Western Institute for Earth & Space Exploration

2022

Western Space is Connecting our Global Community to Develop Unique Perspectives

In collaboration with students at Nunavut Arctic College, an institute research team built and launched Western University's first CubeSat, a mini satellite that has already provided tremendous education and training opportunities and is sure to continue to provide hands-on experience for institute members and partners at all career levels in the planning and execution of space missions. Steps are underway to build an antenna, ground station, and state-of-the-art mission control at Western that will bring together people and large amounts of unique data. This has the potential for tremendous research impact related to topics like climate change, animal migration, remote health care, and so much more.

The institute also played a huge part this year in bringing the Space community together. In October, Western Space hosted the Space as a National Asset for Canada Conference (SNAC). First of its kind, this event was described by participants as unforgettable and a rare opportunity for knowledge exchange and networking among university, industry, and government stakeholders. Equally successful was the institute's annual Space Day, with thoughtful discussions on a wide range of interdisciplinary research topics of societal importance such as reducing landfill methane gas emissions. The event celebrated successful initiatives like being amongst the first to capture groundbreaking images through the James Webb Space Telescope, or the development of an integrated vision system for future rover missions on the moon.

The range of unique interdisciplinary opportunities at Western Space is sure to elevate Western's global impact through improved vision of our place in the world.

KEVIN SHOEMAKER
Associate Vice-President (Research), Western University

A Message from the Acting Vice-President of Research

Our Western Research institutes – The Bone and Joint Institute (BJI), the Institute for Earth and Space Exploration (Western Space), the Institute for Neuroscience (WIN), and the Rotman Institute of Philosophy (Rotman) – have come together to support researchers who advance excellence in interdisciplinary research. This important work complements the strong faculty-based research programs at Western, thereby amplifying research impact and elevating the university's reputation locally, nationally and globally.

Institute programs and services enable institute members to participate in research that would otherwise not be achieved through more traditional individual or team research work. With multiple mechanisms in place to identify important interdisciplinary research questions, support knowledge exchange, enhance interdisciplinary research training, and explore unique perspectives within and outside academia, our institutes have created a research environment that welcomes new ways of being, doing and thinking.

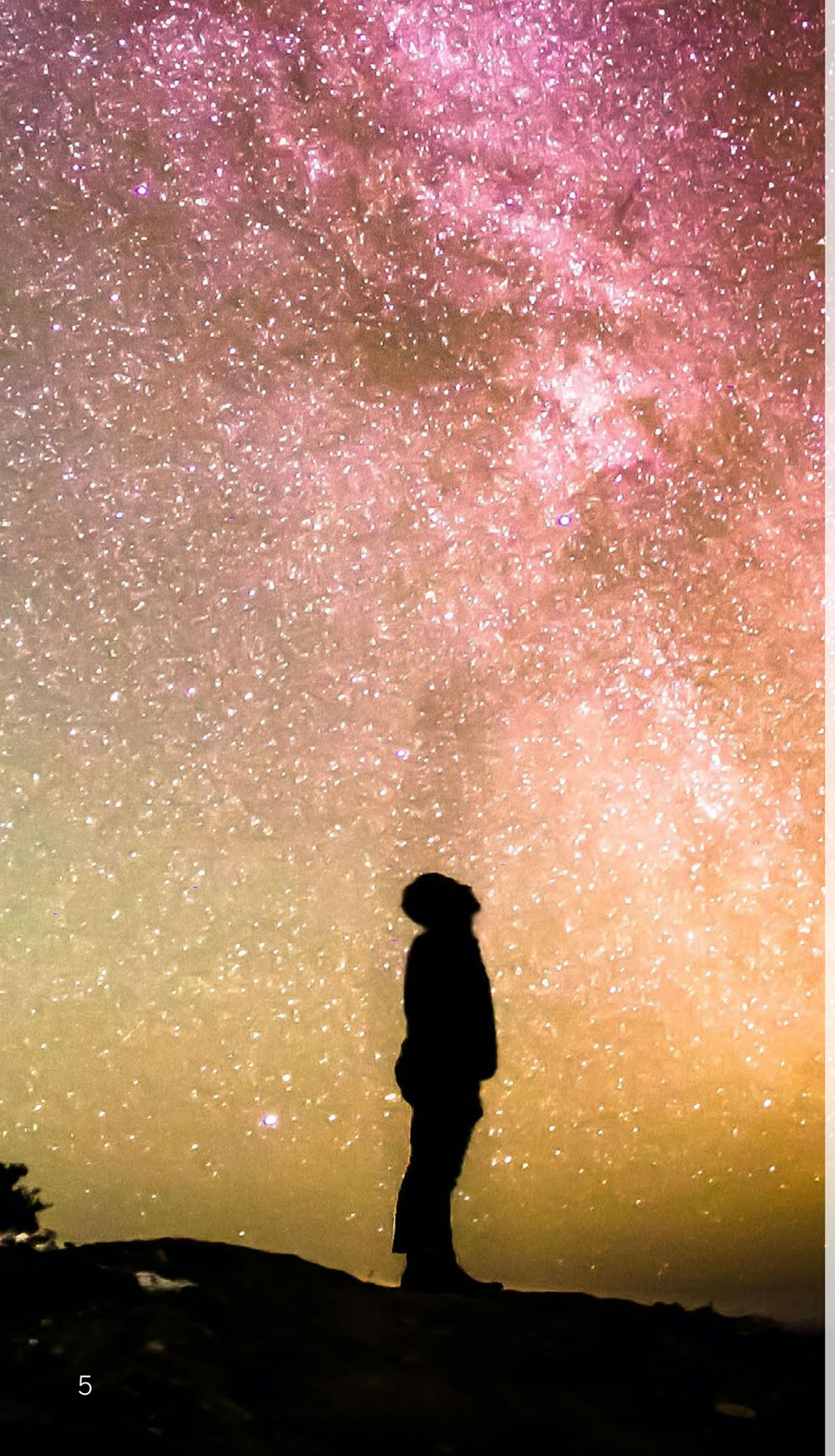
I look forward to seeing what they do next and encourage you to read the highlights from 2022 and to reach out to learn more about current activities as well as ways to get involved.

