more questions about our water, where that water comes from and how it gets to us," says **Mandy Meriano**, Associate Professor, teaching stream, in the Department of Physical and Environmental Sciences at the University of Toronto Scarborough. "Sometimes I think we're a bit too comfortable in our own comfort."

In Ontario, much of our water comes from the Great Lakes, which contain about 20 per cent of the world's supply of fresh water found above ground. Canadians use more than 215 litres each day, for showering, cooking, doing dishes and flushing toilets to name a few of the main uses of our water.

According to Professor Meriano, one of the reasons to conserve is the unnecessary wear it puts on the vast filtration and delivery systems that get potable water to your tap. This infrastructure will eventually need to be replaced, and may include fossil fuel use for transportation.

Professor Meriano conducted a study in Pickering, Ont., that found when treated water was sent into distribution systems, as much as 14 per cent leaked out of water mains and into the ground, contributing to local flood risks and the formation of sink holes.

"We all have an individual responsibility, but I think at a greater level, too, the government has to start paying attention," she says.

"We need to be engaged with how people that we put in government are actually managing, or mismanaging, our resources."

Professor Meriano offers some ways to reduce your water footprint, such as:

- Fix leakages or dripping immediately from toilets, hot water heaters or other pipes, and make sure to turn taps off all the way.
- Showers use less water than baths but if you need to take a soak, don't fill the tub all the way.
- When opportunity arises, choose a new washing machine, toilet, shower head or dishwasher that uses less water.
- Rainwater that flows down gutters can be collected and used to water plants and gardens.
- Water lawns when it's not hot so water doesn't evaporate, and don't water them on windy days.
- Keeping blades of grass longer can also shelter the roots and cause lawns to need less water.

In order to give back and raise awareness about this issue, Professor Meriano is using her background as an educator and funding from the Bill and Melinda Gates Foundation to put together a master's program training graduates in water resources management at universities in sub-Saharan Africa. "All health is reliant and dependent on clean water," she says. "You can't have healthy populations without having access to clean water."

FACULTY PROMOTIONS & AWARDS

(excerpts taken from DPES Chair communication)

PROMOTION OF KAGAN KERMAN TO FULL PROFESSOR

Professional Background

Congratulations to **Prof. Kagan Kerman** who has been promoted to the rank of Full Professor. Professor Kerman obtained his Ph.D. in 2005 from School of Materials Science, Advanced Institute of Science and Technology, Ishikawa, Japan. After three postdoctoral appointments at Japan New Energy Development Organization (Professors Eiichi Tamiya and Kazuhiko Matsumoto), University of Saskatchewan and University of Western Ontario (Professor Heinz-Bernhard Kraatz), Professor Kerman joined the Department of Physical and Environmental Sciences (Primary graduate appointment in the Graduate Department of Chemistry) in 2008. He has since developed an active research program in bioanalytical chemistry with emphasis on the development of electrochemical sensors.

Professor Kerman was promoted to Associate Professor with tenure in 2015. In 2016, Professor Kerman was awarded a Tier 2 Canada Research Chair in Bioelectrochemistry of Proteins, which was renewed for a second term in 2021. Professor Kerman has published over 200 papers in peer-reviewed journals, 11 book chapters, and holds 13 patents. His work has appeared in high impact journals (e.g., ACS Sustainable Chemistry & Engineering, Journal of Power Sources, Analyst, Journal of the Electrochemical Society, Bioelectrochemistry, Biosensors, Analytica Chimica Acta, Analytical Chemistry, Free Radical Biology and Medicine, Journal of Environmental Chemical Engineering, ACS Chemical Neuroscience, and Colloids and Surfaces B: Biointerfaces) and has been recognized by highly prestigious awards. In 2014, Professor Kerman was one of four chemists working in Canada selected for the International Union of Pure and Applied Chemistry (IUPAC) travel award which supports travel and international exposure at an IUPAC-sponsored meeting. He received the W.A.E. McBryde Medal in 2021 from the Chemical Institute of Canada (CIC)/Canadian Society for Chemistry (CSC), which is awarded to a “young scientist working in Canada who has made significant achievements in pure or applied analytical chemistry”. Professor Kerman was also the recipient of the Ontario Early Researcher Award (2012) and the Biomedical Young Investigator Award (2009) from the Alzheimer Society of Canada. According to Google scholar, he has an h-index=63 and over 12,500 citations.

FACULTY PROMOTIONS

(excerpts taken from DPES Chair communication)

Prof. Kerman has established a strong research program in bioanalytical chemistry with emphasis on the development of electrochemical sensors. After joining the Department of Physical & Environmental Sciences, Professor Kerman expanded his research program which now includes four main thrusts: (i) electrochemical biosensors for neurodegenerative diseases, (ii) nanocomposite-modified electrochemical sensors, (iii) development of polymer-nanocomposite solar cells, and (iv) development of ceramic membrane-based microbial fuel cells. Prof. Kerman has obtained significant external funding from a multitude of organizations including: Canada Foundation for Innovation, Ontario Research Fund, MITACS, NSERC Discovery Grants, CIHR, The Weston Foundation, Alion Inc., and the Ontario Centre of Excellence. These various sources of external research funding have been obtained with him either as a lead applicant or co-applicant and are funding a wide range of research based on electrochemical biosensors, including the development of nano-composite sensors (current NSERC Discovery Grant program) and devices for diagnosis of ovarian cancer (current CIHR project grant). **Warmest Congratulations to Professor Kerman on this prestigious promotion. We are very proud of you and wish you many more successes to come!**

PROMOTION OF NIRUSHA THAVARAJAH TO ASSOCIATE PROFESSOR, TEACHING STREAM

Professional Background

Prof. Thavarajah has been promoted to Associate Professor, Teaching Stream. Prof. Nirusha Thavarajah completed her B.Sc. (Hons.), Specialist in Biological Chemistry, at the University of Toronto in 2000. She received her Ph.D. in Synthetic Organic Chemistry, at the University of Toronto in 2004. She spent three years as a post-doctoral fellow at the Ontario Institute for Cancer Research. She has also received a LL.M. in Intellectual Property Law from Osgoode Hall Law School at York University, as well as a M.Ed., Teaching in Higher Education, from the University of Ontario Institute of Technology. She has also held multiple Sessional Lecturer I appointments at York University (Department of Chemistry), University of Ontario Institute of Technology (Department of Chemistry), University of Toronto (Department of Chemistry), University Toronto Scarborough (Department of Physical and Environmental Sciences), and University of Toronto Mississauga (Department of Chemical and Physical Sciences). In 2015, the Department of Physical and Environmental Sciences promoted her to Sessional Lecturer II, and subsequently to Assistant Professor, Teaching Stream, in 2017.

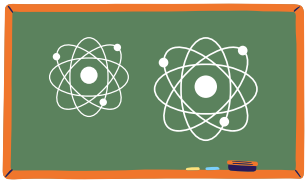
Prof. Thavarajah has been responsible for an impressively wide range of courses from our undergraduate offerings in Chemistry, such as Introductory Chemistry I: Structure and Bonding (CHMA10H3), Introductory Chemistry II: Reactions and Mechanisms (CHMA11H3), Organic Chemistry I (CHMB41H3), Organic Chemistry II (CHMB42H3), Introduction to Inorganic Chemistry (CHMB31H3), Physical Sciences Research Experience (PSCB90H3), Organic Reaction Mechanisms (CHMC41H3), Organic Synthesis (CHMC42H3), Bio-Organic Chemistry (CHMC47H3), Topics in Biophysical Chemistry (CHMC21H3), Bio-Inorganic Chemistry (CHMD69H3), Directed Research (CHMD91H3), Advanced Bio-Organic Chemistry (CHMD47H3), and the Advanced Chemistry Laboratory Course (CHMD92H3). Her ability to design and deliver first-rate courses is truly exceptional!

