College of Engineering and Physical Sciences

ANNUAL REPORT 2021-22

Inspire. Develop. Achieve.

University of Guelph

Improve Life.

Contents

Acknowledgments

Publisher

College of Engineering and Physical Sciences Dean's Office

Writers

Dr. Bethany Davidson-Eng
Dr. Nicolas Déry
Alex Rodgers

Key Contributors

Dr. Leonid Brown
Dr. Richard G. Zytner
Dr. Karen Gordon

Design

Alex Rodgers

Creating impactful research for a better world

Advancing knowledge and teaching excellence

Cultivating a curious, inspired community

Welcome to the College of Engineering and Physical Sciences at the University of Guelph

Change in our world stems from inspiring the next generation, developing innovative approaches to challenges and opportunities and achieving success through excellence.

The College of Engineering and Physical Sciences (CEPS) at the University of Guelph (U of G) is home to more than 3,100 undergraduate students, nearly 600 graduate students, more than 149 full-time faculty and 80 full-time staff spanning our disciplines of chemistry, computer science, engineering, mathematics and statistics, and physics. In partnership with our stakeholders and supporters, our community is driven to improve life through exceptional research and learning.

We extend our gratitude to the faculty, staff and students who study and work in our College, as well as the extensive network of collaborators, partners, funding bodies and other University colleagues who enable our success.

U of G resides on the ancestral lands of the Attawandaron people and the treaty lands and territory of the Mississaugas of the Credit. We offer our respect to our Indigenous neighbours as we strive to strengthen our relationships with them.

Today, this land is home to many First Nations, Métis and Inuit peoples. Acknowledging this reminds us of our important connection to this land where we learn and work.

We affirm our commitment to an inclusive campus and workplace that respects, acknowledges and celebrates every member of our community.

Welcome from the CEPS dean

I am pleased to share the University of Guelph's College of Engineering and Physical Sciences 2021-22 annual report.

The theme of this year's report – inspire, develop, achieve – highlights many journeys we see at U of G, such as our students' experiences from accepting their offer through to walking on stage at graduation, or a researcher's journey from idea to discovery to outcome.

CEPS's unique approach to improving life is grounded in innovative learning, transformative research and connections with our community. Our collective drive for excellence, alongside our focus to build a better world, has resulted in U of G being one of Canada's top learning and research institutions.

Throughout this report, you'll catch a glimpse of the impact we have had in academics and research over the past year. You'll see that we have kept our focus firmly on the future and how we can make a positive difference in the lives of those around us. You will also read just a few of the many individual stories and people that are driving our shared goals forward.

Achieving that shared goal depends on the faculty, staff, students and community members within CEPS. Creating pathways for the next generation to hone their curiosity and learn through stellar academic programming is a critical mission for us. Enabling our researchers to develop new solutions to support our world during a complex time will help create a more sustainable future.

Our world has become even more reliant on digital technologies through the COVID-19 pandemic. Canada is looking to science, technology, engineering and mathematics to position us as a leading country in innovation and development. There are more opportunities now than ever for our disciplines to help solve great global challenges around health, wellness, societal advancement and much more.

We are increasingly on the leading edge of technology developments in research and industry. For example, our master's programs in artificial intelligence, cyber security and data science as well as our Centre for Advancing Responsible and Ethical AI position U of G at the forefront in technological solutions to solve societal challenges.

We are looking at ways we can grow our academic programming and research activities through expanding our engineering capacity and infrastructure to deal with today's challenges. Our computing programs drive strong interest domestically and internationally, with our computer science researchers building our technology reputation. Our mathematical and physical sciences experts command prestige globally for their research output advancing our knowledge in fundamental science and training experiences for students.

I am proud of our community for their resilience and shared values to strive for both excellence in their work, and excellence for all. I sincerely thank the community of support around us – on campus, as well as our alumni, donors, partners and government bodies – for continuing to enable our success.

Dr. Richard G. Zytner, P.Eng., FEC
Interim Dean
College of Engineering and Physical Sciences

A look at CEPS by the numbers

CEPS promotes a culture of excellence and an inclusive environment for learning, research, innovation and growth. Our priorities are centered around fostering strong academic environments and opportunities for students, research excellence and strong global impact, as well as cultivating an inviting community for all.

$20.7
Million in Competitive Research Funding

3,100+
Undergraduate Students

595
Graduate Students

13,000+
Alumni Improving Life around the World

149
Full-time Faculty

#1
in Canada for Research Dollars per Faculty Member*

*According to Infosource 2021 research rankings for the University of Guelph

Research and graduate studies

Our College's research activity strongly supports the University's position as a top-tier research institution. Last year, CEPS researchers secured the most tri-council research funding of any U of G college (>$8.7 million). Since the inception of the NSERC Alliance program in late 2019, our College's faculty members secured 29 of the University's 59 successful applications, largely contributing to the University being number one in Canada in terms of total NSERC Alliance Option 1 funding to date ($23.7 million).

Despite limited lab access and research travel, among other restrictions encountered during year two of the pandemic, we have been able to maintain an illustrious research portfolio that spans areas of national priority, from artificial intelligence and cyber security to chemical conversion of waste products and the development of clean technologies.

In September 2021, we welcomed the inaugural cohort to our Master of Data Science program, recognized by the Vector Institute for Artificial Intelligence (Vector) as preparing graduates for in-demand careers in artificial intelligence (AI). In July 2022, the University announced a $1-million gift from TD Canada Trust for the CEPS-based Centre for Advancing Responsible and Ethical Artificial Intelligence to develop training modules in ethical AI. In August 2022, engineering professor Dr. Graham Taylor was named Research Director of Vector.

As part of a 10-year plan announced in 2018, Canada's national cyber security strategy seeks to boost training and research in cyber security. Meanwhile, our Master of Cybersecurity and Threat Intelligence program continues to grow. And we will receive funding to support additional cybersecurity training programs via our participation in the National Cybersecurity Consortium, which was selected to lead the Cyber Security Innovation Network.

Our researchers continue to make significant advancements in the heterogenous fields that span our College's units. For example, our researchers are: working to transform used plastic bottles and coffee grounds into novel materials used in packing; exploring ways to reduce risk of skin cancer; and providing new insights into the origins of heavy elements found on Earth. I encourage you to read about more of the CEPS research and innovations highlighted throughout our annual report.

A big part of our research success can be attributed to our exceptional graduate students. In line with our stellar research productivity was continued growth in our graduate student numbers. Notably, as of November 2021, we had 233 PhD students. But the growth in student headcount did not come at the cost of quality: Our graduate students secured several competitive prestigious scholarships including four Vector Scholarships in Artificial Intelligence; and a good yield on NSERC awards.

As we look into the future, we will need to find creative ways to ensure our continued positive momentum. We must leverage administrative supports and adopt new technologies to better support our faculty, staff and students. We must continue to align our college's research priorities with national and provincial funding priorities. And, most of all, we must continue to foster an inclusive, positive work environment for all to realize their full potential.

Dr. Leonid Brown, Associate Dean, Research and Graduate Studies (2016-22)

#InTheField with Hannah May, 2020 | MASc Engineering, Water Resources Engineering | Photo credit: Karen Whylie

Scholarly impact and bibliometrics

Last year, faculty from CEPS published their work in peer-reviewed articles, conference proceedings, letters and reviews. In 2021, their research activity resulted in h-index scores rising – average h-index from 2017-2021 was 20 with 2021 average h-index increasing to 27.

529
Total Peer-Reviewed Papers

42,048
Total Citations

507
Average Citations Per Researcher

7
Average peer-reviewed papers per researcher

68
Conference Papers

27
Average Overall H-Index Per Faculty

Disclaimer: This data represents the total number of peer reviewed publications in 2021 and h-index from 2017-21 calendar years, by the tenure-track or tenured faculty members affiliated with CEPS, who currently have a Google Scholar profile. Note that there may be some variation in data based on data source. Publications include peer reviewed articles, proceedings, letters, meeting abstracts and reviews. Data was pulled from Google Scholar on October 17, 2022.

