



## Ancient earth in a drop of rain: Undergrad's research yields big results for climate science

—By Erin King

Colin Goldblatt and Lucas Kavanagh at Cadboro Bay

Photo: Rameses J. D. Souza

How much history can be found in one raindrop? According to UVic alumnus Lucas Kavanagh, raindrop imprints—the craters created when raindrops impact earth—can teach us a lot about ancient earth, evolution, and could even inform future space exploration.

With the help of his supervisor, School of Earth and Ocean Sciences Assistant Professor Colin Goldblatt, Kavanagh's Honours undergraduate research project looked at the size of craters created by raindrops as an indicator of atmospheric density. He compared raindrop imprints in present day Victoria with ancient fossilized imprints in South Africa.

"First and foremost, knowing more about the early earth atmospheric conditions gives a better picture of the world in which life first evolved and how this world stayed warm despite a fainter sun at the time," says Kavanagh. "This knowledge helps us understand how our atmosphere has evolved physically since then, through major compositional changes such as the introduction of oxygen. It also widens the scope for what we consider to be a 'habitable' world when searching for new planets outside of our solar system."

His work drew on a theory by Charles Lyell who, in 1851, suggested that raindrop speed was limited by atmospheric density—the less dense the atmosphere, the faster the raindrop and the larger the crater formed by that raindrop. With this, in 2012 a team from the University of Washington

used fossilized raindrop imprints to posit that the early earth's atmospheric density was not very different from that of today.

Kavanagh tested this theory by dropping water into a tray of sand from a point more than 12 meters up the stairway in the Bob Wright Centre, and comparing the resulting craters with those created in a similar process on the beach at Cadboro Bay as well as ancient fossilized raindrop craters. His results showed that ancient atmospheric density was, in fact, no more than ten times that of today.

His research was published in *Earth and Planetary Science Letters*, quite a feat for an undergraduate research project.

"Lucas was an obvious choice for this Honours research project," says Goldblatt. "He had taken a 200-level course on Earth System Evolution with me and was one of the top students."

Goldblatt's research program is on the evolution of the Earth's atmosphere—understanding how the climate and composition of the atmosphere have evolved together with life and geology of Earth. "Lucas's project directly complements work done by other students in the group, including projects on the amount of nitrogen in the earth's atmosphere, early earth greenhouse gasses, and the energy balance of Earth's tropics," says Goldblatt.

Kavanagh's research was made possible through funds provided by the Jamie Cassels Undergraduate Research

Awards. The awards are designed to provide support for exceptional undergraduate students who might otherwise not be able to obtain a direct research experience as a part of their undergraduate degrees. As Kavanagh puts it, "the program is an excellent way of introducing undergraduate students to research, by providing a relatively accessible source of funding."

Now an MSc student at McGill University, Kavanagh has shifted his focus from the ancient skies to the modern oceans. "I'm using records of ocean chemistry from sediment cores to examine the role of fish in controlling the cycling carbon and nutrients," he says. "While my focus has shifted slightly, my decision to do a research-based masters degree was a direct result of my undergraduate research experience at UVic and the encouragement I received from a number of professors in the School of Earth and Ocean Sciences."

A common misconception is that raindrops are shaped like teardrops. In fact, they begin spherical, but soon change shape and shatter due to air resistance. This gives us a maximum droplet size, crucial to our ability to estimate atmospheric density.



Kelsey Hemphill

## DEAN'S MESSAGE



Science has always been a flagship to integrating teaching and research, and an excellent example of this is Science Honours Fest, where some of our best and brightest undergraduate students show off graduate level research and compete for awards. This year's first-place winner, Karlee Bamford from the Department of Chemistry, took

home the \$2,000 Boehm Family Award for Excellence in Science. Congratulations Karlee!

Two long-time members of the faculty will hand in their keys this spring. Reinhardt Illner from the Mathematics and Statistics department and Terry Pearson of Biochemistry and Microbiology will officially retire this year. Please read more about their UVic careers on page 3.

Lastly I had the honour of being ratified to continue to serve as Dean of the Faculty of Science for a second term. I hope to see you on campus at some events this year, or just for a visit to say hello. Your continued and sustained support is critical to the life of the faculty and success of our students.

Rob Lipson



Fritz Boehm, Karlee Bamford and President Jamie Cassels

## Honours Fest 2015

Honours Fest keeps getting better every year. In February, 49 undergraduate honours students from across Science departments showed off their research with poster presentations, which were judged by a committee of faculty members.