Prof. Thavarajah is a popular and highly respected course instructor, with outstanding course evaluation metrics and comments. She has brought enormous energy, enthusiasm, and creativity to our programs. Her promotion package provides overwhelming evidence that Prof. Thavarajah is a superlative educator, who has shown a sustained level of excellence in teaching at the undergraduate level. Her record includes very significant pedagogical contributions to departmental/divisional curricular initiatives and teaching committees. She has been instrumental in the development of a coherent and unifying curriculum for the Chemistry discipline, spanning first-, second-, third-, and fourth-year courses. Dr Thavarajah has introduced a number of highly innovative teaching techniques that require her to go “the extra mile” by making herself available to students to a greater extent than a typical approach requires. It is not surprising that she is the recipient of multiple Dean’s Merit Awards, and the Teaching Award related to CUPE 3902 Unit 1 Course Instructors and Unit 3 Sessional Lecturers. In her course evaluations, Prof. Thavarajah is consistently ranked within the top 5-10% of departmental and divisional levels. **Warmest congratulations Nirusha!**

FACULTY AWARDS

(excerpts taken from DPES Chair communication)

Congratulations to **Prof. Sanghyun (Kris) Kim** who is one of the recipients of the highly competitive **Early Career Teaching Award**. A brief description of Professor Kim's contributions can be found in the following link: https://www.chemistry.utoronto.ca/news/kris-kim-awarded-university-toronto-early-career-teaching-award



It is extremely rare to find such a uniquely talented colleague, who meets all the criteria of excellence, only 3.5 years after the beginning of his academic career. Although he only joined DPES in July 2019, Prof. Kim's excellent and impactful work makes it seem as if he has been here 10+ years! Amazing accomplishment in all aspects! **Congratulations Professor Kim**, DPES is very proud of you and keep up the great work!

FACULTY AWARDS

(excerpts taken from DPES Chair communication)

Professor Diana Valencia is one of the recipients of the highly prestigious Guggenheim Fellowships. The John Simon Guggenheim Memorial Foundation offers fellowships to exceptional individuals every year in pursuit of scholarship in any field of knowledge (social sciences, natural sciences, humanities) and creation in any form of art.

Professional Background

Professor Valencia is a world-recognized and leading scholar in the field of exoplanets. She was one of the first scientists to conduct research in the interior structure and interior dynamics of Super-Earths, which is now an established and flourishing field of study. Valencia's doctoral thesis is the first to combine geophysical and astrophysical concepts around these planets. As a Ph.D. student at Harvard University, she produced a structural model for Super-Earths, which is now considered a foundational paper (>500 citations). In this paper, she coined the term "Super-Earth" one year before the first discovery. She was also the first to demonstrate that plate tectonics would be feasible on rocky Super-Earths, initiating a healthy debate in the geophysics community; and the first to quantify the degeneracy in composition from mass and radius estimates on Super-Earths. These contributions earned her the "Origins of Life" graduate fellowship. In her postdoctoral years, she held two competitive fellowships: the Henri Poincaré Postdoctoral fellowship, awarded by the French Government and held at the Observatoire de la Côte d'Azur, and the NASA Sagan Postdoctoral fellowship, awarded by NASA and held at the Massachusetts Institute of Technology. Through this research, she was one of the first to show that radius is most sensitive to hydrogen and helium content in mini-Neptunes, and the first to infer the composition of a Super-Earth.

Since joining our department in 2013, Prof. Valencia has expanded her research agenda to include planetary formation, planetary chemical composition and machine learning for planetary sciences. She was awarded tenure and promotion to Associate Professor in 2020. She is the co-founder of the Centre for Planetary Sciences at the University of Toronto and has helped raise funding to support a multitude of academic activities. The impact of her work, research agenda, contributions and initiatives to train Highly Qualified Personnel has helped her to secure external funding, including NSERC Discovery grants, the highly sought–after Early Researcher Award, and the French-Canada Research Fund. Recent awards also include the Paolo Farinella Prize, the inaugural Mercator Visiting Fellow awarded by the German Science Foundation, and a Visiting Fellowship for PlanetS Initiative awarded by the Swiss Science Foundation. Professor Valencia has published over 40 papers in top-tier journals and has been invited to give numerous international academic talks. She regularly reaches the public through interviews for the Discovery Channel, CBC Ontario, CNN Español, among others.

Warmest congratulations on this exceptional distinction, Prof. Valencia!
DPES is very proud of you!

FACULTY AWARDS

(excerpts taken from DPES Chair communication)

Professor Oleksandr (Alex) Voznyy is the recipient of the UTSC Pre-Tenure Faculty Research Award. Professor Voznyy joined the Department of Physical and Environmental Sciences in 2018. His research program focuses on the development of materials for energy applications, with the overarching goal of providing solutions for clean energy technologies.

Professional Background

Clean energy solutions are desperately needed, given that governments and their citizens around the world, are motivated to limit anthropogenic impacts on the environment and the growing realization of the climate change crisis. Prof. Voznyy's research program clearly targets a fundamental and critical need for chemistry and society. One of the major hurdles to the widespread application of clean energy technologies is their prohibitive cost. Prof. Voznyy's research program is multi-faceted and includes both experimental and computational approaches via machine learning that are supporting the discovery of new materials.

Prof. Voznyy's publication record (≈210 papers) is nothing short of prodigious!! His collaborative work has not only yielded an exceptionally high number of publications, but this work has appeared in the most prestigious scientific journals (Science, Nature, Nature Communications, Nature Nanotechnology, Nature Materials, Nature Energy, Nature Chemistry, Nano Letters, Journal of the American Chemical Society, Advanced Materials). Many of these papers have been co-authored with some of the leading scholars in the field of clean-energy technology. Given the time required to obtain funding, establish an experimental chemistry laboratory and recruit trainees, the fact that Prof. Voznyy managed to publish >75 papers since joining the University of Toronto amply demonstrates that he is a highly charismatic scholar with an outstanding productivity and impeccable work ethic. Prof. Voznyy's impressive list of invited talks (Chemical Institute of Canada, Canadian Chemical Engineering Conference, NanoGe, Cornell University, University of Minnesota), stellar number of citations (≈34,000 citations, H-index=87), and recent appointment as an Associate Editor (Applied AI Letters), speak volumes for the superb quality and immense impact of his work. Alex was also the recipient of the Strem Chemicals Award for Pure or Applied Inorganic Chemistry for 2023. This award is presented to a Canadian citizen or landed immigrant who has made an outstanding contribution to inorganic chemistry, demonstrating exceptional promise, while working in Canada. The significance of this recognition can only be understood, if someone reviews the achievements, broader impact, and career trajectories of past winners of the same award (https://www.cheminst.ca/awards/csc/strem-chem/). Another major highlight in Alex's career is induction in the highly coveted list of highly cited researchers in Materials Science by Web of Science in 2020. Each year, Clarivate identifies the world's most influential researchers — the select few who have been most frequently cited by their peers over the last decade. In 2020, fewer than 6,200, or about 0.1%, of the world's researchers, in 21 research fields and across multiple fields, have earned this exclusive distinction.

Warmest congratulations Alex!! DPES is very proud of all your success!

FACULTY AWARDS

(excerpts taken from DPES Chair communication)

Professor Hanno Rein is the recipient of the UTSC Research Excellence Faculty Scholars. Professor Rein obtained his Ph.D. in Theoretical Astrophysics in 2010 from Cambridge University, and continued his studies as a postdoctoral fellow at the School of Natural Sciences, Institute for Advanced Study, Princeton, NJ.

Professional Background

Since joining the department in 2013, Professor Rein has developed a unique research program focused on the development of numerical methods and the study of orbital dynamics of planets, both in our Solar System and beyond. His research addresses fundamental questions related to the understanding of the architecture, formation, and stability of these systems. In particular, Professor Rein has made significant contributions in the following areas of research: (i) formation of planetary systems, where he has been able to pinpoint the role of stochastic orbital migration in shaping the architecture of extrasolar planetary systems; (ii) Saturn's rings, where he demonstrated the physical similarities between protoplanetary disks and Saturn's rings, thereby paving the way for breakthroughs in our understanding of protoplanetary disks; (iii) numerical integration methods, where he has made several significant contributions to increase speed and accuracy of numerical integration techniques, such as the WHFast algorithm with superior performance in accuracy and efficiency relative to comparable integrators; and (iv) the development of the REBOUND code which is a unique open-source software project combining many newly developed numerical integrators for the gravitational problem.

Professor Rein has been able to attract external funding to support his research group with over 50 graduate/undergraduate students and postdoctoral fellows, and has published over 55 significant peer-reviewed papers and book chapters in the top astrophysical journals. The quality, originality, and impact of his work have been recognized by the international research community through invitations to present his work at top tier specialized conferences and departmental seminars in leading universities, such as Yale, Northwestern, ETH Zurich, Cornell University, and Princeton. He is actively involved in outreach activities to communicate complex ideas to broad audiences, and has shown academic leadership by organizing internationally attended workshops at the University of Toronto Scarborough, as well as accepting to serve as the Director of the Centre of Planetary Science. Prof. Rein has also developed several popular iPhone applications such as Exoplanet, Comet Neowise, and Mega Constellations. These visual and interactive apps make recent astronomical discoveries and current events accessible to the general public. His apps have received highly positive reviews, repeatedly ranked as the number one educational apps in Apple's AppStore, and have a combined reach of over 4 million people worldwide.