BRIAN NEFF
Acting Vice-President (Research), Western University

Institute for Earth and Space Exploration

The Institute for Earth and Space Exploration at Western University is the leading organization for Earth and space exploration research and research training in Canada.

The mission of the institute is to collaboratively address the grand challenges faced by humanity and, through research and innovation, generate solutions using space technologies and breakthroughs.



90

members total, including **41** faculty, **42** trainees, and **4** other members (partners, collaborators, and staff)

18

prestigious awards, including **8** Research Chairs, **2** Fellows of the Royal Society of Canada, **2** Distinguished University Professors, and **6** Faculty Scholars

7

faculties are represented through members: **Engineering, Health Sciences, Ivy, Law, Schulich, Science, and Social Science**

$31.6M*

in multi-year funding

648*

grants held by members, an **increase from 530 grants in 2021**

77

papers associated with the institute

13 publications are listed **among the top 10% most cited publications** in the Web of Science database

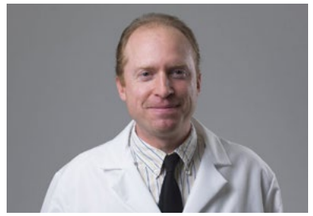
64 publications co-authored with one or more international scholars across 37 countries/regions with an average category normalized citation impact **above the world average at 1.40**

64 publications tracked **in Altmetric** with 62 gaining **638 social media mentions,** and **207** references in **news stories**

**This data does not include grants located at or shared with other institutions or institutes.*

Turning Space Rocks into Snacks

Western researchers explore how to make food out of asteroids.



JOSHUA PEARCE
Electrical and Computer Engineering,
Faculty of Engineering

Imagine the following scenario: a spacecraft docks onto an asteroid, collects some rocks, pulverizes them, and turns them into food using a 3D printer. It sounds like science fiction but could be a reality in the not-so-distant future, according to a team of researchers at Western University.

In 2022, engineering professor Joshua Pearce, Earth Science Collection Manager at the Royal Ontario Museum Ian Nicklin, and Eric Pilles, a research officer at the Institute for Earth and Space Exploration (Western Space), bumped into each other on Space Day, the institute's annual showcase.

Western Space member Pearce, who also runs the Free Appropriate Sustainability Technology (FAST) research group, shared some of his work focused on turning plastic into edible items. In his lab, plastic waste is broken down into an oily substance that certain bacteria like to snack on. The bacteria grow quickly on their oily diet and produce cells that contain about 55 percent protein. With the help of a 3D printer, these proteins can then be converted into human food. The three researchers quickly realized that Pearce's bacteria food and asteroids share surprising similarities.

"When you break down plastic...the outputs very closely match some of the carbon-containing components of an asteroid. And so, with very high confidence, I can say that we can take the same collection of different bacteria and fungi we use to decompose plastic and break down what's in asteroids. Chemically, it makes sense," says Pearce.

Turning space rocks into food could be a groundbreaking discovery to support deep space exploration where resupply missions are not an option. Astronauts could stay in space for longer and go further without ever running out of food.