Most Cited Scholars

(Citations in 2021, per Google Scholar)

1. Dr. Manjusri Misra, (5,079)
2. Dr. Xiaodong Lin, (3,351)
3. Dr. Graham Taylor, (2,965)
4. Dr. Ali Dehghantanha, (2,690)
5. Dr. Animesh Dutta, (1,703)
6. Dr. Aicheng Chen, (1,659)
7. Dr. Simon Yang, (1,382)
8. Dr. Kevin Keener, (1,373)
9. Dr. Bahram Gharabaghi, (1,124)
10. Dr. Eric Poisson, (1,102)

Engineering and physical sciences technology transfer highlights

Last year, faculty from CEPS mobilized their research and discoveries to innovation outputs. In 2021-2022, there were a number of spinoff companies formed or continued, inventions disclosed and patent applications made to the University's Research Innovation Office.

5

SPINOFF COMPANIES

8

REPORTS OF INVENTIONS

8

PATENT APPLICATIONS

3

NEW PATENTS ISSUED

CEPS at the University of Guelph houses five departments and schools: the Departments of Chemistry, Mathematics and Statistics, and Physics; and the Schools of Computer Science and Engineering.

CEPS is also home to the esteemed Centre for Advancing Responsible and Ethical Artificial Intelligence and the Morwick G360 Groundwater Research Institute.

Chemistry innovations to reduce byproduct waste

Undesirable byproducts can be reduced through innovative chemistry transformations

If you have ever taken aspirin to relieve a fever or headache, then you have used a product that was developed by organic synthesis. Organic synthesis is the process of creating a substance, such as aspirin, from readily available, naturally occurring carbon-rich materials. However, undesirable byproducts are often created during the process, causing less of the desired product outcome (the aspirin) to be produced.

Within the field of organic synthesis, there has been a shift towards using transition metal catalysts, such as iridium, to create a favourable chemical reaction. These catalysts open innovative avenues for chemical functionalization – the process that can introduce new features, properties, and functionality to a molecule. For example, the functionalization of inactive carbon-hydrogen bonds.

Of particular interest in organic synthesis is the intermediate oxabenzonorbornadiene (OBD). In a multi-step chemical reaction, an intermediate is a temporary substance that is produced, but then is used up in a later step. OBD is of interest because it has multiple points of reactivity that allow for diverse functionalizations—important for creating all kinds of materials—making it a desirable and versatile starting material in organic synthesis.

However, its specific transformation depends on the preferred functionalization between different reaction sites with the resulting product being favoured over another, otherwise known as regioselectivity.

Dr. Leanne Chen (left), Assistant Professor, and Dr. William Tam, Professor
Department of Chemistry

Currently, the regioselectivity of OBD functionalizations are not fully understood. Further understanding is needed to optimize production of the target molecule (the aspirin), over other less desirable byproducts. These initial studies can improve our understanding of these reaction mechanisms.

U of G chemistry professors, Drs. Leanne Chen and William Tam, along with chemistry PhD student Austin Pounder, recently used density functional theory, a model used to study the structure of chemical systems such as molecules and atoms derived from quantum mechanics – looking at the behaviours of matter and light at the scale of atoms and electrons – to develop a deeper understanding of iridium-catalyzed reactions of OBD.

Their goal was to confirm the origin of regioselectivity. The team proposed a catalytic cycle that utilized iridium with a major step where the oxidization process, forming a new carbon-to-carbon bond, is reversed (reductive elimination).

Based on their analysis, Chen and Tam predicted that reductive elimination and the creation of the carbon-to-carbon bond is the origin of regioselectivity because this step is irreversible due to the energy required for converting one molecule into another. Ultimately, these findings will help reduce toxic byproducts resulting during the process and increase the output of the desired products.

"This research will impact the fields of chemistry, agriculture and medicine, which all use organic synthesis to develop important products we use everyday. Understanding the origin of regioselectivity will enable us to produce products like shampoo and plastics while reducing toxic byproducts and improving yields, resulting in a more environmentally friendly and cost-effective production process," says Tam.

This work was supported by Natural Sciences and Engineering Research Council of Canada (NSERC) Discovery Grants and an NSERC Postgraduate Scholarship – Doctoral program.

Academics in CEPS

Over the past year, our faculty and staff have continued to innovate and provide excellent learning experiences for students while navigating return to classes along with some remote delivery.

I would like to acknowledge the Department of Chemistry's lab coordinator team, comprising of Robert Reed, Kate Stuttaford, Jennifer Proulx and Dara Schaefer, who received the University's Exemplary Team Recognition Award for their efforts to provide exceptional learning experience for students taking chemistry courses.

In 2021, Dr. Nagham Mohammad in the Department of Mathematics and Statistics received the Distinguished Professor Award for Excellence in Teaching from the University of Guelph Faculty Association, given for excellent contribution towards teaching and learning. Dr. Matt Demers, also from mathematics and statistics, received the Guelph Engineering Society's Professor of the Year Award, voted by student society members.

Our innovative, talented undergraduate students continued to demonstrate their innovation and how they will help shape our world with initiatives on and off campus. Last November, the University of Guelph co-hosted a Leadathon with the University of Waterloo, a national competition encouraging students to try and solve complex global challenges.

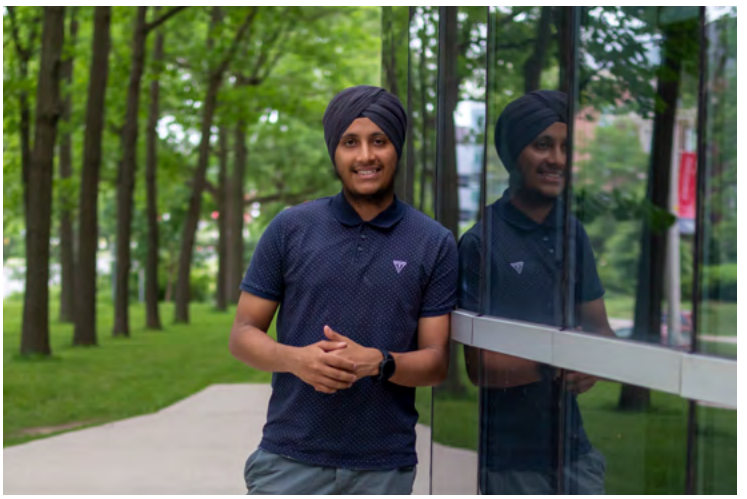
In May, a group of students held a hands-on computing initiative for their peers and launched GryphHacks, formed under the Guelph Coding Community. Off-campus, just one of many efforts included U of G students participating in the Canadian International Rover Challenge and participate with a rover they built for this year's competition in Alberta.

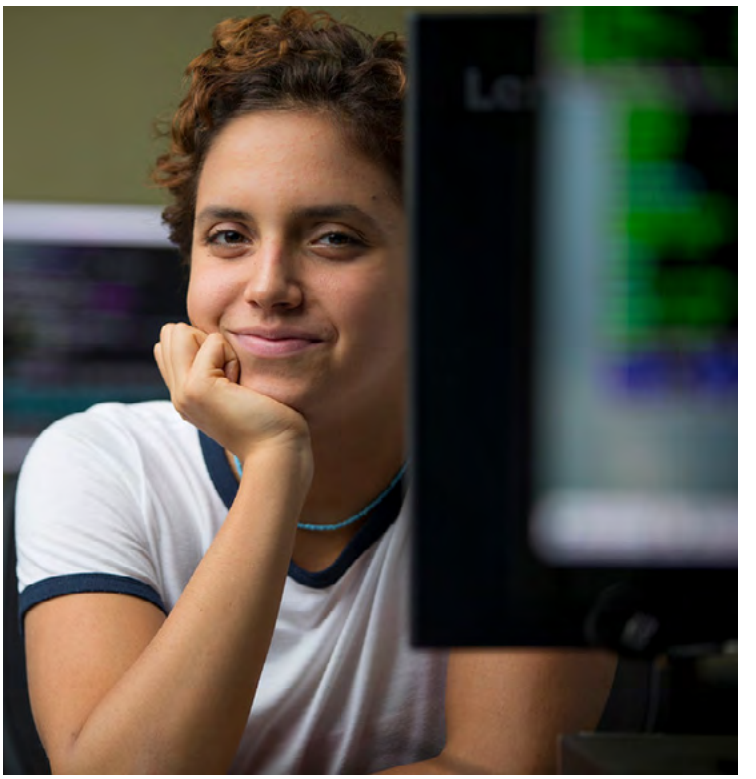
Demand for programs in the College of Engineering and Physical Sciences were strong last year, with application numbers at the University of Guelph largely paralleling Ontario provincial application numbers to computing and engineering programs. Physical sciences applications were also in alignment with provincial trends, with opportunities to increase enrollment in mathematical sciences. There were increases in application numbers and confirmations across our programs.

