University of Victoria
Science

ScienceMatters

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Photo: National Astronomical Observatory of Japan

Astronomy researchers instrumental in building the world's largest telescope

The summit of Mauna Kea in Hawaii is one of the world's most sought after locations for ground-based telescopic observations because of its altitude and isolation. Its height of 4,200 meters places the summit above the clouds, allowing for over 325 days a year of clear skies. Its isolation in the middle of the Pacific Ocean also cuts down light pollution, making it the best location on earth for submillimeter, infrared and optical observations.

An international team of scientists and engineers has been developing the technology for the Thirty Meter Telescope (TMT) since 2005, and University of Victoria researchers are playing a key role in its development. When finished, it will be the largest and most advanced optical telescope in the world when it comes on line in 2020. Astronomers will be able to detect and study light from the earliest stars and galaxies, analyze planets around nearby stars, and test many of the fundamental laws of physics.

"The TMT will be 200 times more powerful than the largest telescope currently in operation," says adjunct professor and Canadian TMT project scientist Dr. Luc Simard (PhD Physics 1996). "It will literally show us the birth of galaxies, stars and exoplanetary systems."

The TMT project is a partnership among the California Institute of Technology, the University of California, and the Association of Canadian Universities for Research in Astronomy (ACURA). "We currently have three main teams spanning 15 different institutions—not to mention industry—and two continents," Simard explains. "It's already a big job, and it will get bigger as our new partners—Japan, China and India—get integrated into the instrument teams and we get started on actual construction."

The telescope isn't just about the discoveries that it will help make, stresses Simard. It's also about taking astronomical instruments to the next level. "The TMT represents a change of scale for astronomers," says Simard. "We're used to building instruments that are the size of a small car. Now we're talking about instruments that are the size of a house. "

Mechanical engineer Dr. Colin Bradley (PhD Mechanical Engineering 1992) and his adaptive optics team are developing test instruments to help solve one of the key challenges facing TMT observations—turbulence from the Earth's atmosphere. The TMT will have a set of deformable mirrors that Bradley says "will basically change shape in real time to compensate for image distortions caused by the Earth's atmosphere." This will provide a finer quality of detail, and allow for the correction of blurring caused by atmospheric distortion that limits terrestrial telescopic observations. "In terms of the engineering, this is an extremely complex system. Canada is a world leader in this kind of work."

Bradley's adaptive optics technology will be shipped to the Subaru telescope, currently the world's fourth largest, in Hawaii for a one-and-a-half-year testing period.

Astronomer Kim Venn has been involved with teams that are testing instruments and technologies that will be used for equipment and observing procedures at the TMT. "These tests are necessary because the additional aperture size (30-m rather than 10-m) actually means that observing methods will need to be changed to maximize the potential of the TMT," says Venn. And that potential means the ability to see back in time, to the formation of our galaxy.

"Since light travels at a finite speed, when we look into distant space we are also looking back in time," says Venn. "The TMT will make it possible to identify and study extremely faint sources in the very distant universe, when galaxies began to form."

The TMT will be built on the summit of Mauna Kea on the Big Island of Hawaii, with construction beginning late this year.

Thirty Meter Telescope

An artist's illustration of the Thirty-Meter Telescope atop the volcanic peak of Mauna Kea in Hawaii.

The Thirty Meter Telescope will be the most powerful telescope in history. With its 30-metre diameter mirror, the TMT will have nine times the light-gathering power of the largest telescopes in use today and more than 10 times the resolution of the Hubble Space Telescope.

DEAN'S MESSAGE

Welcome to the fall edition of *Science Matters*. This September Dr. Jamie Cassels began his first term as UVic's seventh President, marking a significant changing of the guard. This marks a new era at UVic, having just passed its 50-year anniversary, and I am confident that the Faculty of Science will continue to play a huge role in the next 50 years given its commitment to research and teaching excellence.