Warmest congratulations for this well-deserved recognition, Hanno!!

COVER STORY

EPSA GRADUATE GALA

The Environmental and Physical Sciences Students' Association (EPSA) hosted the inaugural DPES Graduate Gala for the class of 2023 on April 27th in the Environmental Science & Chemistry Building. Take a look at the event photos and find some familiar faces! Warmest congratulations to our newest graduates from the department! We wish you all a bright and prosperous future!
Photos Courtesy: *Chai Chen*

(L-R): Irena Frances Creed, Shadi Dalili, Kris Kim, Effie Sauer, Marco Zimmer-De Iuliis, Alen Hadzovic, Jamie Donaldson, Lana Mikhaylichenko, Nirusha Thavarajah, Raymond Akbar (Staff)

(L-R): Chai Chen,Veronica Cavallari, Tom Meulendyk, Scott Ballantyne, Raymond Akbar, Tony Adamo

Photo Captions:

Top Left: Event check-in table
Top Right: DPES faculty and staff at the Graduate Gala
Middle Left: EPSA President Nahidha Jauhar giving opening speech
Bottom Right: DPES staff at the Graduate Gala
Bottom Left: EPSA executive members at the Graduate Gala

HIGH SCHOOL OUTREACH

by Shadi Dalili

On Tues April 11th, 2023 DPES was host to a group of 40 visiting grade 11 students from Francis Libermann Catholic High School here in Scarborough organized by Professor Dalili and CSU. The students gained some hands-on experience performing various experiments in our first floor teaching labs in the ESCB building, developed and guided by our superb CSU executive team and the amazing volunteers they recruited, who gave their time and energy teaching and interacting with the students.

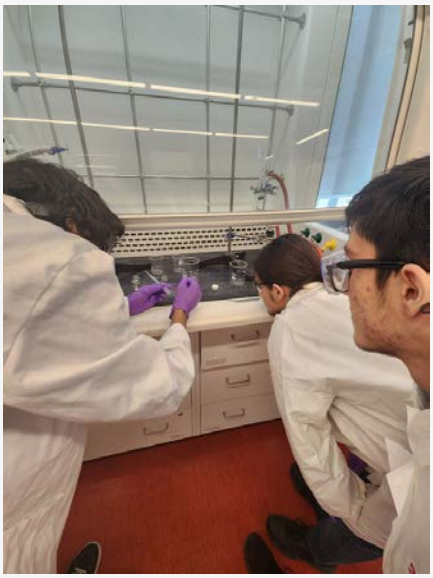
In addition, the students were able to tour our TRACES facilities, thanks to Tony Adamo, our energetic TRACES manager who educated and entertained them at the same time with his vast knowledge of the instruments and his endless humor.

During lunch, the students had the benefit of asking questions and hearing about our programs and life as a university student from our panel of professors, composed of Professors Kris Kim, Lana Mikhaylichenko, Oleksander Voznyy and Nirsuha Thavarajah.

Finally, the students ended their jam-packed day at the Admissions and Recruitment Office in Highland Hall, where they were able to learn about the various academic programs at the UTSC campus as well as tour the campus facilities and buildings.

The students truly valued and appreciated the experience, especially after 3 years of COVID restrictions that had prevented them from being able to participate in any field trips. Their teacher, Mr Leo Babu Joseph, shared with us some pictures and testimonials from the students:

(see following page)



"On the trip to the University of Toronto - Scarbrough campus, the part I enjoyed the most was the questions and answers panel with the university professors. I was surprised to find out how kind and welcoming the professors were, especially since before the trip, I had no idea what university professors would be like. I was also really glad about all the advice they gave us, not just about studying for exams but about even after one finishes their undergrad. Moreover, I was nervous that I would have to go to university already knowing what I was going to be and could not change my mind after starting studying but was reassured that many of them majored in different fields than the ones they are in now. Overall, I enjoyed every part of the trip from the labs to the tour at the end, but I would have to say my favourite part was the panel with the professors." - Joseph G.

“Based on my experience exploring the UTSC campus, I was able to catch a glimpse of the well connected and welcoming community. Also, being able to participate in university chemistry lab activities definitely sparked a deeper interest in chemistry. It was overall a great experience for a high school student like myself.”
- Anonymous

"Exploring UTSC's facilities - including the state-of-the-art TRACES centre - was an exciting and fascinating experience!" - Jadon V.

“Participating in labs done at UTSC was a very eye opening experience. Definitely made me want to pursue a post-secondary degree in chemistry” - Calton L.

"The experience at UTSC was one filled with reassurance, wonder, and knowledge. To walk into a school with such wisdom was a one of a kind trip and we were very thankful for it. Walking around the university made us feel as though we were walking right into our future. When we were doing the university science labs, we learned how to manage and conduct experiments. We learned first hand how it felt like to be a student at UTSC. The whole experience was one to remember; one that highlighted our grade 11 year at Francis Libermann. As STEAM students, we're so thankful for the great tour and lab experience at UTSC." - Aliyah R.

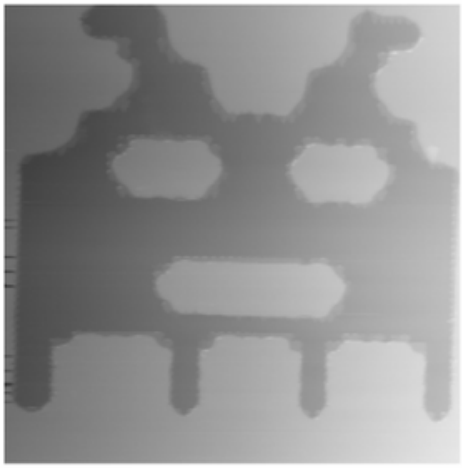
"UTSC provided us, students with a great opportunity to know what kind of labs and experience are in store for our potential futures. All while making it a fun, one of a kind trip that will be memorable for all" - Lauren A.

"The tour provided by us by the staff and volunteers of the University of Toronto Scarborough campus was an overall wonderful and insightful experience for the students involved. Information given on later portions of the tour about the campus itself was enticing enough to have students further consider post-secondary opportunities there, and the lab was incredibly engaging and enjoyable to participate in. The buildings seemed to appropriately suit the likes of the students, as well as the material studied in each respective building, even further enticing most students there. In an attempt to demonstrate an ideal post-secondary experience in a scientific field, those involved made a genuinely fun time for the students. A simple 'Thank you' could never suffice" - Francisco A.

"UTSC and all the student volunteers made the experience extremely enjoyable while still making the experience knowledge-filled. We were able to meet students and professors who can provide insight on their personal experiences. This trip was one of a kind and peaked my interest in chemistry." - Krizelle V.

MICRO-PHOTOGRAPHY: TESTING THE CAPABILITIES OF AN EDUCATIONAL AFM

Libertad Rojas and Dan Weaver



What makes the above images interesting? They appear to be just some shapes and an alien-looking octopus. However, now consider that each side has a total of only 20 micrometers, making them completely invisible to the human eye and to most optical microscopes. In fact, optical microscopes fail to produce quality images at the microscales and are not capable of reaching the nanoscale. This led to the creation of microscopes that made use of other interactions such as atomic forces to create surface images of micro and nano-samples (Meyer, 2000). This type of microscope is known as the Atomic Force Microscope (AFM) and is part of the Scanning Probe Microscopes (SPM) family.

Unlike optical microscopes, AFMs do not create images by focusing light on surfaces, but rather by physically “feeling” the surfaces of the samples using a flexible cantilever with a microtip (Eaton & West, 2010). It measures the atomic force interactions between the microtip and sample while the height is kept constant (or vice versa) to create surface images. This scanning method is known as a contact mode technique which can be set to either work in contestant force or constant height mode. Unlike other nanomicroscopes or SPMs, AFMs do not require a sample to be polarized, have a specific conductivity, or be rigid (Eaton & West, 2010). In fact, AFMs can scan anything from cells to metal samples without the need for specific ambient conditions, such as vacuum at low temperatures.