President Jamie Cassels opened the awards ceremony with an impassioned speech on the importance of scientific exploration and student research. VP Academic David Castle reiterated those comments and talked about what student research means to the university. Dean of Science, Rob Lipson then handed out awards to nine students; one honourable mention from each department, and cash prizes for the top 3 research posters. Second and third place, respectively, went to Evan Kiefl from Physics and Astronomy and Janessa Li from Biochemistry and Microbiology. First place, and winner of the \$2,000 Boehm Family Award for Excellence in Science, went to Karlee Bamford, a chemistry student. Fritz Boehm, the donor for the award, was in attendance for the first time and had an opportunity to talk with Karlee and President Jamie Cassels. Fritz is huge supporter of the Faculty of Science, and we were delighted he could be with us for the event. Special thanks go to Dean's Assistant Tracy Sobotkiewicz, who was instrumental in coordinating such a fantastic event.



Eric Foxall

Photo: UVic Photo Services

# UVic student completes solution of Mandelbrot's problem

— By Julie Sloan and Rod Edwards

Benoit Mandelbrot is arguably one of the most well-known mathematicians of modern times for his discovery of what we now call the Mandelbrot set, and for “fractals,” whose beautiful images have become the hallmark of the modern mathematical fields of dynamics and chaos. Mandelbrot also did seminal work in the analysis on the problem of ‘scaling’ in language and other fields. In 1955, he published a partial solution to this problem, but it remained incomplete until very recently.

Ten years ago, Rod Edwards, now Chair of the Department of Mathematics and Statistics, along with two colleagues from McGill—Ted Perkins and Leon Glass, started working on Mandelbrot's incompletely solved problem as a side project.

Enter Eric Foxall, a graduate student in mathematics at UVic. Rod discussed the problem with Eric and asked if he could help. Eric more than helped. He produced the key piece of analysis that allowed the team to complete the solution. Not only that, Eric took it a step further and solved a more general problem than Rod and his colleagues had been aiming for. The technical result was published in the *Electronic Journal of Linear Algebra*, but the team has also shown, in a recent paper in *Nature Communications* (14 Oct. 2014), its wide applications in many fields ranging from protein folding to musical sequences. Rod explains:

“If one ranks the words in English in order of how frequently they occur, their frequency of occurrence is inversely proportional to their rank—the ‘scaling’ is  $1/\text{rank}$ . So the tenth most common word occurs about twice as often as the 20th most common word. Mandelbrot showed that a similar inverse scaling (with the inverse of some power of the rank) applies

even if a sequence of words is correlated – the word preceding ‘tolls’ is more often ‘bell’ than most other words, for example. He also realized that this same scaling phenomenon occurs for other sequences of items, where the probabilities of one thing following another can be specified – for example, the sequence of configurations a protein molecule can adopt as it undergoes folding.”

And Rod continues to explain where Eric comes in:

“Such sequences can be thought of as random walks on a network of items linked by their ‘transition probabilities.’ But not all such sequences have this inverse power (‘power law’) scaling. What has never been clear, until now, is exactly what determines whether the scaling will be power law or not, and exactly what other types of scaling can occur. Eric was able to determine (and prove!) exactly how the type of scaling depends on the structure of the network.”

As Rod puts it, “it is a rare student (or even experienced mathematician) that can do this. We were struggling with the problem. Eric worked it out, tightened it up and made it beautiful.”

Eric, who did his undergraduate degree in Engineering Physics at UBC, worked on the problem while writing his PhD thesis on Stochastic Growth Models. So what comes next for a humble young mathematician who has just made such a significant contribution to his field? Eric will head to Arizona State University in the fall to do post-doctoral research on interacting particle systems, with a long-term goal of research and teaching in the halls of academia.

# CANCER DETECTIVES: UVic research discovers a promising new way to detect lung cancer

— By Suzanne Ahearne

Based on a KnowEdge article prepared by UVic Communications and Marketing

It's good to have a fast metabolism if you're talking about maintaining a healthy body weight. But cancer cells are also fast metabolizers, which makes them more active and faster growing than healthy cells. And it's what makes them so dangerous.

But their speed also makes them vulnerable. Long before cancer cells are detectable to most screening tests, their quick-metabolizing behaviours will still give them away—if you know where to look and what to look for.

A University of Victoria research team led by chemist Fraser Hof and engineer Reuven Gordon, in partnership with Vancouver-based Biomark Diagnostics, is developing an inexpensive, non-invasive way to detect cancer with a simple urine test.

In the trial now underway, a person swallows a dose of the prescription drug Amantadine, which is a common antiviral. When the drug metabolizes in the body, it creates a molecule (or biomarker), which is excreted in urine. Cancer cells metabolize the drug faster and in a

characteristic way. If you have cancer, the levels of this metabolized marker in your urine will be higher. Clinical trials are proving that it's a reliable way to tell if someone has an increased risk of having cancer. This could save lives by diagnosing early-stage cancers before a person is symptomatic.