This past summer, we used an online platform called The Quad for the third consecutive summer, which provides virtual opportunities for first-year students to engage with faculty, staff and upper year students. We have found that the peer mentorship program, where students can connect with upper-year peers, to be a particularly successful element of the platform.

In alignment with the University's priorities and opportunities to diversify our community, nearly 10 per cent of our undergraduate students were international students in 2021-22. We hope to continue this trend through targeted University recruitment initiatives.

Dr. Daniel Thomas, Acting Associate Dean Academic (2021-22), for Dr. Karen Gordon, Associate Dean Academic






Summerlee
Science Complex

Professor Lautens was bestowed the Officer of the Order of Canada in 2015 by Governor General David Johnston, an honour that recognizes outstanding achievement, dedication to the community and service to the country. One unexpected bonus of this honour was the opportunity to preside over Canadian Citizenship Ceremonies and interact with new citizens. Lautens has presided nearly 100 times since then, both in-person and virtually.

Grad's journey in academia comes full circle from first-generation student to acclaimed mentor

Dr. Mark Lautens, B.Sc. '81, D.Sc. '16

At the beginning of each first-year lecture, Lautens shows several photographs. They range in subject matter but have included scenery from international conferences he has attended, scientists he met, special meals, and even animals he's seen on hikes.

The pictures are not so important as the message he is trying to convey with each photo: Science can take you places you never thought you would get to go.

That was certainly the case for Lautens growing up. As a first-generation university student, he never imagined he would become one of the most decorated organic chemists in Canada, as well as a respected leader in graduate student experience.

Lautens had one goal going into his undergraduate university degree as someone from a modest background: "I need a job."

He hadn't planned to become a professor at all, but when he saw the intent behind the role: teaching people who were eager to learn, sharing knowledge that could help others create new knowledge, and passing on practical information – that had a high level of appeal, he says.

The revelation occurred when, as a first-year student at the U of G, he was invited to Dr. Patrick Henry's chemistry lab to see chemistry research in action. At the time, Lautens had no idea professors did research.

After the tour, Lautens realized he wanted to pursue organic chemistry and he wanted to become a professor.

One of the elements that Lautens credits to his success is mentorship and the hands-on experiences he received at U of G. He credits the daily interaction with his supervisors, Dr. Gordon Lange one summer, and Dr. Henry another, as being difference-makers.

"I would not have done so well in a massive institution where you need to be a fighter," says Lautens. "When you come from a modest background, you wait for the tide to push you. I didn't think I had any right to fight."

Lautens credits his mother for some of the decisions that guided his career, such as taking these lab research opportunities rather than higher-paying work at a steel company during summers. She even helped type up much of his PhD thesis.

With support from his professors at U of G and family at home, Lautens went on to complete his PhD at the University of Wisconsin and a postdoctoral fellowship at Harvard University, before joining the University of Toronto (U of T)'s Department of Chemistry as a faculty member in 1987.

Now, Lautens seeks to incorporate that same mentorship lens into his own research and training programs. Training and fair experiences for graduate students are at the heart of his lab operations, which also has payoffs for his own research. For example, taking on many visiting international students benefits their research outputs.

"What I remember most from my time at Guelph is how important it is for students to be properly mentored," Lautens says, noting he thinks about this all the time in structuring his lab for positive learning experiences.

His leadership as a mentor and a world-renowned chemist have been recognized nationally and internationally.

Lautens' research in fundamental organic chemistry is "driven by curiosity," and seeks to understand chemical reactions and chemical industry, ultimately reducing the environmental impact of making pharmaceuticals. In his career he has authored 420 research publications and given 450 lectures in 30 countries.

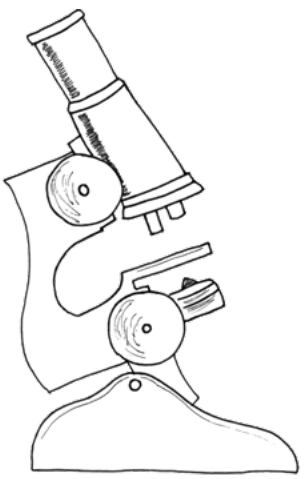
He is the J. Bryan Jones Distinguished Professor, AstraZeneca Professor of Organic Synthesis, and holds the designation of University Professor at U of T. He has also been awarded numerous international visiting professorships throughout his career.

In addition to his research and teaching work, Lautens has penned opinion editorial articles in national newspapers, advocating for increased funding for early career researchers, science-based decisions in government policy, and calling for better support for graduate students and postdoctoral fellows.

"Science is inherently competitive, which can put some students at a disadvantage if they don't have proper mentorship supports in place," Lautens says.

Lautens continues to maintain strong ties to his own beginnings at the U of G, having become lifelong friends with his mentors and respected friends of the University, such as Tony and Anne Arrell, whom he has bonded with over unexpected U of G journeys.

"Reflecting back on my life, I never realized how important people are," says Lautens. "You're going to meet many people who will impact your life, but you won't know how they will influence you until years later. People underestimate that."



Sangeet-Pal Pannu, B.Sc. Physics '19, M.Sc. Physics (in progress)

Grad student finds home at U of G improving nuclear physics research

While rooted in fiction, Bruce Banner's transformation to the infamous Hulk is relevant to Sangeet-Pal Pannu's real-life master's research in U of G's Department of Physics.

Pannu is looking at the structure of atomic nuclei to understand how protons and neutrons interact, and the resulting structures that are created. He uses an array of detectors at the Institute Laue-Langevin in Grenoble, France, where they use a technique known as neutron capture.

In neutron capture, a stable sample of material is put into a reactor. The atomic nucleus collides and merges with one or more neutrons to form a heavier nucleus at a high energy level (excitation) in a nuclear reaction. When the action decreases in energy (deexcitation), the nuclei emit gamma rays – that's where we see similarities with the Hulk. Bruce Banner was exposed to gamma rays and turned into the Hulk – but seriously, this won't happen in real life. These gamma rays can be used to determine the properties and states of the deexciting nucleus.

Pannu is studying the situations where multiple gamma rays are emitted at once to see if there is a correlation between the angle of the ray and the properties of the nuclear state. His goal is to apply the findings to configure the Institute's detector automatically, eliminating the need for human intervention.

"Sangeet is incredibly dedicated to his work," says Dr. Paul Garrett, a professor in the Department of Physics and Pannu's graduate supervisor. "He has a strong sense of obligation, giving nothing less than 100 per cent to whomever or whatever he is tasked with. He has a bright future and a prosperous career ahead."

Pannu's curiosity for discovery and creation began from a young age, though far from nuclear physics: He had a passion for drawing and painting, which carried through his high school years. He began a Landscape Architecture degree at U of G, applying his artistic skillset to land conservation and design.

While at U of G, his curiosity was piqued by a second-year physics mechanics elective, PHYS*2310, which he took out of personal interest. It was there that Pannu met Garrett and was inspired by the course content and Garrett's teaching.

"Sangeet stood out as one of the top students in that class. I knew I would offer him a place in my Nuclear Research group for the summer," said Garrett.

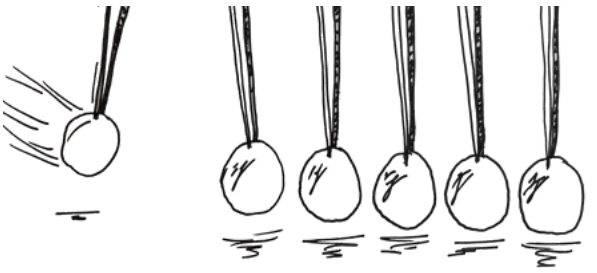
Pannu would later receive multiple NSERC Undergraduate Student Research Assistantships (USRAs) in Garrett's research group.