In most cases, all the components of the AFM would be packed into a box-like case. Although this lowers external sources of noise distortions, it is not convenient if one seeks to fully understand the mechanism of an AFM. Therefore, considering this, an educational AFM was selected to become part of the list of experiments available for PHYC11 students. This AFM is particularly well suited for learning purposes since it has all its main components exposed as shown in Figure 1. It also requires students to manually assemble and align the instrument which serves to further enhance the understanding of how each component fits together and the principles behind AFMs.

In brief, the educational AFM makes use of a laser beam which is reflected by a metallic tip called a cantilever into a four-segmented photodiode that acts as a detector. Note that the part that makes contact with the sample is the single microtip (see Figure 1) located at the end of the cantilever’s tip. The force interactions between the cantilever tip and the sample are then detected as the deflected beam moves in an XY plane on the photodiode.

The detected voltage in each of the photodiode regions is then received by a Digital Signal Processor (DPS), which then allows the sample's surface height differences to be measured (Atomic Force Microscope, 2018). The same voltage then causes the piezo solids (in the piezo XYZ controllers) to expand, which is an effect known as the inverse piezoelectric effect, converting the electrical to mechanical signals that control the piezo positioning stage. It is important to note that piezo solids are highly sensitive and will expand even when the voltage signals they receive are on the microscale. The implementation of this feedback system is what truly sets this instrument apart from other microscopes as it allows for more precise control of the cantilever's tip (Atomic Force Microscope, 2018). For instance, to maintain a constant force, the DSP will drive the piezo controllers to move the cantilever away from the sample when there is a rise in the sample's surface. Lastly, all controllers are connected to a Data Acquisition (DAQ) Card which serves to store all the data about the sample's surface as voltage measurements and then sends it to the computer where the AFM Software is used to create the final images and measure the interactive forces (Atomic Force Microscope, 2018).

Before beginning the scanning process of an interesting sample, a sensor chip was used to set the optimal scanning parameters. Using the default parameters, as shown in Figure 2a, the scan was unsuccessful.

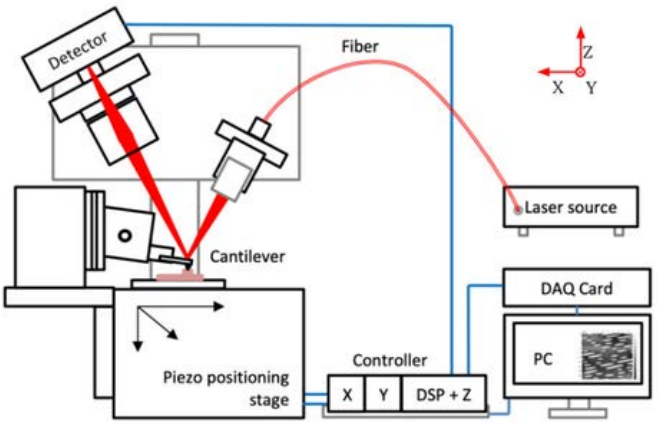


Figure 1: AFM setup Schematics (Atomic Force Microscope, 2018)

Such an image was either the result of a broken microtip or the scanning parameters being inappropriate for the sample. To fix this, for the second scan (Figure 2b) the number of pixels scanned per second was increased and the grey range scale was set to auto-adjust (preventing the high grey contrast region). Following this, the PID values were slowly increased until the lines became clear as shown in Figure 2c. PID values are constants that control the feedback signal's speed and can cause unwanted oscillations that lead to distortions in the shape of line ripples (Atomic Force Microscope, 2018). As a final adjustment, the resolution was increased to get rid of the pixelation along the border of the lines in Figure 2c. All the parameter changes are summarized in Table 1.

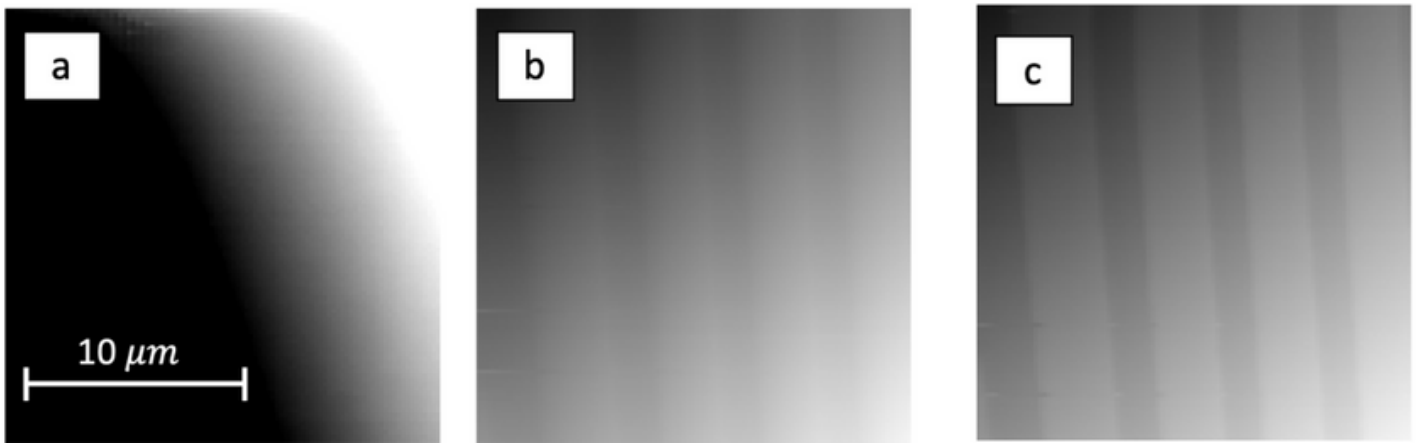


Figure 2: (a) First scan with default parameters, (b) increasing scanning speed, and (c) increasing PID values.

With the revised scanning parameters, the AFM was used to scan a steel panel covered with a ZincNickel (ZnNi) alloy corrosion protection coating (Kumar et al., 2019). Sample was donated by a nanotechnology company, Integran Technologies. This first scan was done implementing a constant force mode. Although it allows one to have an idea of the graininess of the surface, there are several lines (ripple) distortions. These were most likely a result of cantilever oscillations due to PID values that were too high or low. When the tip of the cantilever is in contact with the sample, adhesion forces of the sample's surface cause it to snatch onto it. Recall that PID values regulate the speed of the feedback system. This means that when the tip is pulled away too fast from the surface, the adhesion forces will hold onto it until they are overcome by the repulsive forces (Atomic Force Microscope, 2018). This in addition to the flexibility of the cantilever, will lead it to momentarily oscillate causing the ripples.

One solution to get rid of these ripples can be to further adjust the PID values. Still, these distortions will constantly be present to some extent since there will always be delays when transferring information through the mechanism. Another, faster way to solve this issue is to use a constant height mode. The height of the cantilever is not changed in this mode meaning that it does not depend on the PID values and will thus not have such ripple distortions (Atomic Force Microscope, 2018).

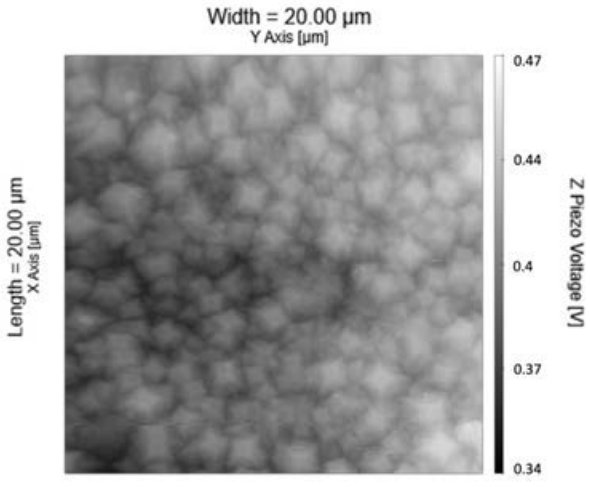


Figure 4: Constant height scan of ZnNi sample.

Table 1: Initial (default) and final parameters.