As a first step in investigating the possibility of making food from asteroids, the interdisciplinary team examined already mapped asteroids and co-wrote a paper that will form the theoretical foundation for future studies.

"Our paper examines the theory of food production from asteroids," says first author Pilles. "We're using assumptions from the experimental procedures on plastic, as well as the known composition of organic-rich asteroid types, to calculate how many years one single asteroid could potentially feed one astronaut."

"With very high confidence, I can say that we can take the same collection of different bacteria and fungi we use to decompose plastic and break down what's in asteroids. Chemically, it makes sense."

However, identifying the asteroids and their potential conversion to edible protein is just one step. Another challenge will be to create a 3D food printer that is small and light enough to be fit for space travel. Luckily, Pearce was already ahead in solving this problem. Building 3D printers that are compact, easy to manufacture, and low-cost is one of his specialties.

While his lightweight 3D printers could turn food supply in space on its head, they also have the potential to break ground on Earth. From printing medical devices that improve health care in developing countries, to empowering remote communities to create their own supplies: the possibilities are endless.

With an eye on societal benefits, Pearce is an advocate for making sure the 3D technology is open-source. This would allow anyone to modify, use, improve and share a printer's design.

"I would like to see this kind of technology accessible and used by anyone. Just look at Linux. It's superior because thousands of people added their code and made it better. That's how innovation happens."

Traditional food printers, like the one in the background, are massive and expensive. Pearce's food printer would be a fraction in size, weight, and cost.

Western Heads to Space

Western's first spacecraft, a mini satellite, is on its way to the International Space Station.

JAYSHRI SABARINATHAN
Electrical and Computer Engineering,
Faculty of Engineering

It's been five years in the making, but the big day is finally here: Western's first CubeSat, a square-shaped miniature satellite the size of a rubrics cube, traveled to the International Space Station (ISS) to be launched into orbit later this summer – a major milestone for Western University.

The CubeSat named Ukpik-1 departed from the Kennedy Space Center, Florida, on June 5 as part of SpaceX CRS-28, a resupply service mission. Earth and Space Exploration Institute member and principal investigator Jayshri Sabarinathan, a professor in the department of electrical and computer engineering, is excited to see her hard work finally pay off but is also quick to point out that CubeSat has been a true team effort. The project involved a collaboration with Nunavut Arctic College, four industry partners, the Canadian Space Agency, as well as Western researchers and students across the Faculty of Engineering, the Faculty of Science, and Western Space.

If it weren't for the support of the institute, the project would have been difficult to achieve, says Sabarinathan: "Building and Launching a CubeSat is a very complicated project. From project management to grant proposals, student training, and outreach, there's absolutely no way we could have done it without help from the institute."

Western's CubeSat project started in May 2018 when the Canadian Space Agency (CSA) announced the winners of the Canadian CubeSat Project. The proposal led by Western University in partnership with Nunavut Arctic College, was one of only 15 successful proposals. The project has meanwhile produced one mini satellite (with another one on its way) and attracted $1.1 million in funding, including two CSA grants and a Western Strategic Priorities grant.

CubeSats might be small in size, but they are making a great impact at Western and beyond.

The mini satellites can play an important role in providing insights into pressing societal issues, such as climate change or nature conservation. They are relatively easy and inexpensive to design and manufacture, which means they can be deployed quickly and without the million-dollar price tag larger satellites come with.

One project already on the way will see a team of researchers led by Sabarinathan and Chris Guglielmo, director of the Centre for Animals on the Move, build a second CubeSat called the Western Skylark. Skylark is scheduled to be deployed in 2025. It will track bird migrations to understand the life cycles and threats to these animals.

Similar to a relay station, Skylark will collect data on migratory songbirds, waterbirds, and shorebirds from a ground-based network of receivers that tracks tagged birds, and then transmit that data to a ground station at Western.

"Currently, they place trackers on all these birds, and all the information goes to remote posts that are located on ground stations, and somebody has to go in person from time to time to retrieve the data," says Sabarinathan. "With Skylark, we can collect that information and relay it to our Western ground station and increase the number of remote posts that we get information from at faster intervals."

A 'CubeSat' is a cubical mini satellite measuring 10 cm X 10 cm X 10 cm and weighing only 1 kg. They can be used alone or in groups of multiple units up to a maximum of 24.

A key objective of Skylark will be to train students in building a CubeSat while learning how to operate space-based instrumentation. The project will also provide interdisciplinary training to students in engineering and science, who will develop a remote-sensing application.