Pannu transferred to a Bachelor of Science majoring in Physics and continued to spend time in Garrett's research group. He then decided to pursue a Master of Science working with Garrett, and even received the prestigious Canada Graduate Scholarship-Master's in the 2021-22 competition.

"Throughout my undergraduate, and now my master's, the people and professors in the Department and College are helpful, outgoing and they go that extra mile," says Pannu. "I found that the faculty and students will always spend the extra time to engage and teach concepts that are not easy to understand."

Pannu has found a home at U of G where he is learning to solve problems, expand his thinking and be creative. While not studying or working, Pannu can be found longboarding, spending time with family or continuing his childhood love for painting.

"I plan to complete my M.Sc. and then continue on to my PhD," says Pannu. "Hopefully I can continue here because I feel like this is where I belong."



Alumni and donor impact

One of the foundational U of G communities include our alumni – those who were once present in our halls and now champion U of G's values in the world – as well as its donors – critical supports to our student success, research and training programs.

In 2021–22, CEPS alumni, partners and donors greatly contributed to the professional development of a new generation of students and the advancement of U of G research through donations, event participation, new scholarships and much more.

TD Bank Invests in Ethical Artificial Intelligence

U of G's Centre for Advancing Responsible and Ethical Artificial Intelligence (CARE-AI) received $1 million from TD Bank over five years to launch training modules targeting mid-career professionals. The modules will equip workers with judgement and data literacy skills to recognize and address ethical challenges posed by the increasing use of AI. As the world evolves and AI becomes more ubiquitous, this type of training is imperative to ensure that data-driven technologies do not unintentionally cause harm. The funding, which comes from the TD Ready Commitment initiative, was brokered thanks to CARE-AI leadership in collaboration with University Alumni Affairs and Development.

Martin Bosch Gives Big to Support Chemistry

Martin Bosch obtained his undergraduate degree in Chemistry from U of G in 1969 and, in 1971, his Master of Science. In 2004, Bosch completed his PhD in Chemistry and Biochemistry, where he successfully balanced his business career with the demands of an active laboratory-based graduate program. A former Alumni Volunteer Award winner (2006), Bosch has continuously found ways to give back to the University. Last year, he gifted $500,000 to support students' graduate studies in Chemistry. Combined with a matching contribution from a UofG fund for graduate scholarships, the funds will be used to establish two annual $20,000 awards for PhD students in U of G's Department of Chemistry, enabling the Department to recruit the brightest young minds to pursue high-calibre chemistry research.

Christina Walker Honours Late Husband via Endowed Bursary for Engineering Students

In memory of her late husband Colonel Carl Walker, U of G alum Christina Walker has provided a $100,000 gift to establish an endowed bursary for undergraduate engineering students. Both Carl and Christina are U of G graduates and Guelph was where Carl received his start in Biological Engineering, before leading a successful career as an engineer, physician and military leader in the Canadian Armed Forces. The $3,500 bursary will be given once annually to students who demonstrate financial need, and special consideration is given for students who have a connection to the Canadian Armed Forces.

Aardvark Drilling Gives $50K for new Morwick Groundwater Research Centre

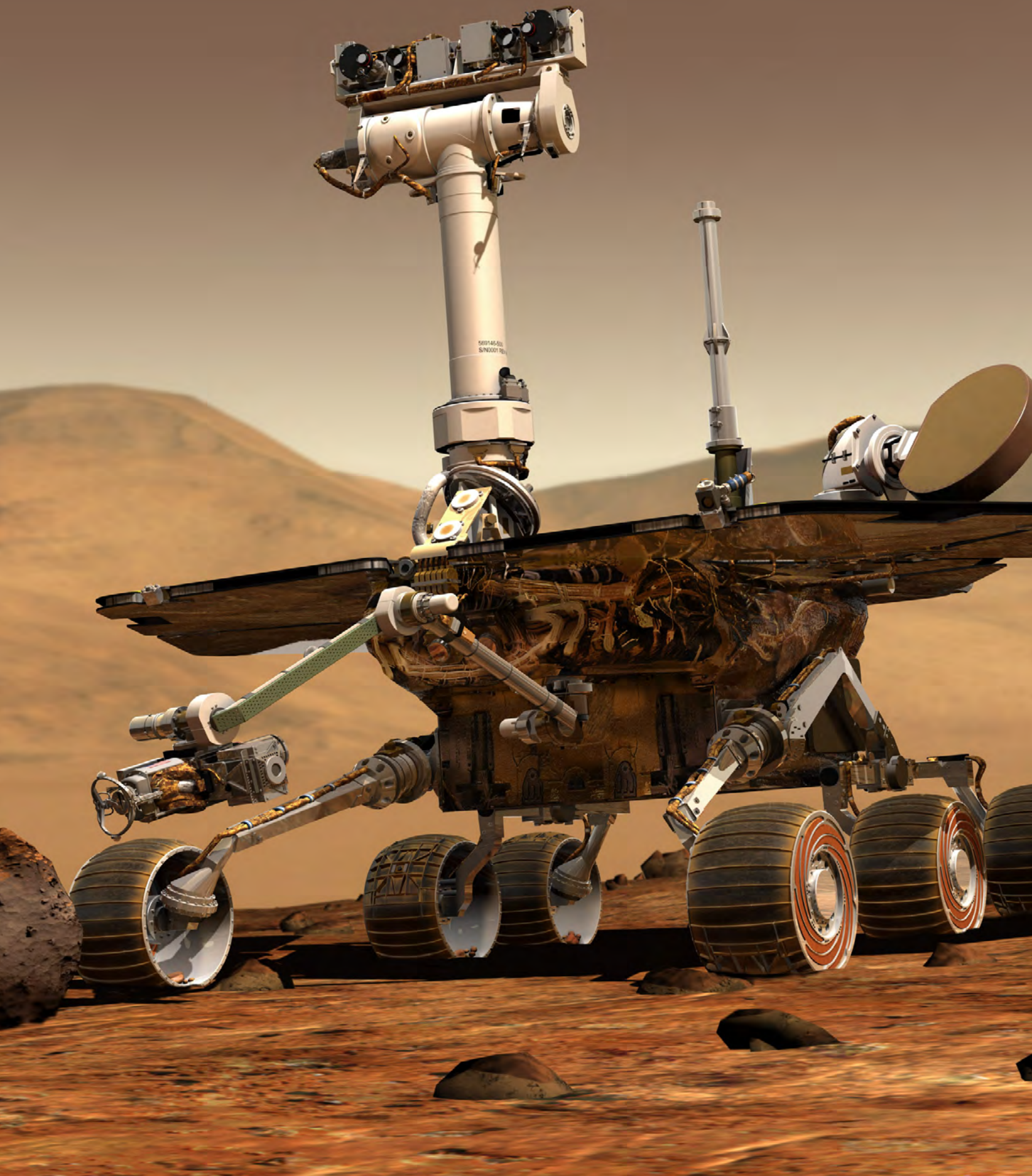
The Morwick G360 Groundwater Research Institute received $50,000 from Aardvark Drilling Inc, which is being put towards a $7 million fundraising goal for a new research, training and collaboration space. When complete, the Centre will house classrooms, a rock core library, teaching wells and technology demonstration displays, serving as a focal point and staging ground for groundwater projects and student education. Aardvark Drilling Inc. is a Guelph-based drilling contractor who has long provided quality drilling services, equipment, and expertise for many research projects.

Desire2Learn Supports Student Funding

Desire2Learn (D2L) has generously donated $50,000 to the U of G to renew a bursary for open education programs and courses, and to establish two $2,500 annual scholarships for undergraduate students in CEPS's School of Computer Science. One of the motivating factors behind the D2L scholarship was the quality of computer science majors from Guelph that the company has been hiring. D2L is a fast-growing Kitchener-based company that develops leading edge software for online learning and teaching.