Parameter	Initial Value	Final Value
Laser Source	2.5 mW	2.5 mW
Photodiode Voltage Detected	0.6 V to 4.0 V	0.6 V to 4.0 V
Sample Pixels	100 x 100	250 x 250
PID Values	0.1, 0.1, 0.1	1.2, 0.5, 0.2
Scanning Speed	50 pix/sec	100 pix/sec

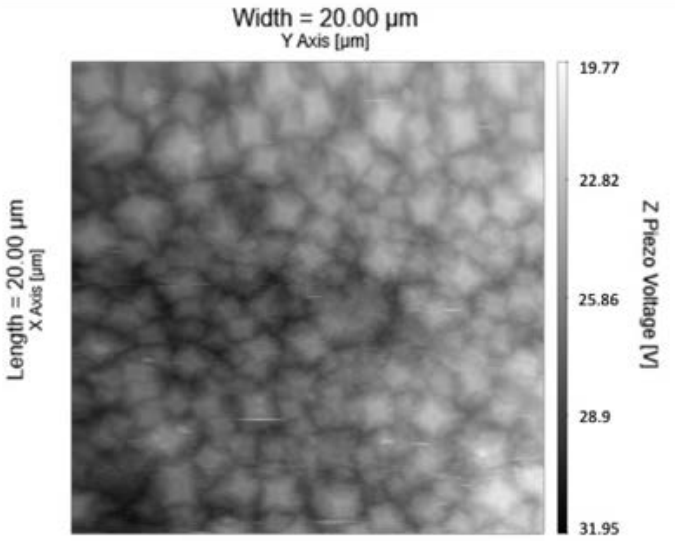


Figure 3: Constant force scan of ZnNi sample

The results in Figure 4 are impressive on their own; however, when compared to the results of a professional research study, such as that shown in Figure 5, the true capabilities of this instrument are seen.

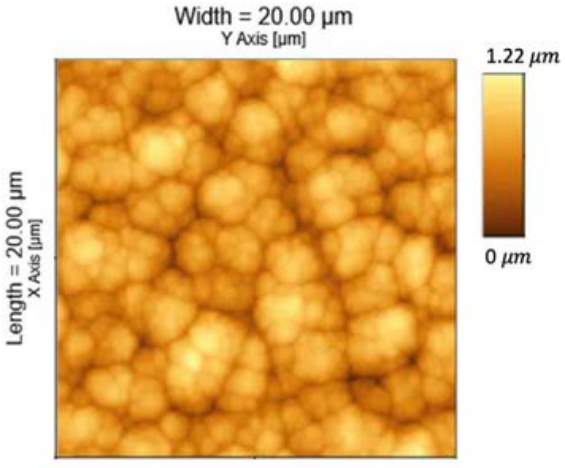


Figure 5: Surface scan of ZnNi form research that studied corrosion properties of ZnNi alloys (Ramanauskas, Gudavičiūtė, Kaliničenko, & Juškenas, 2005)

The fact that this experiment's result for the ZnNi sample was able to approximate those produced by a research institution shows the exceptional quality that can be reached even with an educational AFM. Even with the blurriness of the constant height scan, the characteristic grainy surface of this sample is visible and there are no major distortions.

Overall, this AFM was able to produce excellent-quality images; however, it is important to note that these are not the only applications of this instrument. Aside from producing the scans, it is also able to produce Force-Distance Curves, which can provide information about the elasticity of a sample. This data is especially significant when studying softer samples such as flexible polymers and human cells. Furthermore, using the numerical data sheets, which are also provided by the computer software, the actual values of the Adhesion force could be calculated, the different heights on the surface could be approximated, and one could even create a three-dimensional representation of the surface using an extended software. All these applications of the results provided by the AFM will not only serve to enhance the experience of future PHYC11 students as experimentalists but would also allow them to produce more in-depth analysis of samples such as the ZnNi.

References:

Atomic Force Microscope. (2018). Thorlabs, Inc.

Eaton, P., West, P. (2010). Atomic Force Microscopy. New York: Oxford University Press Inc.

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Ramanauskas, R., Gudavičiūtė, L., Kaliničenko, A., & Juškenas, R. (2005). Pulse plating effect on microstructure and corrosion properties of Zn-Ni alloy coatings. Journal of Solid-State Electrochemistry, 9(12), 900–908. https://doi.org/10.1007/s10008- 005-0049-z

NEW PROGRAM HIGHLIGHT:

Minor in Applied Climatology

The Department of Physical and Environmental Sciences is proud to announce a new Environmental Science program offered at UTSC: the **Minor in Applied Climatology**!

This program offers students a unique academic experience, combining a fundamental understanding of climate change science with analyses of related atmospheric processes and their impacts. Students will observe and analyze changing climate conditions and related industries through an applied science perspective, learning how to find solutions to current and future climatic challenges. Climate change science incorporates many scientific disciplines, from computer science and mathematics, to geography and biology. This program will prepare students for this intersection of scientific excellence with an understanding of the physical and dynamic processes associated with climatic events and their impacts.

GRADUATE STUDIES

Admissions Season MEnvSc

As many of DPESers will already know, the department offers a unique 12-month Master of Environmental Science program (Part-Time option available). It is a course-based masters program where students can complete either a research project or an internship over the summer. The program focuses on helping students with a solid foundation in science to transform that knowledge into hands-on experience in the environmental sector.

The admissions committee was extremely pleased to review many strong applications and the competition for the entrance scholarships was very fierce. We are looking forward to welcoming the 2024 cohort this September. Incoming students bring diverse experience and expertise from a variety of undergraduate degrees.

One question we repeatedly received from prospective students was regarding the level of support MEnvSc students can expect to get for securing internships. The Graduate admin team are always pleased to answer this question especially with this year's cohort continuing the trend of 100% of students securing an internship, a rate that the program has boasted since its inception in 2006. This year, all students secured meaningful positions earlier than ever. Students receive an exceptional amount of professional skills development and training. This comes in the form of resume and cover letter review and support, interview coaching, networking activities and so much more. This level of career coaching can cost thousands of dollars to individuals, but professional support it is all built right into our program!

The early deadline to apply to the program was February 15th (for international applicants and students hoping to be considered for an entrance scholarship) however **we continue to accept applications on a rolling basis until May 15th 2023.** Application Process: *https://www.utsc.utoronto.ca/physsci/application-process-menvsc*

Think.Shoot.Change:

Every year the Master of Environmental Science (MEnvSc Program) holds the Think.Shoot.Change video competition for incoming students. Open to all students, domestic and international, this funding opportunity is based entirely on the creativity of our incoming students to present an informative and interesting video on an any Environmental issues that they are passionate about and feel needs more public awareness.

In the past we asked for submissions to be no longer than 2 minutes. This year, however, we shortened the length to a 1.5 minute reel in the style of a social media post. This is beneficial for incoming students as we are seeing more MEnvSc internship job descriptions that indicate experience communicating environmental and scientific issues to a broad public.

The review committee is excited to dig into some popcorn and see what the incoming cohort has created! Check out prior year winning submissions here: *https://utsc.utoronto.ca/physsci/video-competition-previous-winners*

GRADUATE PROFESSIONAL DAY

A Graduate Professional Day was hosted in-person at U of T Scarborough (UTSC) on Thursday, March 23, 2023 from 3pm-6pm by UTSC's Centre of Teaching & Learning in collaboration with the UTSC Equity, Diversity, and Inclusivity Office, and the Graduate Students' Association at Scarborough (GSAS). At this graduate professional day, a conference was held to address equity, diversity and inclusivity in STEM, as STEM researchers come from a wide variety of backgrounds, in both research interest and orientation. The conference aimed to answer questions such as "What's it like to be 2SLGBTQIA+ in STEM? What are the challenges and opportunities for researchers in the classroom, the lab and the workplace?"

Additionally, the afternoon included a talk about how STEM students in the sciences can create desired career paths and address issues of inclusivity, over two sessions:

1. What inclusivity looks like in the workplace
2. STEM researchers' and entrepreneurs' experiences in the field

The two talks were followed by a Q&A session with the guest speaker panel. Speakers at the panel included:

RAE CURRIE (SHE/THEY), UNIVERSITY OF TORONTO FACULTY OF MEDICINE

Rachel (Rae) Currie is a University of Toronto Mississauga graduate, currently in the final year of their MD at the Temerty Faculty of Medicine. They are a prospective obstetrician and gynecologist, with intent to develop a practice centered on queer communities and gender-affirming care, reproductive justice, and equitable access to contraception and abortion. She has also complemented this focus with extensive work in mental health care, including development of treatment protocols for HQ Toronto, an integrated healthcare clinic for gay, bisexual and trans men in Toronto. They are driven by interests in mentorship, education, and advocacy, and have held affirming roles including the student leadership of Out in Medicine, Temerty's queer visibility and advocacy group, and UTM Positive Space, the like group at the University of Toronto Mississauga, She looks ahead to her medical residency and future career, where they will continue to engage as a grateful learner and educator alike within the fields of obstetrics and gynecology.