Educating and training students has also been key for the CubeSat Project. So far, roughly 80 graduate and undergraduate students had the opportunity to get hands-on experience in planning and executing a space mission, while working closely with academics, government, and industry partners. Students will also be involved in operating Ukpik-1's virtual reality camera and help build and run Western's new ground station. The station is currently under construction and will enable faculty and students to communicate and receive data and photos from Ukpik-1.

Ukpik-1 is equipped with two cameras that can capture 360-degree virtual reality images. The first task of Ukpik's camera system will be to capture never-seen-before images of the International Space Station (ISS), says Sabarinathan: "When CubeSats are launched from the ISS, typically they're not allowed to turn on any of their system for 30 minutes to ensure that they don't interfere with ISS operations. We got special permission to turn on just the cameras as soon as we deploy and take images of the ISS... and transmit them back to Earth."

Ukpik-1's images have already attracted a lot of interest from the CSA, the ISS, and NASA, and are set to make a public splash. For now, Sabarinathan is busy crossing her fingers for Ukpik-1's launch into space: "It is a high-risk project, but I'm really excited. We keep our fingers crossed and we see how it goes."

Spectacular Images of Orion Nebula Reveal New Insights about Planets and Stars

ELS PEETERS
Physics and Astronomy,
Faculty of Science

If you look into the sky on a clear winter night, you might notice Orion, one of the most well-known constellations around the world. If you look closely, you might spot a fuzzy gray smudge under Orion's Belt. That smudge is the Orion Nebula, a star-forming region, located around 1,350 light-years away from Earth.

Due to its relative closeness to Earth and its similarities to the environment in which our Solar System was born, the Orion Nebula is one of the most widely studied celestial objects. On September 2022, the James Webb Space Telescope (JWST) capture never-before-seen images of the inner region of the nebula that have researchers buzzing with excitement.

"The images and the data are fantastic. I'm not exaggerating when I say that scientists can work on this data for the next ten years," says Els Peeters, an astronomer and professor at Western University.
(Continues on next page.)

Peeters is one of the principal investigators for the JWST observing program known as PDRs4All. The team, which includes researcher across the globe from 18 different countries, started the project in 2017 and waited for five long years to finally capture groundbreaking images of the Orion Nebula.

“The images and the data are fantastic. I’m not exaggerating when I say that scientists can work on this data for the next ten years,”

JWST’s images aren’t just stunning, they also hold enormous amounts of new information essential for our understanding of the formation of stars, planets, and the evolution of galaxies. The nebula was previously captured by the Hubble Space Telescope, but Hubble cannot penetrate through the massive amounts of stardust that obscure the centre of the nebula. The JWST’s infrared instruments can peer through clouds of dust and gas to reveal star-forming regions and other areas of interest to astronomers.

Of particular interest is a cluster of young massive stars called the Trapezium Cluster within the Nebula that emits intense ultraviolet radiation capable of shaping clouds of dust and gas.

“We’re especially interested in this area because by understanding how that radiation changes the environment in which the next generations of stars will form, we can get a better handle on star formation,” says Peeters. “That can help us reconstruct the solar environment out of which our own Solar System was formed. So, we might learn a bit of the history about our little piece of the universe.”

Peeters, who is also a member of the Institute for Earth and Space Exploration (Western Space), says that while the institute wasn’t directly involved in the initiation of PDRs4All program, a $30,000 catalyst grant she received from the institute in 2020 contributed to the program’s success.

The grant enabled a collaboration between astronomy, astrophysics, and chemistry at Western. Bringing these disciplines together led to novel research on polycyclic aromatic hydrocarbons (PAHs). PAHs are carbon-rich compounds abundant in space. They play a key role in processes important in forming stars and planets and galaxy evolution and are very difficult to observe. The catalyst grant helped Peeters and her team develop a theoretical framework that is essential for the interpretation of light radiated by PAHs which the JWST can detect.

Support from the institute did not stop there. It also provided summer interns, says Peeters, who were instrumental in helping to analyze the JWST’s data and in assisting with several outreach initiatives that allowed her to share her research with an international community of researchers, industry, government, and the public.

Peeters is exited to continue to learn from JWST’s data and share new information about our universe with the world: “There is so much information in those data sets. At this point, we’re just scratching the surface, and we expect many discoveries about young stars, their associated disks in which planets form, and the environment in which they are formed.”

“Western Space provides a natural way of interacting with other people to see what type of research is done at the university and where you can make links and connections.

ELS PEETERS
Physics and Astronomy,
Faculty of Science

“The Earth and Space Institute’s support allowed us to be successful to fund the next CubeSat phase. The CSA [Canadian Space Agency] was confident to give us funding because we already had infrastructure in place and the fact that CubeSat wasn’t just run by a single faculty member was important too.

JAYSHRI SABARINATHAN
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