The University of Guelph Gryphon welcomes attendees to Alumni & Reunion Week 2022

PHOTO CREDIT: NASA/JPL/CORNELL UNIVERSITY



Learning from the longest-active Mars Rover

Data from the Mars Exploration Rover Opportunity gives insights into a different environment on the Red Planet.

The Mars Exploration Rover Opportunity dared go where no one had gone before when it landed on the Red Planet, on January 25, 2004. Its mission: to explore the terrain and determine where water might have been present.

The aim was to determine plausibility of past life on Mars. The rover was equipped with the Alpha Particle X-Ray Spectrometer (APXS), an instrument designed at the Max-Planck-Institute for Chemistry by a team that included Dr. Ralf Gellert, U of G physics professor and lead scientist for the APXS since 2005. The APXS measures the chemical composition of surface materials found on Mars using radiation.

Gellert partnered with Dr. Scott VanBommel and collaborators to learn from the last data collected from the Opportunity rover. VanBommel completed his BSc, MSc and PhD at the U of G. He is now based at Washington University in Saint Louis and is a NASA Participating Scientist on the Mars rover, Perseverance.

The rover began exploring a crater on Mars called the "Endeavour" on August 9, 2011. Although Opportunity was only meant to survive 90 Earth days but managed to remain active for over 14 years. This makes it NASA's longest-active rover. During this time, Opportunity was the first to complete a marathon on another planet – that is 26.219 miles or 42.195 kilometers – with a finish time of roughly 11 years and two months!

Dr. Ralf Gellert
Associate Professor
Department of Physics

The team used data from the Opportunity to examine the western rim of the Endeavour crater to better understand the geological history of the area. The team assessed the geological features and compared Opportunity's observations to rocks from craters here on Earth.

The data showed two geologic formations along the Endeavour crater's rim, characterized by different types of sedimentary rocks that resulted from impact events prior to and after the formation of the Endeavour crater. The researchers also found that the amount of magnesium, calcium and chlorine on the rock surfaces hinted at the presence of salts, deposited via flowing water. Finding evidence of water could indicate that past conditions were conducive to microbial life on the Red Planet.

"By examining the data gathered from the Opportunity, we have a small window into the history of Mars," says VanBommel. "We have shown that water and salts moved through the area at one point. All of this information helps us piece together the story of the planet's paleoclimate and evolution to present day around the Endeavour crater."

This work was supported by NASA, including via the Mars Exploration Rover Participating Scientist Program and Planetary Science Research Programs. Rover operations were led by the Jet Propulsion Laboratory, California Institute of Technology, under a contract with NASA. The work at Guelph was supported by a CSA grant for the operation of the APXS on the MSL Curiosity rover.

Susan McCormick, Graduate Program Assistant to the Department of Mathematics and Statistics, CEPS

Not all heroes wear capes

Most academic units have a hidden hero who works diligently behind the scenes to provide critical support to their community. They're behind well-structured programs, they put students and faculty alike at ease, and they are a staple for their department.

The U of G has such a hidden hero in Susan McCormick, who has been with its Department of Mathematics and Statistics for decades. She joined the University in 1982 in the Department of Political Science but left to pursue a certificate in travel and tourism. She later returned in 1988 as a receptionist in Mathematics and Statistics and moved into the undergraduate secretary position. After a brief adventure in Vienna, Austria working for the United Nations, McCormick again returned to U of G in 1995 as the mathematics and statistics Graduate Program Assistant, where she has been ever since.

This year, McCormick was awarded the CEPS Staff Excellence Award, an award given to the staff member who has provided exceptional contributions towards fulfilling the College's mission and mandate.

"Susan has provided invaluable support to faculty, staff and students alike," says Dr. Anna Lawniczak, a mathematics professor. "With her friendly personality, professionalism and compassion, she has contributed to the creation of a respectful, collegial and supportive environment among graduate students and faculty."

McCormick handles all aspects of the graduate programs within the department: Application, evaluation, admissions, in-course graduate student administrative duties, awards; as well as thesis defense and graduation.

In addition to caring for the Department, McCormick is also a certified aquafit instructor and teaches at the U of G athletics centre part-time. "In my off time, I love to swim, travel, read and spend time with family," says Susan. "This year I pushed myself to even learn to tap dance and performed this past June!"

In Summer 2021, the Department launched the Master of Data Science, a professional course-based program. McCormick led the charge with the new program responding to student inquiries, assisting with visas, confirming program eligibility and managing all the incoming students through the pandemic. She took care to ensure all students were taken care of, her dedication to the students never wavering.

McCormick has stayed with the Department because of the faculty, staff and the students.

"I love working with them all," she says. "Meeting new students each year is one of my highlights. There is nothing better than getting to see them grow in their perspective fields, graduate and enter the world. Sometimes it is hard to let them go."

Some students even see McCormick as a surrogate parent who helps them get through their program while managing related or personal challenges through their degree. McCormick is often included in thesis acknowledgements for her unwavering dedication and support to students.

"She is such an integral part of our culture that we cannot imagine the Department without her," says Lawniczak.

CEPS Faculty and Staff Awards

Four additional members of the CEPS community were recognized for their outstanding efforts in teaching, research and excellence.

Dr. Leanne Chen, Department of Chemistry, Assistant Professor Research Excellence Award.

Dr. Ed McBean, School of Engineering, CEPS Graduate Supervision Award.

Dr. Stacey Scott, School of Computer Science, CEPS Undergraduate Supervision Award.

Dr. Ritu Chaturvedi, School of Computer Science, CEPS Excellence in Undergraduate Teaching Award.

Positioning STEM for next generation

In March of 2022, the Ontario government announced the first update to its science and technology curriculum in more than a decade. The revised curriculum includes a focus on science, technology, engineering and mathematics, with related learning expectations embedded through elementary school and grade nine, including coding and emerging technology.

The update reflects the province's focus on science and technology innovations to drive its economy and improve the lives of Canadians, aiming to position Ontario as an international leader in STEM.

The move also complements years-long outreach efforts in CEPS and its departments and schools, which have championed introducing engaging STEM activities to children and youth during their formative years.

"Our goal is to engage young people in STEM so they feel comfortable with these concepts before barriers begin to develop, such as drop-off rates for women entering these programs in university or self-doubt about the perceived difficulty of science-rooted disciplines," says Jean Hein, CEPS Outreach Manager.

Bringing STEM to Anishnabeg Outreach Centre

Indigenous children engaged in hands-on STEM learning as part of a free, on-site summer camp hosted in partnership with the University of Guelph through Creative Encounters with Science at the new Anishnabeg Outreach Centre in Kitchener, Ontario. Creative Encounters instructors travelled to the Centre with activities to help children learn technical and creative skills, and help students feel more comfortable with STEM concepts.

"STEM for a lot of individuals doesn't seem accessible," says Clare Reid, Creative Encounters director, talking about stereotypes in STEM. "Either you're a science kid or a math kid or an arts kid. STEM is whatever you make of it. The camp allows them to explore different career opportunities and realize they're capable of way more than they might have thought."

Giving Science an Olympian Stage

More than 700 high school students travelled to U of G campus for the first in-person high school science competition since 2019, a reflection of the competition's popularity with science teachers in the province. The event began in 2009, when it was called Science Olympics, with roughly 450 high school students, and allows Ontario youth to engage in STEM concepts and show off science skills, such as creating a spaceship that could survive a Mars landing to acting as forensic scientists. More than 100 U of G volunteers supported 30+ individual events.

"For the grade nine and 10 students, we have junior-level events that we hope will motivate students to continue to study science in grade 11 and 12," says Bonnie Lasby, Academic Program Counsellor for physical sciences programs. "For the grade 11 and 12 students, we have senior events that we hope will inspire them to pursue their interest in science at the post secondary level. The event also allows us to connect directly with high school science teachers."