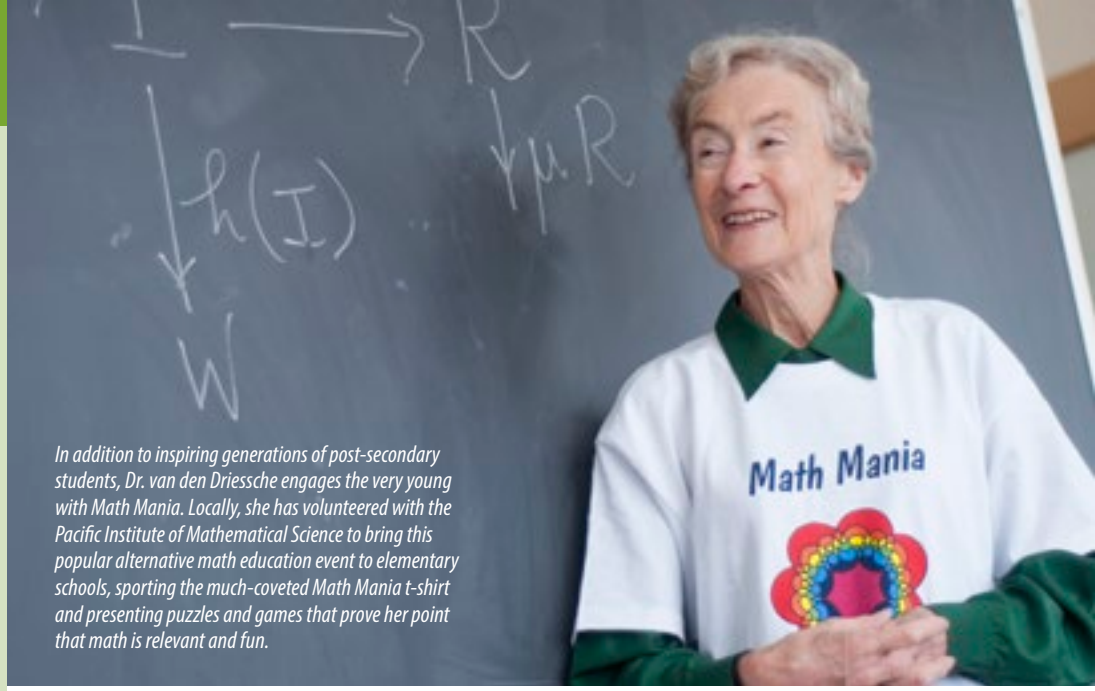
On the research front, UVic Science continues to punch above its weight, having propelled UVic into the top one per cent of universities in the world and among the top-ranked in Canada for its scientific impact and its involvement in scientific collaboration, according to the prestigious Leiden rakings. This is not surprising, considering our contributions to a wide number of fields including some described in this newsletter: cancer research, the instrumentation for the Thirty Meter Telescope – the largest telescope in history, and nanoscience using the world's most powerful microscope. This list is simply a taste of the myriad of scientific activities, which are putting UVic on the research map.

Our award-winning faculty members continue to be recognized for their contributions. Professor emerita Dr. Pauline van den Driessche, from Mathematics & Statistics, won the inaugural David. H. Turpin Gold Medal for Career Achievement in Research, while Dr. Frank van Veggel, from the Department of Chemistry, won the Craigdarroch Award for Excellence in Innovation and Entrepreneurship. A hearty congratulations to both. You can read more about them, and their work, in the following pages.

In September we continued our outreach into the community by welcoming renowned Stanford chemist, Dr. Richard Zare, to campus as our 2013 Vifor Pharma Distinguished Lecturer.

Undergraduate enrollment is up 13 per cent overall at UVic, which equates to 4,700 new students, many of those in the sciences. I know how grateful our students and faculty are for your continued and sustained support. Your role in the life of the Faculty is critical. I therefore encourage you to keep in touch, and to be involved with the Faculty of Science and the university. We welcome your feedback, and hope to see you on campus throughout the year.

