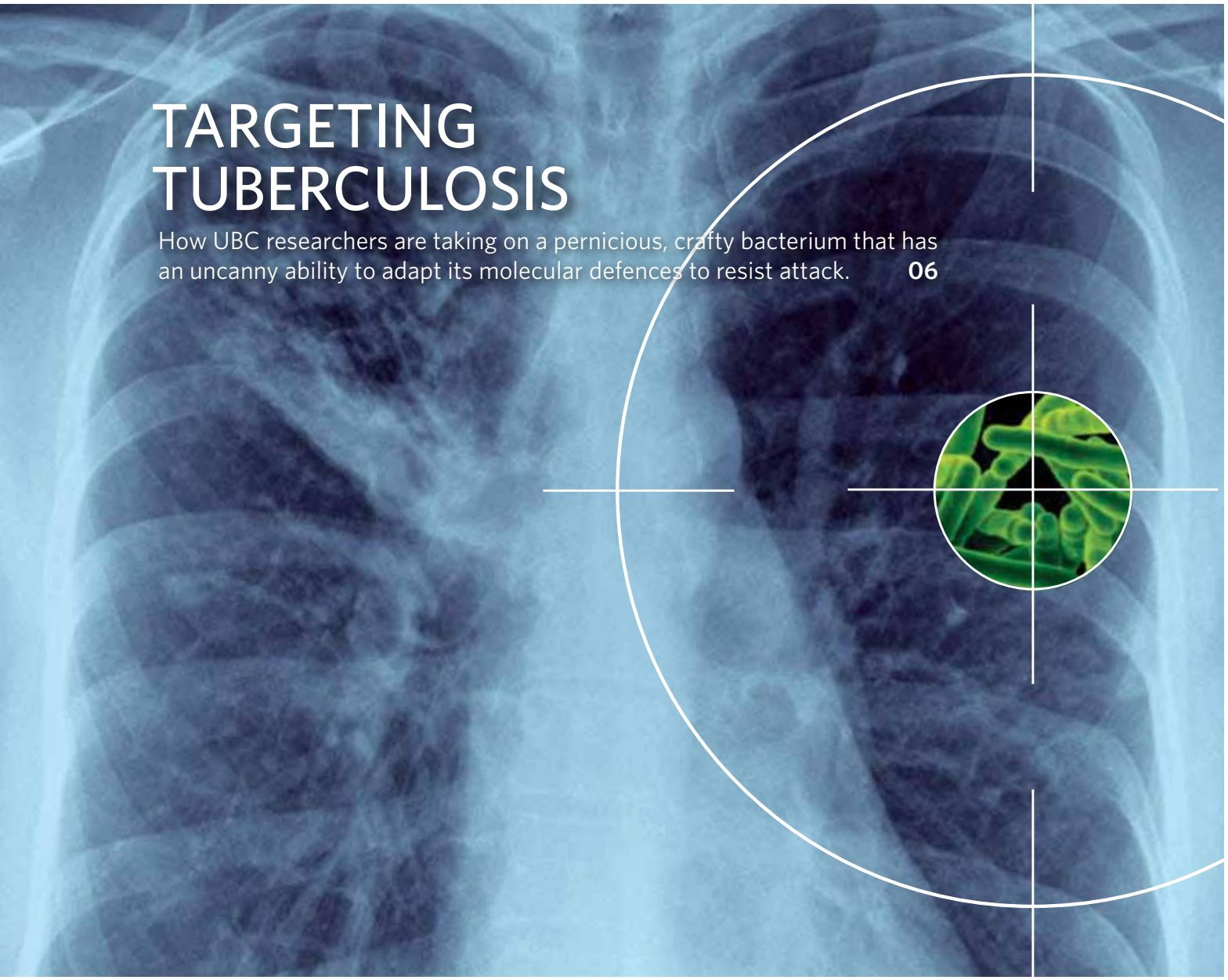
ISSUE 01/2011

SYNERGY

JOURNAL OF UBC SCIENCE



TARGETING TUBERCULOSIS

How UBC researchers are taking on a pernicious, crafty bacterium that has an uncanny ability to adapt its molecular defences to resist attack. **06**

a place of mind

THE UNIVERSITY OF BRITISH COLUMBIA

TARGETING TUBERCULOSIS

The life sciences take centre stage in this issue of Synergy. In particular, we focus on our researchers' efforts to battle tuberculosis, a re-emerging infectious disease that is having a devastating impact in developing nations, and a disproportionate impact on Canada's First Nations and other aboriginal communities and in Vancouver's own Downtown Eastside.