While lung cancer is Biomark's primary target for the discovery, other types of hidden cancers like colorectal could also be targeted. A positive reading on a urine test would be followed up with other tests to determine the location of a tumour.

"This approach is really unique," says Hof. "We aim to create a process that is fast, convenient, and cheap enough to enable trials with thousands of patients. We hope to improve decision-making prior to the elaborate scans and invasive biopsies that doctors currently use to diagnose lung cancer."

Fraser Hof is a professor in the department of Chemistry, and holds a Canada Research Chair in Supramolecular and Medicinal Chemistry.

For more information on the Hof lab: [web.uvic.ca/~fhof/](http://web.uvic.ca/~fhof/)

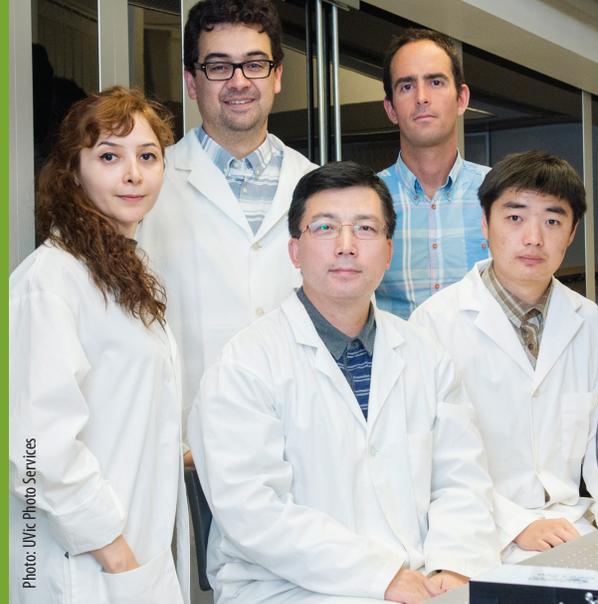


Photo: UVic Photo Services

Left to right: Ghazal Hajisalem (Gordon lab), Fraser Hof, Wei Li (Hof lab), Reuven Gordon, Guangyi Cao (Gordon lab)

## FACULTY RETIREMENTS

### Reinhardt Illner

Professor, Mathematics and Statistics

Reinhardt Illner has been a pivotal member of the Department of Mathematics and Statistics for 30 years. He came to UVic as a rising star in the field of Kinetic Theory, which models gas dynamics. Illner has made a significant contribution to this field over the course of his career, his work being used, for example, by NASA. He has been an exemplary applied mathematician, using analytic tools and sharp insight to help understand many other phenomena from traffic flow to the spread of infectious diseases. He served as department chair, mentored a host of younger colleagues, and has always been a social hub of the department. And his joke-telling skills are legendary.

### Terry W. Pearson

Professor, Biochemistry and Microbiology

Terry has been a faculty member in Biochemistry and Microbiology for 35 years where his research on African sleeping sickness has achieved international prominence. His focus is on developing diagnostics using immunological methods; most recently coupling antibodies with mass spectrometry. His spin-off company is likely to make his retirement very busy! Terry has lived and traveled extensively in Africa and continues to do collaborative research on sleeping sickness with laboratories in Europe, North America, and Africa. Terry has delighted thousands of students with his unique lectures on immunology, replete with first person accounts of the early days of molecular biology at the MRC Laboratory in Cambridge.

## Welcome—John Burke

Dr. Burke is an assistant professor in Biochemistry and Microbiology at UVic. He previously did his undergraduate degree at the University of California at Berkeley with a double major in chemistry and molecular and cellular biology. He followed this up with a PhD in Biochemistry at the University of California at San Diego in the laboratory of Dr. Edward Dennis. He was an EMBO postdoctoral fellowship at the MRC Laboratory of Molecular Biology in Cambridge, England, carrying out work characterizing the molecular basis of regulation of lipid signaling enzymes involved in cancer and immunodeficiencies.

He is currently studying the molecular mechanism of how lipid-signaling pathways are regulated, with a specific focus on their involvement in human disease. Many diseases such as cancer, inflammation, and pathogen infection are mediated by misregulation of lipid signaling. The long term objective of this research is to develop novel therapeutic strategies to target diseases mediated by this misregulation, specifically cancer, viral infection, and malaria.