Rob Lipson



In addition to inspiring generations of post-secondary students, Dr. van den Driessche engages the very young with Math Mania. Locally, she has volunteered with the Pacific Institute of Mathematical Science to bring this popular alternative math education event to elementary schools, sporting the much-coveted Math Mania t-shirt and presenting puzzles and games that prove her point that math is relevant and fun.

Mathematician recognized for career achievement

Her passion, energy and a commitment to making the world a better place for everyone has earned professor emeritus Pauline van den Driessche UVic's top research award for 2013, the David H. Turpin Gold Medal for Career Achievement in Research.

Dr. van den Driessche is an internationally recognized mathematician for her work in both mathematical biology and linear algebra. Her major impact in mathematical biology is the application of new mathematical methods to study the dynamics of epidemics. She has developed a suite of tools to analyze disease outcomes—including outbreaks, oscillating infection levels and disease extinction—as well as the impact of vaccination methods. Researchers are applying these tools to study multi-city disease dynamics, Influenza, tuberculosis, HIV/AIDS, and more recently, West Nile Virus.

Considering the devastating impact of these diseases, especially the resurgence of drug-resistant strains, van den Driessche's research is at the very forefront of bettering our global society.

She joined UVic's Department of Mathematics in 1965 as a young Assistant Professor and retired in 2006 as Professor Emerita after devoting more than 40 years to the pursuit of excellence in research and education.

In 2005, the leading linear algebra journal, *Linear Algebra and its Applications*, published a special issue honouring her lifetime accomplishments. The preface to that issue states: "Pauline has made significant contributions to the study of non-negative matrices, matrix factorization, matrix stability, perturbation theory, max algebra and M-matrices."

While many may not fully—or even partially—understand these areas of mathematics, it's important to recognize that a significant contribution to just one area deserves commendation, let alone six. Moreover, this appraisal of her "lifetime accomplishments" was based on 145 published papers. In the eight years since then, she has published an additional 70 papers. Altogether, her work has been cited more than 1600 times by more than 1000 authors. And just this year, she was elected a Fellow of SIAM, the Society for Industrial and Applied Mathematics.

"Not only is Pauline's work useful, it involves beautiful and challenging analysis. In this she exemplifies the ideal applied mathematician—her work is significant in both mathematical and scientific circles," notes Dr. Mark Lewis, Canada Research Chair in Mathematical Biology at the University of Alberta, who himself was taught by van den Driessche during his undergraduate studies at UVic, and has collaborated with her as a researcher since 1987.

"Her work in the combinatorial algebra and specially in the matrix algebra has been fundamental," says Dr. Jianhong Wu, York University's Canada Research Chair in Industrial and Applied Mathematics. "Some of her results in this area have become standard tools in the stability analysis of dynamical systems, and have been applied to a number of problems in neural networks, ecological systems and infectious diseases."

Her contributions to mathematics have not gone unnoticed. She has earned national and international prizes, including, in 2007, the Krieger-Nelson Prize from the Canadian Mathematical Society and the inaugural Olga Taussky Todd Award by the International Congress of Industrial and Applied Mathematical Society. "This is a huge honor for an applied mathematician," notes Wu.

Her current mentoring activity to graduate students is exemplified by her unstinting service to the PIMS International Graduate Training Centre in Mathematical Biology. She has been an active participant in this centre since its inception in 2007, and continues as a great supporter and contributor, well into her retirement.

Harnessing the power of the world's most powerful microscope

On a quiet afternoon this past March, mechanical engineer Rodney Herring took an image of a cluster of gold atoms using UVic's new STEHM microscope, and produced the world's most highly magnified image. The image he took proved what he had hoped—the scanning transmission electron holography microscope (STEHM), the microscope he conceptualized 11 years before, was indeed exceeding all expectations, opening the door for scientific research that was never possible before.