RENE HARRISON (SHE/HER), VICE-DEAN GRADUATE & POSTDOCTORAL STUDIES, UTSC

As Vice-Dean Graduate & Postdoctoral Studies, Professor Harrison is responsible for the development and implementation of new graduate programs, and oversees locally administered graduate programs. The Vice-Dean liaises regularly with the School of Graduate Studies (SGS), and coordinates the flow of graduate student funding. The office also administers local graduate and Post-doctoral fellowship scholarships and fellowships as well as travel awards. The Vice-Dean Graduate & Postdoctoral Studies also has oversight on all graduate program reviews.

IGNACIO MONGREL (HE/HIM),
ASSISTANT DIRECTOR ICUBE, UTM

Originally from Uruguay, Ignacio moved to Canada in 2010 and earned a Master's of Business, Entrepreneurship and Technology (MBET) from the University of Waterloo. He has been working with entrepreneurs for 15+ years at the Waterloo Accelerator Centre, Haltech Regional Innovation Centre, and currently supporting students, alumni and community members by leading ICUBE, a business accelerator at the University of Toronto Mississauga. Ignacio is also an entrepreneur at heart and co-founded and exited his own start-up (Apartmint). Ignacio is also the Chair of Positive Space at UTM, advocating for 2SLGBTQ+ students, staff, and faculty. In 2022 he received the Principal's Award for Advancing Equity, Diversity and Inclusion.

JACIE NEWFELD (THEY/THEM),
MSC STUDENT, ECOLOGY AND EVOLUTIONARY BIOLOGY

Jacy Newfeld earned their HBSc in Ecology and Evolutionary Biology at the University of Toronto. Their current research focuses on the evolutionary genomics of host adaptation in bacterial plant pathogens. They are also interested in the predictors of gynecological health, especially the vaginal microbiome, in trans people pursuing medical transition. Jacy is passionate about improving accessibility in STEM through community-focused, peer-to-peer advocacy and support. They work with diverse student and community organizations to develop community, social, and institutional supports for queer, trans, and disabled students.

NAT RAMBOLD (THEY/THEM),
SPECIALIST, EDUCATION AND TRAINING

Nat is a facilitator in the 519's education and training program, specializing in creating queer and trans inclusive environments. They have worked across educational settings, including K-12, post-secondary, and community-based settings. With an M.A. in Gender Studies, Nat has had the opportunity to share knowledge across a variety of subject areas including anti-violence initiatives, and equity-focused education.

On behalf of DPES, we'd like to thank our campus partners for their hard work coordinating this event!
We look forward to continuing working together on inspiring inclusive excellence at the University of Toronto Scarborough.

VOLUNTEER WITH REGENESIS

UTSC Bike Clinic Looking for Volunteers!

Do you know how to make minor repairs to your bicycle? If you do and are interested in being part of a sustainable initiative to increase access to cycling, Regenesis UTSC is looking for you! The UTSC Bike Clinic will operate Wednesdays 2-5 pm at the UTSC Farmers Market May - Sep 2023. Volunteer as a bike clinic facilitator where you can mentor fellow community members on how to take care of their bikes and do minor repairs. All student volunteers will be trained by professional mechanics and provided all equipment necessary. This opportunity will count towards the CCR program in UTSC & the Sustainability Citizen Program. Honoraria will be provided. For more information, contact utsc@regenesis.eco

Signup form: **https://forms.gle/zRKT7CqfhpGAdMFs6**

UTSC Free Store Move-out Volunteers

The UTSC Free Store is looking for around 20 volunteers to help with donation collection and sorting during residence move-out on Friday April 28th 12-4pm and April 29 Saturday - May 1st Monday, 10-4 pm. Pizza lunch will be provided for volunteers and volunteers can sign up for the shifts they will be available. Come and support the UTSC community and keep the Free Store thriving. Volunteers will also get first access for any items they wish from the new donations.

Signup form:
https://docs.google.com/forms/d/e/1FAIpQLSeN_e_wmO1RccZkq4SmgmtmxXUqGvtN5NjXxeh6WSd-vgHGAw/viewform

FROM THE TRACES CENTRE

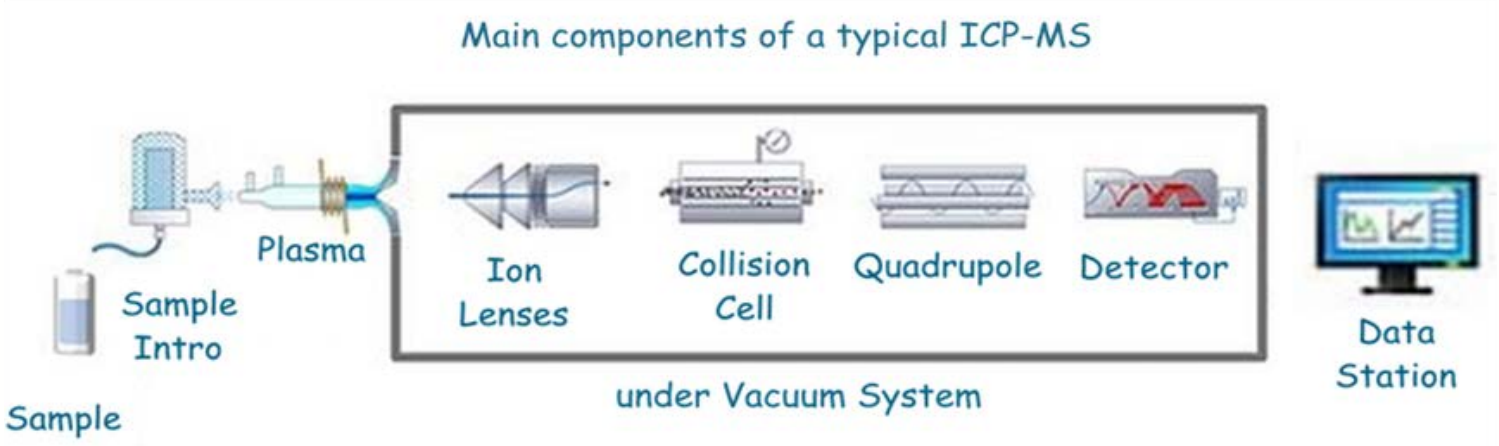
INSTRUMENT FEATURE: ICP-MS

WHAT IS ICP-MS?

Everything around us is made of different combinations of elements. When analysts need to identify which elements something is made of, they will often use a technique called **inductively coupled plasma mass spectrometry** (ICP-MS, or ICP Mass Spec). ICP-MS is an elemental analysis technique, meaning it is used to measure elements, rather than the molecules and compounds that are measured by LC/MS and GC/MS.

ICP-MS uses an argon (Ar) plasma—the ICP—to convert the sample into ions that are then measured using a mass spectrometer—the MS. ICP-MS is similar to inductively coupled plasma optical emission spectroscopy (ICP-OES), however the ICP-OES uses an optical spectrometer to measure the light emitted from elements as they pass through the plasma, whereas ICP-MS measures the elements (ions) directly. Both techniques provide fast analysis of multiple elements in a sample, but ICP-MS provides much lower detection limits than ICP-OES, so it's a better choice for trace element analysis.