500 participants in Go CODE Girl, Go ENG Girl, Pi Day and Girl Guides

6 CEPS clubs and dozens of student volunteers at College Royal

700 students attended Science Olympics 2022

Led by Creative Encounters with Science

30 familes participated in public library workshops

80+ Girl Guides of Canada welcomed to campus

22 outreach classroom visits

40 STEM summer camps across 8 weeks


CAUTION
DO NOT CREATE TRIPPING HAZARDS


TRIVIA!
CATEGORY • 1
WORD PUZZLE
CATEGORY • 2
PICTURE PUZZLE
EQUATIONS


WOMEN IN
BIRD'S
AMPER
UNIVERSITY of GUELPH

Infinite possibilities with machine learning

Refining the algorithms that train computers makes Machine Learning more accurate.

Dr. Mihai Nica
Assistant Professor
Department of Mathematics and Statistics

Behind facial recognition, driverless cars, and virtual assistants is Deep Learning—a Machine Learning technology that imitates how the human brain learns using multiple layers of networks. These networks are collections of interconnected nodes that mimic biological neurons.

The driving force behind these networks are mathematical algorithms, which draw on data to train computers and create predictive models. Training machines is an iterative process—with each iteration, the model grows more complex and more accurate—and that accuracy is driven by underlying mathematical algorithms.

To make strides towards achieving the breakthroughs Deep Learning is capable of, U of G Mathematics professor, Dr. Mihai Nica and colleagues have presented cutting-edge research on a type of neural network called Residual Neural Networks—ResNets—at the 35th Conference on Neural Information Processing Systems. ResNets are models that add extra connections between layers in Deep Neural Networks, improving accuracy and performance.

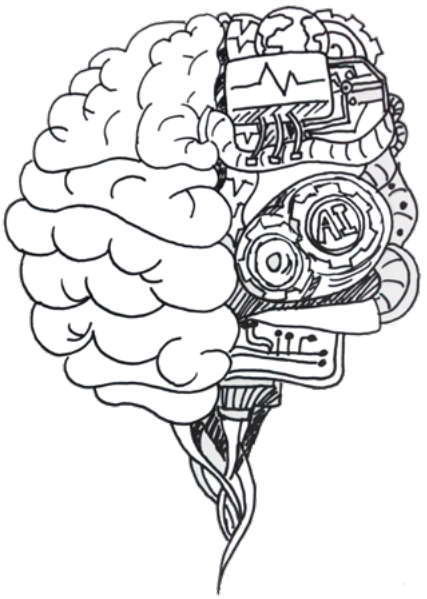
This study builds on a breakthrough in the field of Deep Learning: algorithms that allowed the width of the neural network—the number of nodes within a layer—to grow infinitely. Nica and his colleagues noticed that, while applying infinite limits to width helped improve accuracy, the depth of the network (the number of layers) was still treated as a static value. The team set out to explore what happens when both depth and width of the network are treated with infinite limits.

The team applied mathematical techniques to adjust the algorithms and found that their theory provided more accurate predictions of the network properties than the previous model that only accounted for infinite width.

In the process, their analysis also revealed that ResNets demonstrated "hypoactivation," where less than half of the artificial neurons were activated when the algorithms are initialized. To deal with this roadblock, the team developed a technique that corrects the hypoactivation.

"Our work shows that as depth increases, neural networks behave differently than the predictions of the older theory that assumes the depth is small compared to the network width" says Nica. "Despite how popular neural nets are, understanding why neural networks perform the way they do is still a huge mystery. Theoretical work like this puts us closer to understanding what is going on and hopefully unlocking even more powerful neural networks in the future."

This work was supported by a Natural Sciences and Engineering Research Council (NSERC) Discovery Grant.



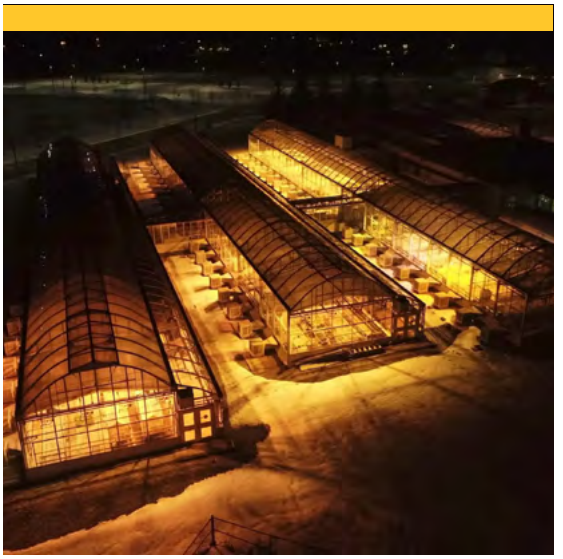
Developing solutions to support the planet

CEPS researchers are improving lives and the environment through cutting-edge research and innovation.

Airlift Pump Named One of U of G Innovations of the Year

Dr. Wael Ahmed, founder and CFO of FloNergia Inc., and his team in the School of Engineering designed an energy-efficient airlift pump for moving gas, liquid and solids using compressed air.

The innovation was a recipient of the University of Guelph's 2021 Innovation of the Year Award. The annual awards from the Office of Research and the Research Innovation Office recognize researchers for creative strategies or products that make a difference in people's lives.



U of G Project Aims to Curb Greenhouse Light Leaks

Greenhouse growers need plenty of light to nurture crop plants and flowers, but the nighttime glow from increasing numbers of glasshouses in Ontario has municipalities looking to crack down on light pollution.

Dr. William Lubitz, a professor in the School of Engineering, and graduate student Benjamin Snow, launched a pioneering drone project to help curb light leaks from commercial greenhouses, ensuring optimum plant yields for the province's ever-growing vegetable and flower production.

U of G Vaccine Candidates Listed by World Health Organization

Four novel vaccine candidates developed by Dr. Mario Monteiro, Department of Chemistry, have been recently recognized by the World Health Organization (WHO) for potential use in treating what medical experts call a "hidden pandemic."

A new WHO report lists four of his potential vaccines against bacterial infections – three in preclinical development and one in human trials – caused by C. difficile, E. coli, Campylobacter and Shigella.

Paying it forward: A biomedical engineering student's relationship with STEM and mentoring

Even as a child, Rachel Tait knew she wanted to work in healthcare when she grew up. At first, she wanted to be a veterinarian. She would play with stuffed animals and pretend she was healing them.

The interest grew as Tait progressed through school. She says that in a personality test she took in grade six, her responses reflected a focus of helping others. During high school, her interests solidified and she became set on biomedical engineering.

"I really like math and physics, but medical school isn't necessarily the path for me, so biomedical engineering seemed like the best of both worlds," says Tait. "I applied to multiple schools and, when it came down to it, the program at Guelph appealed the most to me."

She likes the structure of the Bachelor of Engineering, noting the ability to specialize in a major from first year and the interdisciplinary aspects of the program.

Tait wasn't new to the University of Guelph when she moved into campus residence for her first year in 2021. She had, in fact, many memories from her childhood that flooded back to her those first few weeks.

Tait was enrolled in Creative Encounters with Science summer camps by her parents – STEM outreach summer camps through CEPS. She says she always enjoyed attending the camps, and they were one of her first exposures to engineering and science-related activities.

"One specific memory I have of camp is making this little fan, with a toilet paper roll, a motor and a battery inside of it," says Tait with a smile. "I knew I wanted to work at Creative Encounters when I came to Guelph as a student, because I wanted to be able to give the same experience I had to new campers."

Tait applied to work at Creative Encounters during summer 2022 and became a camp instructor, helping inspire others the way she was inspired.

Tait herself is still exploring her passions in biomedical engineering. She plans to take pharmacy-related courses, and sees herself ultimately entering the medical field and developing ways of improving healthcare.

"I love design and the design elements of the program," says Tait, speaking of the interdisciplinary, hands-on focus of the University's Bachelor of Engineering. "I've learned a lot from the hands-on aspect, working with others and meeting new people."

Tait had the opportunity to apply the design process to a Creative Encounters camp program for grade two and three attendees. Preparing for the summer months, her and a partner were tasked with developing an educational camp that would run through the summer.

They developed programming for "Building Buddies," a hands-on camp with creative building challenges for campers in grades two to three. On Fridays, the camp incorporated a design day that applied engineering design process concepts to a scale that school-age children could understand. Campers used what they learned to build aluminum foil boats during the week, a challenge that Tait had been tasked with in her first year.