The microscope's impact on the scientific community will be enormous. It will allow scientists to see images in the picometer range, which is four times better than a standard electron microscope, and two million times larger than what the human eye can see. This increased magnification will make it possible to investigate electron bonds—the electrons bonding atoms together. Researchers in physics, chemistry, biology, medicine, materials science and electronics may all see unprecedented and transformative advances in their fields because of the STEHM.

Dr. Elaine Humphrey is the manager of the Advanced Microscope Facility, housed in the Bob Wright Centre for Ocean, Earth and Atmospheric Sciences on campus. "The STEHM has all kinds of new technologies in it," says Humphrey. "For example, the STEHM's vacuum is similar to that of the moon or space, and when examining electrons, the better the vacuum, the better the resolution. A typical transmission electron microscope has 20 electromagnetic lenses to make the beam round. This one has 65." When the shape of the electron beam is made more round, the spatial resolution of the image becomes sharper.

Dr. Humphrey and Adam Schuetze, a mechanical engineering graduate student, are in the process of creating training programs for users of the microscope, and UVic graduate students are some of the first able to get their hands on it. Nima Moghimian, a master's student working in Dr. Rustom Bhiladvala's mechanical engineering lab, is going to use the microscope to look at gold and rhodium nanoparticles. Zeinab Mohammidi, also a master's student, working in Dr. Reuven Gordon's electrical and computer engineering lab, will be looking at electron vortex beams, harnessing the full pico power of the microscope.

Academics, national and international scientists and engineers are all lining up to use the microscope with businesses and governments joining the queue. Fuel cell research will see huge benefits from the STEHM, with companies such as Ballard Power Systems, as well as government organizations such as the National Research Council of Canada all collaborating with UVic scientists.

Dr. Rodney Herring works on the new scanning transmission electron holography microscope (STEHM), which is opening the door to transformative scientific research.

TAKING ON CANCER

Despite advances in care and treatment, cancer remains a feared and formidable disease. An estimated 173,000 new cases of cancer will be diagnosed in Canada this year. Based on incidence rates from the past year, nearly 40 per cent of Canadian women and 45 per cent of Canadian men will develop cancer in their lifetimes. Fortunately the prognosis is good: survival rates in Canada are improving and researchers continue to learn more about how cancer begins, and spreads.

The Faculty of Science is home to a number of distinguished researchers who are leading scientific discoveries and developing technology for the treatment and diagnosis of cancer.

Dr. Frank van Veggel in the Department of Chemistry is a true pioneer in the world of prostate cancer research, creating very small things—light-emitting nanoparticles, to be precise—that are revolutionizing how doctors can find and treat the disease.

Nanoparticles, objects on the scale of a billionth of a meter, could be the ticket to better imaging of tumors and a possible delivery system to the cancer itself. Nanoparticles are much smaller than even the smallest biological cells and they can be carried as cargo on proteins programmed to find specific organs or tumors within the body. Once in place, radiation can illuminate the location of this nanoparticle— transforming it into an effective visual marker for cancer diagnosis and treatment plans. The nanoparticles may even be engineered to carry bits of radioactive material directly in the tumor, offering highly focused radiation therapy.

This ground-breaking research has resulted in 11 patents and disclosures to date and has the potential to be leveraged as a diagnostic tool in a number of other cancers—building on this chemist's reputation as an entrepreneur bent on making the world a better place, one nanoparticle at a time.

The applications of this work extend beyond prostate cancer and the Canadian Institutes for Health Research have funded projects in his lab with similar goals related to breast and brain cancer. The use of nanoparticles is still far from the clinic, but it does emphasize how his fundamental studies link directly to important real-world applications that meet a clear health need.

In May, UVic recognized Dr. van Veggel's work with its 2013 Craigdarroch Award for Excellence in Innovation and Entrepreneurship.

Professor van Veggel illuminates a vial of erbium nanoparticles using an infrared laser. Nanoparticles could lead to better diagnosis and treatment of prostate cancer, a technology he is developing in partnership with the BC Cancer Agency.