## Science Co-op Student of the Year: Tesi Carmona Wagner (Biology)

Tesi Carmona Wagner has always been interested in animal behaviour and wellbeing. For her first three work terms, she ventured abroad, completing two co-op terms in Mexico researching birds in captivity and in the field, and one in Germany where she studied urban and rural blackbirds. Although she'd been primarily keen on the study of birds, Tesi rounded out her experience with a final eight-month placement as a research and animal care assistant in UVic's Neuroscience Lab under the supervision of Dr. Leigh Ann Swayne, where she managed and studied mouse colonies. Wagner's natural curiosity and enthusiasm for science and research has made her a standout employee in Swayne's lab, where she is still working. She has also undertaken many extracurricular activities related to her degree—she volunteered with the Wild Animal Rehabilitation Centre and Parks Canada and currently helps out at Rocky Point Bird Observatory. Wagner hopes to continue in academia and pursue her Master's and eventually a PhD.

# Alan Astbury Scientific Symposium

The Director General of CERN, Rolf Heuer, will give the inaugural Alan Astbury Public Lecture at 7:30 pm on **Monday, 27 April 2015**.

**Breaking the wall of the hidden universe—what the discovery of the Higgs boson tells us about Physics, Mankind and the Universe**

**Abstract:** With the start of the Large Hadron Collider (LHC) at CERN, particle physics entered a new era. The LHC will provide a deeper understanding of the universe and the insights gained could change our view of the world. This public talk will present some of the reasons for the excitement surrounding the LHC, which is expected to yield insights into the origin of mass, the nature of dark matter and into many other key questions. This lecture will address the exciting physics prospects offered by the LHC, discussing in particular the recent discovery of the Higgs-Boson, and present a look forward.

Rolf Heuer was awarded an honorary degree from UVic in 2011. In his role as Director General of CERN, arguably the most significant position in high-energy particle physics, he maintained a continuing interest in the vitality of physics in Canada and UVic. Numerous UVic physicists, graduate and undergraduate students have contributed to CERN-based projects for more than two decades. Rolf has remained a friend of the UVic particle physics group throughout his

career. When asked if he would consider speaking at an event memorializing Alan Astbury, he agreed immediately.

Rolf's visit is a fitting honour indicative of the esteem in which Alan Astbury was held as a scientist. He was a pillar of the particle physics group, of the University of Victoria, and of Canadian science. Alan joined the Department as the R.M. Pearce Chair of Physics in 1983 and served as Director of the Canadian Institute of Particle Physics from 1991-1995, as Director of the TRIUMF Laboratory from 1994-2001, and as President of the International Union of Pure and Applied Physics from 2005-2007. Alan was an exceptional scientist, a true gentleman, and a great friend to many in the Department and in the global physics community.

For more information on the symposium, go to: [uvic.ca/astbury/](http://uvic.ca/astbury/)



Alan Astbury (1934-2014)

## DISTINGUISHED ALUMNI AWARDS

Congratulations to this year's Distinguished Alumni from the Faculty of Science and the Division of Medical Sciences. Our recipients were honoured on February 4th at an awards ceremony celebrating their significant career achievements, commitment to community, and contributions to their fields.



Dean of Science Rob Lipson and Robert Beecroft

### Robert Beecroft, BSc '84 (Microbiology)

Robert is the founder and owner of ImmunoPrecise Antibodies (IPA). The Victoria-based company's staff of 16 includes 11 graduates of the Department of Biochemistry and Microbiology. IPA has completed antibody projects with top pharmaceutical companies, such as Merck, Novartis, AstraZeneca, Pfizer and Sanofi-Aventis.

Robert spent 14 years at UVic as a senior research assistant where he developed expertise in antibody production and immunoassays. To date his company has successfully made antibodies to cancer biomarkers, human pathogens, salmon pathogens, animal pathogens, as well as hundreds of other antigens.



Regional Associate Dean Bruce Wright and Dr. Tom Rimmer

### Tom Rimmer, BSc '89 (Biology/Environmental Studies)

Dr. Tom Rimmer, a graduate of UVic Biology and Environmental Studies programs, has been a family physician in Duncan since 2000, where he has gained national recognition for outstanding patient care, exemplary contributions to the health and well-being of the community and dedication to family medicine, research and teaching.

He helped launch a maternity clinic in the Cowichan District Hospital and he's a mentor for physicians transitioning into electronic medical records. Tom is also a founding board member of the Cowichan Valley Division of Family Practice Society and serves on its board.

## Giving Back

Our alumni make a difference by volunteering at events, speaking to classes, hiring co-op students or supporting scholarships. To help change the lives of our current students, you can make a donation today at [uvic.ca/givingtouvic](http://uvic.ca/givingtouvic) or by contacting the Development Coordinator, at 250-472-4210 or [devtcoor@uvic.ca](mailto:devtcoor@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. [alumni.uvic.ca/events/reunions.php](http://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. Send your story ideas and feedback to Julie Sloan at [jsloan@uvic.ca](mailto:jsloan@uvic.ca).



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