An ICP-MS instrument consists of the ion source (the ICP), a mass spectrometer (MS)—usually a scanning quadrupole mass filter, and a detector. The ICP is at atmospheric pressure, while the MS and detector operate in a vacuum chamber, so an ICP-MS also requires a vacuum pump, a vacuum interface, and some electrostatic ion "lenses" to focus the ions through the system. Modern ICP-MS systems also typically contain some device or mechanism to resolve spectral interferences. Below is an overview of the ICP-MS:



FROM THE TRACES CENTRE

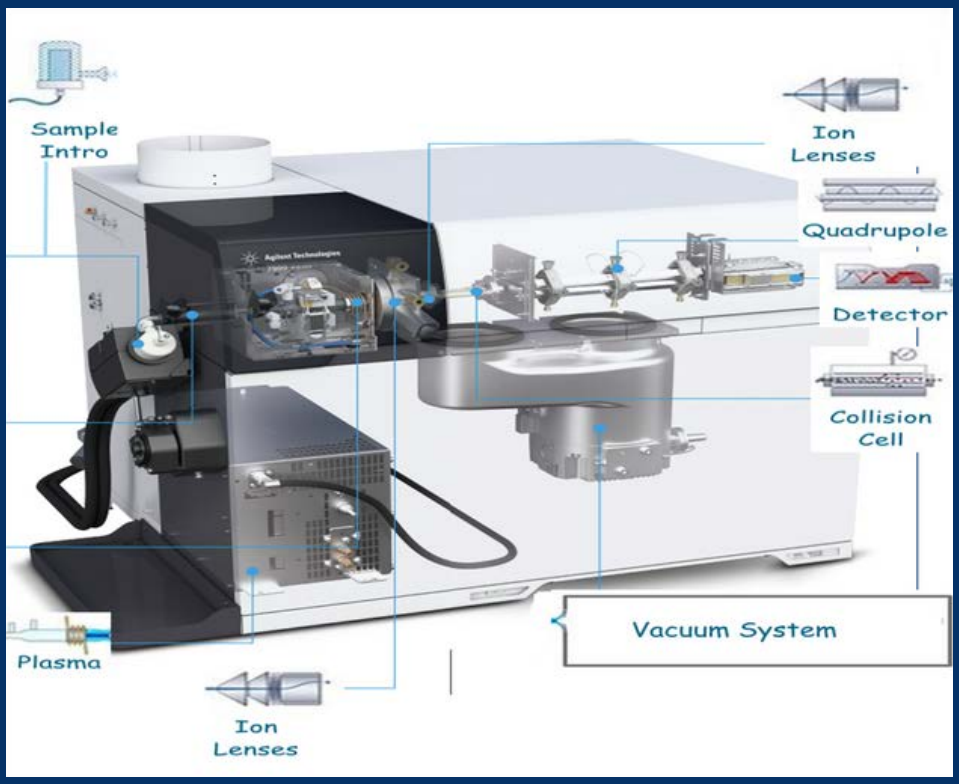
INSTRUMENT FEATURE: ICP-MS

HOW DOES AN ICP-MS WORK?

An ICP-MS instrument uses a plasma (ICP) to ionize the elements in a sample and then measures the ions using a mass spectrometer (MS).

The main components of a single quadrupole ICP-MS instrument are:

1. Sample introduction system to form a fine aerosol mist from the liquid sample.
2. Plasma (ICP) to convert the elements in the sample aerosol to ions.
3. At the interface, the ions are extracted into the vacuum system and ion lens will focus the ions and separate them from background signals.
4. Collision/reaction cell (CRC) is used to resolve the analyte ions from interfering ions.
5. Mass spectrometer quadrupole will filter the analyte ions by mass.
6. The electron multiplier detector will capture and augment the signal.
7. Data processing will occur using proprietary software.



Schematic cross-sectional view of the Agilent 7900 ICP-MS (in TRACES)

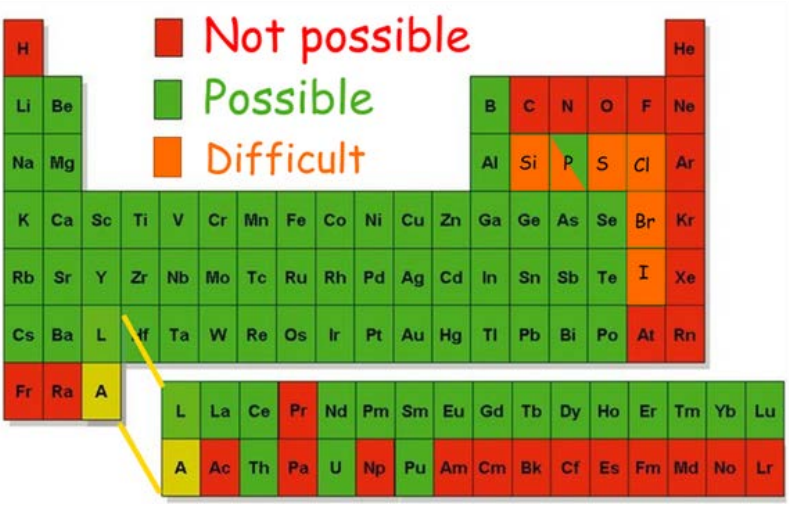
WHY USE AN ICP-MS?

ICP-MS analysis is used in practically every industry from routine environmental monitoring, consumer product testing, food, and pharmaceutical safety applications, through life science and clinical research, mining and metals analysis, geochemistry, nuclear, and petrochemicals, to measuring trace metal contaminants in high purity chemicals and materials used in semiconductor manufacturing.

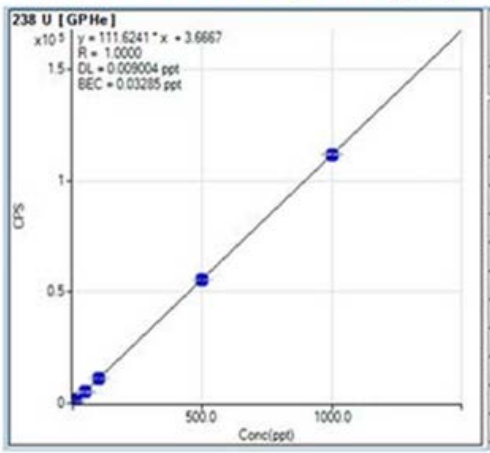
FROM THE TRACES CENTRE

INSTRUMENT FEATURE: ICP-MS

ICP-MS can measure virtually every naturally occurring element plus many non-natural “radiogenic” isotopes such as technetium, neptunium, plutonium, and americium. The only elements that ICP-MS is unable to measure are H and He (which are below the mass range of the mass spectrometer), Ar, N, and O (which are present at high level from the plasma and air), and F and Ne (which can’t be ionized in an argon plasma).



Uranium 238 Calibration Curve (0.0-1000 ng/mL)



Analyte Information (238 U [GP He])

Current Sample	Calc Conc.	CPS	Ratio	Det.	Con..
Blank	-0.003	3		P	-43

Calibration

Level	Rjct	Conc.	Calc Conc.	CPS	Ratio	Det.	RSD
1		0.000	0.000	4		P	9.1
2		0.100	0.107	16		P	15.
3		0.500	0.493	59		P	2.6
4		1.000	0.998	115		P	3.3
5		5.000	4.906	551		P	0.8
6		10.000	9.833	1101		P	2.9
7		50.000	45.715	5107		P	1.5
8		100.00	98.213	10967		P	0.3
9		500.00	497.168	55500		P	0.3
10		1000.0	1001.811	111830		P	0.7

Another reason ICP-MS is so widely used is that it provides extremely low detection limits for nearly all the elements it can measure. ICP-MS can detect many elements at levels below 0.1 part per trillion (ppt) – equivalent to one drop of water (50 uL) in 200 Olympic-sized swimming pools (500 million liters). While it can achieve low levels of detection, ICP-MS can also measure elements at concentrations up to 100s or even 1000s of parts per million (ppm). One thousand ppm is 0.1%, and the concentration range from 0.1 ppt to 0.1% covers 10 orders of magnitude. No other technique has such broad elemental coverage, low detection limits, and wide measurement range. Lastly, ICP-MS has a high sample throughput which enables multielement scans to be acquired quickly for a large number of samples in various matrices.

FROM THE TRACES CENTRE

INSTRUMENT FEATURE: ICP-MS

WHAT APPLICATIONS CAN ICP-MS BE USED FOR?