Welcome – Dr. Kristin Morell, Geologist

The Geology department welcomes new faculty member Dr. Kristin Morell. Morell received a B.A. in Geology from Wellesley College, Massachusetts in 2004 and a PhD in geosciences from Penn State University in 2011. Since obtaining her doctorate degree, Morell has held a position as Research Fellow at the University of Melbourne. Her research specializes in the interactions between plate tectonics and Earth surface processes, which she uses to explore the growth and erosion of active mountain belts. This research has focused on a number of tectonically active areas across the globe, including Costa Rica, Panama, Taiwan, the Indian Himalaya, and East Timor.

"I am delighted to join the faculty in the School of Earth and Ocean Sciences, and am looking forward to the many new opportunities ahead."

Stephen Johnston, Director, School of Earth & Ocean Sciences, says of Morell: "She's a geologist who, through her research in Central America, the Himalaya and the Indonesian archipelago, has made fundamental contributions to our understanding of earthquake cycles, seismic risks, and the topographic evolution of mountain belts."

Welcome to campus, Dr. Morell!

Alumni Going Places:

Nathan West's (PhD Microbiology 2013) dissertation on breast cancer research, along with his 9.0 grade point average, earned him the Governor General's gold medal this spring, given annually to the top PhD student. West is now working at the University of Oxford in the experimental medicine division at John Radcliffe Hospital, focusing on research into colorectal cancer and how the immune system is involved in cancer development.

Kate Pachal (BSc Honours Physics 2011) is now a PhD student at Oxford doing research at CERN. This past March, she was one of three women at CERN selected to present on a panel about girls and women in science at the UN Economic and Social Council (ECOSOC) youth forum in New York City, opened by the UN Secretary General Ban Ki-moon. The event took place last March in New York city.

Biochemistry alumna Leigh Wicki-Stordeur (BSc 2011) was one of five UVic PhD students to receive a 2013 Vanier Canada Graduate Scholarship in September. Each scholarship is worth $50,000 per year for three years. Leigh is pursuing a neuroscience graduate degree with the Division of Medical Sciences, researching post-natal neurogenesis, which is the formation of new neurons from pools of existing neural stem cells in the brain. She looks specifically at how stem cells can produce new cells and how specific ion channels can be targeted to promote brain repair, such as after a stroke.

DID YOU KNOW. . . ?

Science Venture hired 23 undergraduate student mentors to teach summer camps this year.

Almost 13,000 kids developed a deeper love of science this year thanks to the Science Venture program. In its infancy 22 years ago, the program reached about 140 kids per year. With its considerable growth since, the program enlisted 23 undergraduate student mentors from the faculties of Engineering, Science, and Education to teach summer camps this year. In addition, staff and faculty gave presentations and facility tours to inspire prospective young scientists through interactive learning.

In-school workshops make up Science Venture's largest program, followed by summer camps and afterschool and weekend events held throughout the year. Developing strong ties with communities across the Island, Science Venture is often invited to provide science outreach for groups like the Friendship Centre and the Sooke Nation. Program Director Melisa Yestrau says the next step is to increase outreach to remote communities. Thanks to a recent NSERC PromoScience grant the program reached communities as far as Burns Lake.

Biology graduate student Eric Hertz delivers a mentor event for the Junior Scientist camp at Science Venture. Campers learned about the anatomy of fish.

Giving Back

Our alumni make a difference by volunteering at events, speaking to classes, hiring co-op students or supporting scholarships. To explore how you can help change the lives of our current students, contact Jody Kitts, Development Manager, at 250-853-3245 or kittsj@uvic.ca

Planning a reunion?

The UVic Alumni Association can help by promoting your event to classmates, arranging speakers or providing door prizes. Network and keep involved by exploring the list of groups and upcoming events to find something that's right for you. www.alumni.uvic.ca/events/reunions.php

Alumni Newsletter

Science Matters is published twice yearly by the Faculty of Science to communicate the faculty's goals, strategic direction and activities in order to connect alumni with each other and the university.

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