Tait leveraged her engineering connection, inviting professors Dr. Ryan Clemmer and Dr. Abdallah Elsayed to take campers through the design steps and have them visit a real lab as well as replicate the boat challenge for a younger age. The experience culminated when campers tested how many coins their boats could hold in water.

Having returned to school for second year, Tait will shift her focus towards exploring her interests, preparing for her first co-op placement in Summer 2023 and mentoring other incoming students.

Tait was nominated as first-year representative in 2021 for the Guelph Engineering Society, one of the major engineering student clubs on campus. For this school year, she'll be second-year representative, with a goal of helping new students get involved and meet more people.

While she plans to keep her options open during her degree, Tait continues on a path of leadership and helping others.

Rachel Tait, Biomedical Engineering (second year)


Reynolds Building

U of G research supporting people with colour blindness

Researchers are helping people who are colour blind distinguish between colours using symbols.

There are an estimated 300 million people worldwide who have colour vision deficiency (commonly known as colour blindness), a condition where certain colours cannot be detected by the human eye the way that the majority of the population can. Our society colour codes the physical world, such as medication labeling, to signify changes, categorize items, and more. This can lead to an accessibility issue for those with colour vision deficiency.

People with colour vision deficiency often find it frustrating and even dangerous when faced with a task that requires accurately identifying or distinguishing between different colour codes. To assist people with colour vision deficiency navigate our heavily colour-coded world, there has been research conducted to explore the use of inserting patterns over colours. These patterns are often unintuitive and require significant training to understand.

Colour patterns to help those with colour vision deficiency distinguish between colours

University of Guelph School of Computer Science professor Dr. David Flatla and team have developed two new colour patterns to assist people with colour vision deficiency to more easily distinguish between colours. Their first pattern, ColourIconizer, uses detailed patterns that provide a direct analogy for the colour they represent. For example, blue is represented using a water droplet and pink uses a flamingo. Their second pattern, ColourMix, assigns shapes to the colours red, yellow, green and blue. For example, red is represented as an X and green as a + (positive sign). These shapes are then combined to create additional shapes that represent new colours.

They compared their two new colour patterns to the previously published colour pattern ColourMeters, enlisting volunteers with and without colour vision deficiency for the study, via Reddit and Facebook. The evaluation contained three new colour tasks — Selection, Transition and Sorting. The Selection Task used a grid of varying colours, which an individual with colour vision deficiency could confuse for the targeted colour, and the participant had to select all the target-coloured blocks.

The Transition Task required the participant to order a set of colours to complete a gradient, for example moving from orange to yellow to green. Lastly, the Sorting Task presented a single colour that the participant needed to label with the correct colour name.

One pattern exceeded the others in terms of accuracy and performance

ColourMix, ColourIconizer and ColourMeters each had their own strengths when it came to identifying colours. ColourMix provided the best overall performance for all three tasks, whereas ColourIconizer helped the most in both the Selection and Sorting Tasks but failed to provide much assistance for the Transition Task. Importantly, ColourMeters was shown to be not as helpful as previously demonstrated in an earlier evaluation. Overall, ColourMix showed great promise as a future colour pattern option, as it combines the best aspects of both ColourIconizer and ColourMeters. Future work will aim to enhance pattern training, test the limits of patterns, test patterns in real-world settings, and further incorporate the experiences of end users.

“We observed through our study that there is indeed a clear benefit to different types of colour patterns for communicating colours,” says Flatla. “This study and future research will aim to help people with Colour Vision Deficiency distinguish and interpret colours throughout their lives in a world that is driven by colour-coding.”

Dr. David Flatla, Associate Professor
School of Computer Science

Awards and accolades September 2021 – August 2022

We celebrate and congratulate College of Engineering and Physical Sciences faculty and staff who received awards, honours, and recognitions in 2021–22, including the following:

Dr. Wael Ahmed	2021 Innovation of the Year Award from the University of Guelph
Dr. Ritu Chaturvedi	Excellence in Undergraduate Teaching Award from the College of Engineering and Physical Sciences, University of Guelph
Dr. Leanne Chen	CEPS Graduate Supervision Award from the College of Engineering and Physical Sciences, University of Guelph
Dr. Prasad Daggupati	Young Engineer of the Year Award from the Canadian Society for Bioengineering
Dr. Prasad Daggupati	Young Engineer Award from the Northeast Agricultural and Biological Engineering Conference
Dr. Ali Dehghantanha	IEEE Oustanding Leadership Award from the IEEE Technical Committee on Services Computing
Dr. Ali Dehghantanha	2022/2023 Research Excellence Award from the University of Guelph
Dr. Bob Dony	2022 Meritorious Service Award for Professional Service from Engineers Canada
Dr. Marwan Hassan	Certificate of Recognition, Outstanding Service to the PVP Division and the Fluid-Structure Interaction Technical Committee for Several Years from the American Society of Mechanical Engineers
Dr. Lei Lei	Star in Computing Networking and Communications 2021 from N²Women
Dr. Xiaodong Lin	2020 Best Paper Award for IEEE Transactions on Mobile Computing from the IEEE Computer Society
Dr. Ed McBean	2021 Excellence in Innovation in Civil Engineering Award from the Canadian Society for Civil Engineering
Dr. Ed McBean	CEPS Assistant Professor Research Excellence Award from the College of Engineering and Physical Sciences, University of Guelph
Susan McCormick	CEPS Staff Excellence Award from the College of Engineering and Physical Sciences, University of Guelph
Dr. Nagham Mohammad	2021 Distinguished Professor Award for Excellence in Teaching from the University of Guelph Faculty Association
Dr. Ramesh Rudra	Fellow of the American Society of Agricultural and Biological Engineers
Dr. Stacey Scott	CEPS Undergraduate Supervision Award from the College of Engineering and Physical Sciences, University of Guelph

Remembering Dr. Daniel Ashlock

The University of Guelph celebrates the life of professor Dr. Daniel Ashlock, chair and professor in the Department of Mathematics and Statistics, who passed away on April 5, 2022 at the age of 60 following a brief battle with cancer.

Ashlock grew up in Lawrence, Kansas and attended the California Institute of Technology for his PhD in Mathematics. He spent 13 years at Iowa State University, then joined the Department of Mathematics and Statistics at the University of Guelph in 2004 as an associate professor. Ashlock advanced to full professor in 2007 and ultimately was appointed as chair in 2021.

Ashlock's work spanned diverse research areas, including mathematics, bioinformatics, ecology and evolutionary biology and artificial intelligence, with a range of applications to help solve real-world problems and improve human wellness.

Colleagues call Ashlock's contributions to student supervision, outreach, teaching, departmental administration and research "extraordinary." He was mentor and advisor to many graduate and undergraduate students, having advised or co-advised at least 17 doctoral and 18 master's students, and dozens of Masters of Bioinformatics projects, while at the University of Guelph.

Ashlock played a pivotal role in the interdisciplinary bioinformatics programs at both Iowa State and the University of Guelph, being a founding member of the program at Iowa State. He was instrumental in the launch and success of Guelph's Ph.D. program in Bioinformatics.