ICP-MS Drinking Water:

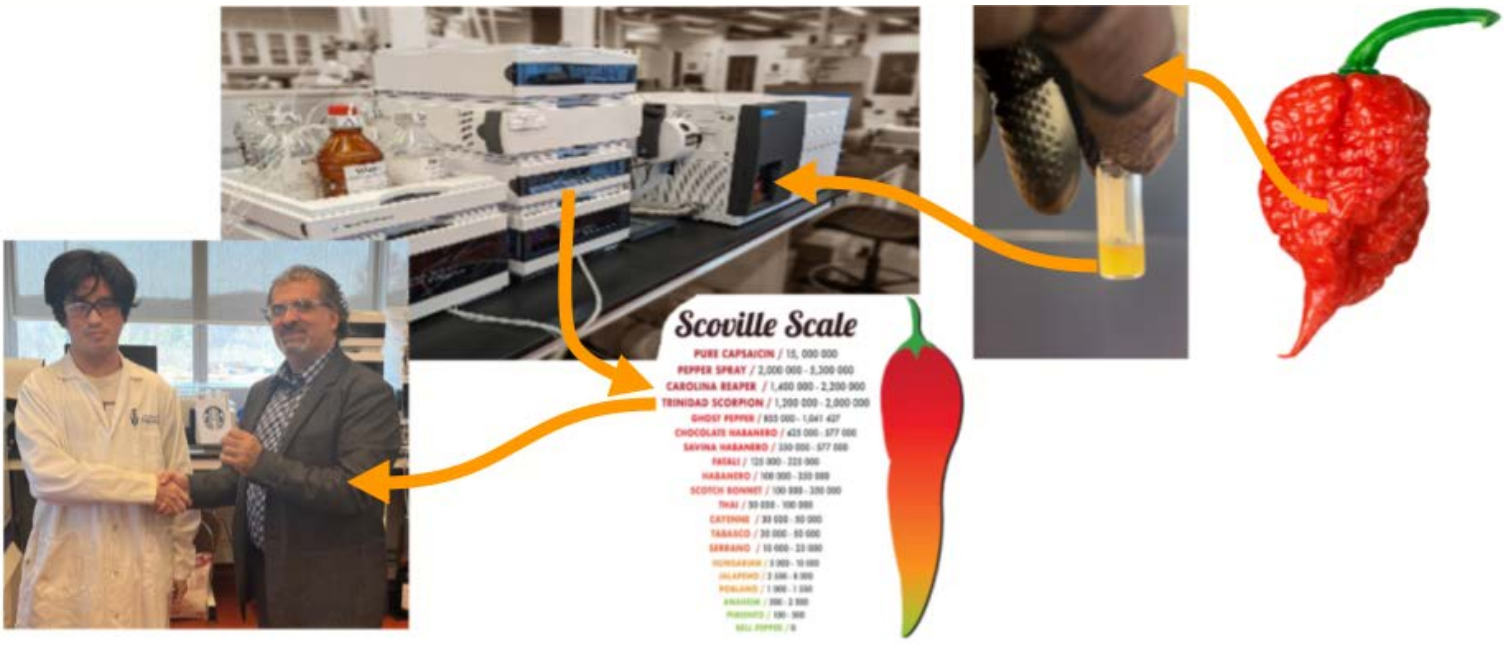
US EPA Method 200.8 is a well-established method delivered by the U.S. Environmental Protection Agency (EPA) for the analysis of ground waters, surface waters, drinking waters, and waste waters by inductively coupled plasma mass spectrometry (ICP-MS).

ICP-MS Environmental Samples:

US EPA method 6020 is a multi-element (60+ elements) determination using ICP-MS in environmental samples. The measurement of high matrix samples typical of environmental, clinical research, food, nuclear, and geological applications, can be accomplished using a High Matrix Interface (available in TRACES).

CHMC16 'Hottest' Pepper Competition

This past semester, students were invited to bring their own pepper to determine the capsaicin content aka 'hotness'. The 2023 winner is Jordan Morin's Carolina Reaper which registered a scorching 1.2 million on the Scoville Scale! Jordin was presented with a $50 Starbucks card (below). Congratulations!



DPES PROGRAMS SUMMARY

TOTAL PROGRAMS: 17

COOP PROGRAMS: 9

COMBINED DEGREE PROGRAMS: 3

CHEMISTRY

Chemistry Specialist
Chemistry Major
Biochemistry Major
Medicinal and Biological Chemistry Specialist
Environmental Chemistry Specialist
Environmental Chemistry Major

PHYSICS AND ASTROPHYSICS

Physics and Astrophysics Specialist
Physics and Astrophysics Major
Physical and Mathematical Sciences Specialist
Physical Sciences Major
Environmental Physics Specialist
Minor Program in Astronomy and Astrophysics

ENVIRONMENTAL SCIENCE

Environmental Biology Specialist
Environmental Geoscience Specialist
Environmental Science Major Environmental Science Minor
Natural Sciences and Environmental Management Minor

ENVIRONMENTAL STUDIES

Environmental Studies Major

CO-OP

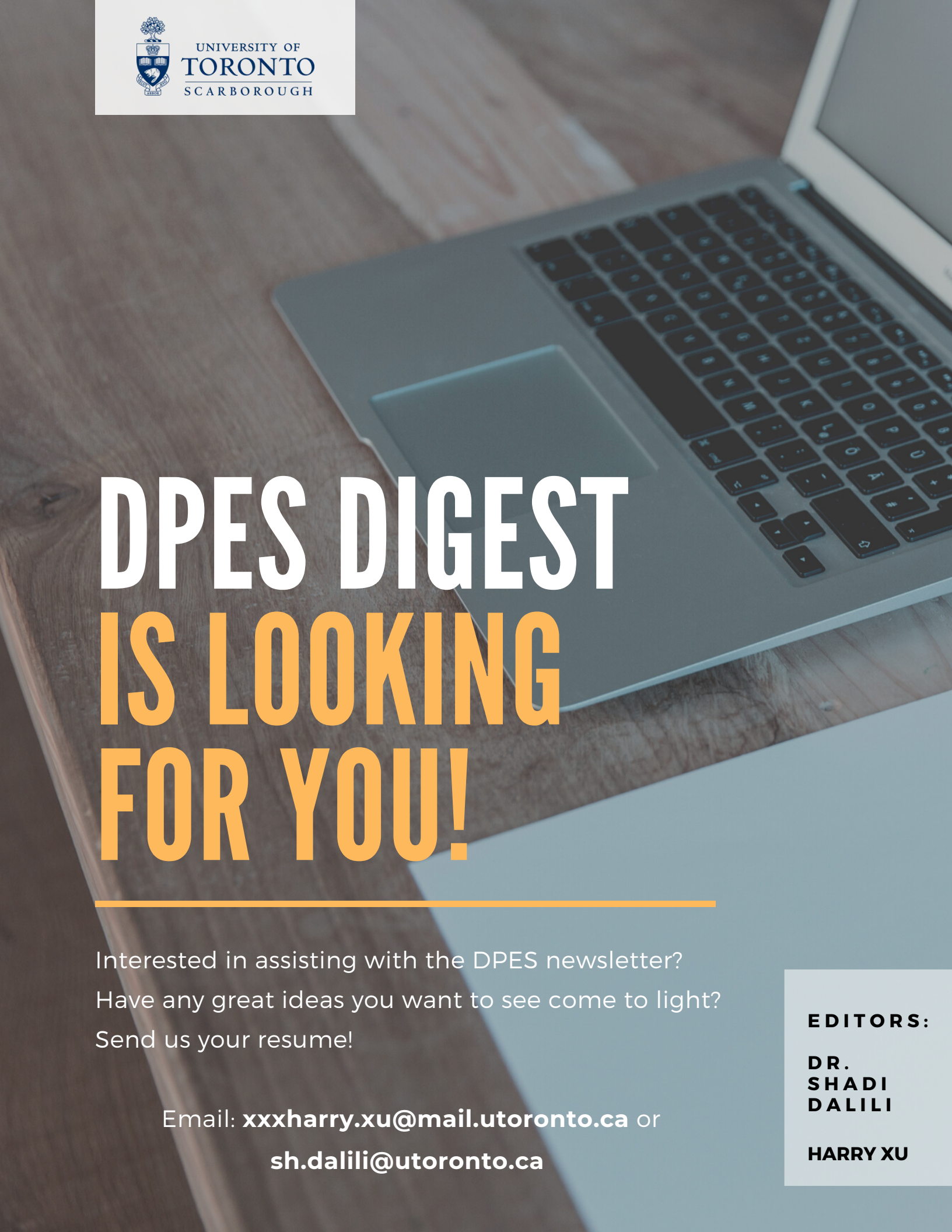
Chemistry Specialist - Coop
Chemistry Major - Coop
Biochemistry Major - Coop
Biological Chemistry Specialist – Coop
Environmental Chemistry Specialist – Coop
Environmental Biology Specialist-Coop
Environmental Geoscience Specialist-Coop
Environmental Physics Specialist- Coop
Environmental Science Major-Coop

COMBINED DEGREE PROGRAMS

HONOURS BACHELOR OF SCIENCE / MASTER OF ENGINEERING

HONOURS BACHELOR OF SCIENCE / MASTER OF ENVIRONMENTAL SCIENCE

HONOURS BACHELOR OF SCIENCE OR HONOURS BACHELOR OF ARTS / MASTER OF TEACHING



UNIVERSITY OF TORONTO SCARBOROUGH

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Interested in assisting with the DPES newsletter?
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