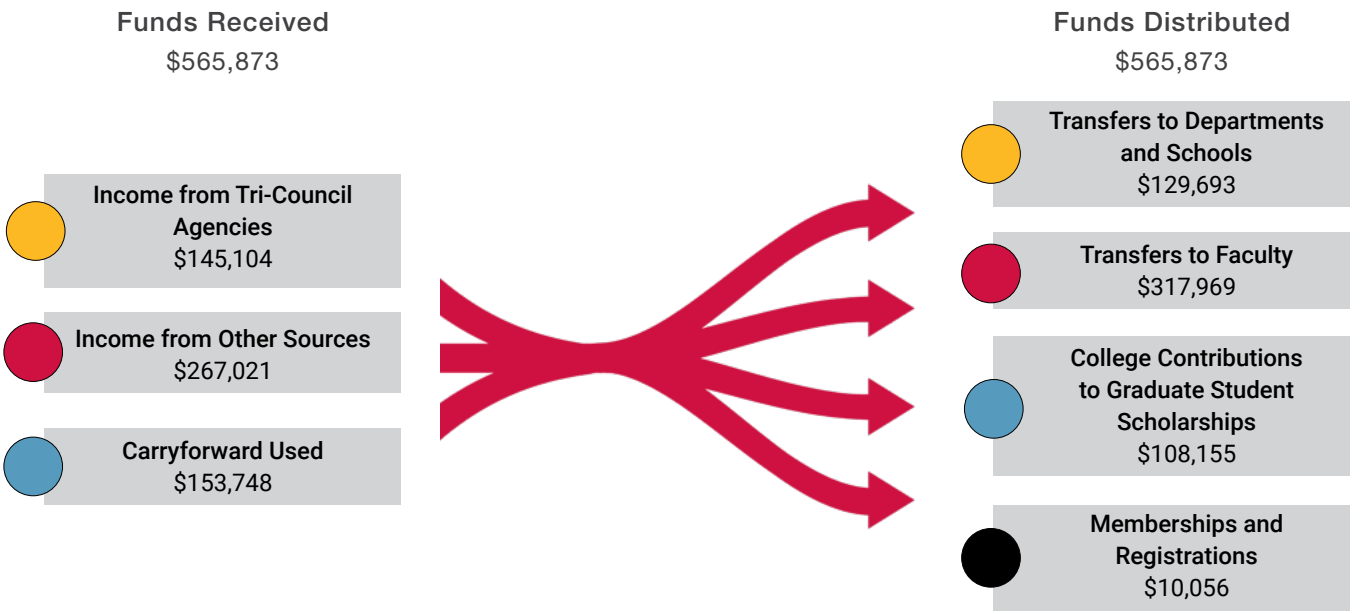
During his career, Ashlock authored more than 300 scholarly articles, as well as authoring and co-authoring several textbooks. He received numerous awards for his teaching and research commitments, including the 2019 CEPS Excellence in Undergraduate Supervision Award.

Among his formal achievements, Ashlock was an avid advocate for mathematics education and helping ease apprehensions around pursuing education in math. He participated in University of Guelph talks on the importance of mathematics, ran a blog called Occupy Math dedicated to mathematics education and outreach, as well as designed educational games.

College financials at-a-glance

The indirect costs of research recovered by the dean's office from CEPS faculty grants and research contracts were utilized to support the College's research enterprise. In 2021–22, the indirect costs of research provided to the CEPS dean's office from the University of Guelph were $565,873. The funds distributed were greater than the funds received, so the College used its carryforward to cover the balance.

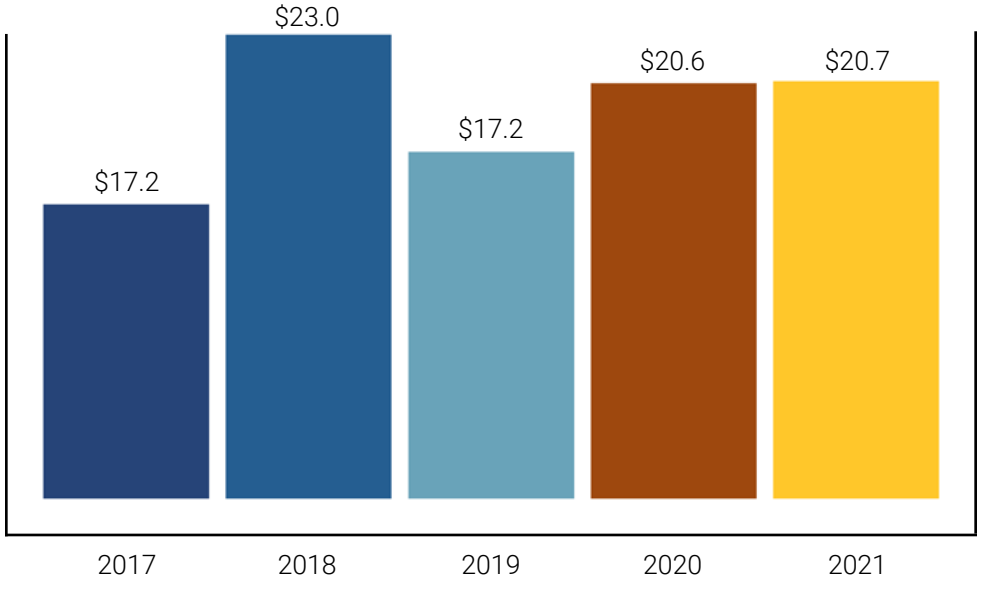
RESEARCH SUPPORT FUNDING IN CEPS



Disclaimer: The indirect costs of research recovered are calculated based on a percentage of the direct research expenses incurred in the 2020–21 fiscal year. The values distributed by CEPS represent the costs incurred by the College in the 2020–21 fiscal year.

RESEARCH FUNDING FIVE-YEAR TRENDS

2017-21 ($, Millions)



Research funding

The research funds secured by CEPS in the 2020–21 fiscal year include all research projects with start dates falling in the University's fiscal year May 1, 2020, through April 30, 2021. For ongoing projects, the funds secured include project installments with start dates in the same period. The figures represent award or installment values, without reference to when research revenues or funds were received.

1 Business and Industry **$4,211,019**

2 Federal Government Departments **$3,224,057**

3 Internal University **$368,880**

4 Natural Sciences and Engineering Research Council of Canada **$8,708,550**

5 Non-Profit & Charitable Organizations **$1,082,793**

6 Ontario Ministry of Agriculture, Food and Rural Affairs-U of G Agreement **$1,851,094**

7 Ontario Government Departments **$531,112**

8 Barrett Family Foundation **$506,250**

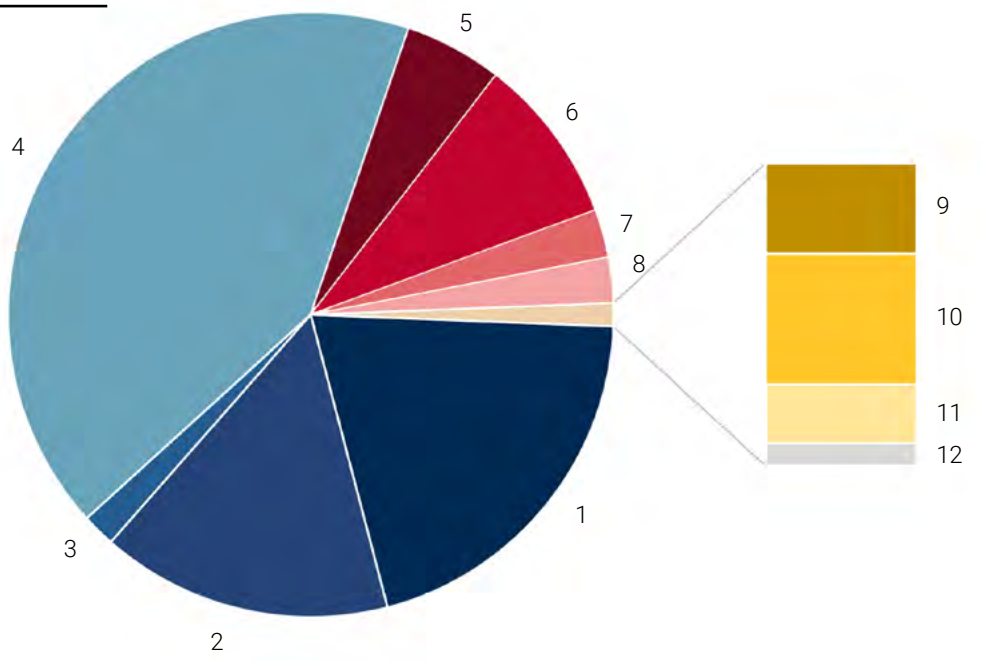
9 Canada First Research Excellence Fund **$76,500**

10 Other Provincial and Municipal Governments **$110,000**

11 Other Postsecondary **$50,000**

12 Social Sciences and Humanities Research Council of Canada **$18,808**

Total: $ 20,739,064



UNIVERSITY of GUELPH

COLLEGE of ENGINEERING AND PHYSICAL SCIENCES

Summerlee Science Complex
50 Stone Rd E., Guelph, Ontario N1G 2W1

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