An exceptional team of microbiologists and immunologists with UBC's Centre for Tuberculosis Research is working with colleagues in the Faculty of Medicine and at the Centre for Drug Research and Development. They are investigating the uncanny ability of Mycobacterium tuberculosis to co-opt the body's biological mechanisms to aid its own survival, and how it might be targeted with new combinations of existing drugs.

You'll also read about a very

NEWS

'Athletic' Salmon Populations More Likely to Survive Climate Change

Individual populations of Fraser River sockeye salmon are so fine-tuned to their environment that temperature shifts caused by climate change could lead to the disappearance of some populations, while others may be less affected, according to new work by UBC zoologists.

For the study, published in Science, UBC researchers studied eight populations of adult Fraser River sockeye and found that populations with the most difficult migrations were more athletic, displaying superior swimming ability and specialized heart adaptations. They also found that the optimal water temperature for a population matched the historical river temperatures encountered by each population on its migration routes.

"This is the first large-scale study on wild fish to show how different populations of the same species have adapted to such specific migration conditions," says Erika Eliason, a PhD candidate with the Department of Zoology at UBC and lead author of the study. "As climate change alters the conditions of the Fraser River watershed, our concern is that some populations may not be able to adapt to these changes quickly enough to survive."

Eliason, who worked on this study with UBC researchers Tony Farrell and Scott Hinch, says this research is important to conservation efforts for Fraser River sockeye and may inform efforts to conserve biodiversity of fish in other watersheds worldwide.

The Fraser River, the longest river in British Columbia, is known for its large salmon runs, where typically several million sockeye salmon return to the river to spawn each year. There are more than 100 distinct populations of sockeye salmon in the Fraser River watershed, and to spawn, each population completes a unique migration route that varies in distance, elevation gain, river temperature and river flow. Sockeye salmon have been in decline since the early 1990s.

Photo: Matt Casselman (Scotch Creek spawning ground in September 2010).

imaginative outreach program facilitated by graduate students and post-doctoral fellows at UBC's Life Sciences Institute: CSI at the LSI. Leveraging the popularity of the CSI television franchise, the program invites high school science teachers to bring their classes to UBC for a day of hands-on lab experiments wrapped in murder mystery role-playing.

The goal, of course, isn't to encourage students to pursue careers as crime scene investigators. The goal is to give high school students a taste of the thrill of discovery that only field work can provide, and to encourage them to consider the wide range of opportunities presented by careers in science and technology. I'm proud to say that LSI at the CSI is just one of the university's many outreach initiatives to receive support from the Government of British Columbia's 2011 Year of Science initiative, which wraps up this summer.

And with summer in mind, I invite all our alumni to take time out over the next few months to visit the UBC Botanical Garden. The Faculty of Science is pleased to be serving as the new administrative home to the garden, and we hope that our alumni and friends will embrace this wonderful, and historic, venue.

NANO-STRUCTURES

A Better Way to Predict the Optical Properties of Nano-Structures

UBC chemists have developed a new, simplified model to predict the optical properties of non-conducting ultra-fine particles. The finding could help inform the design of tailored nano-structures, and be useful in a wide range of fields, including the remote sensing of atmospheric pollutants and the study of cosmic dust formation.

Aerosols and nano-particles play a key role in atmospheric processes as industrial pollutants, in interstellar chemistry and in drug delivery systems, and have become an increasingly important area of research. They are often complex particles made up of simpler building blocks.

Now research published this week by UBC chemists indicates that the optical properties of more complex non-conducting nano-structures can be predicted based on an understanding of the simple nano-objects that make them up. Those optical properties in turn give researchers and engineers an understanding of the particle's structure.

"Engineering complex nano-structures with particular infrared responses typically involves hugely complex calculations and is a bit hit-or-miss," says Thomas Preston, a researcher with the UBC Department of Chemistry.

"Our solution is a relatively simple model that could help guide us in more efficiently engineering nano-materials with the properties we want, and help us understand the properties of these small particles that play an important role in so many processes."

PHYSICS

New Technology Could Use Cosmic Rays to Discover Mineral Deposits

A new mineral exploration technology built on the research of UBC physicist Douglas Bryman received $1.8 million in proof-of-concept funding from Western Economic Diversification Canada this March.

The technology, muon geotomography, relies on the detection of cosmic ray particles deep within the earth to create three-dimensional "pictures" of dense ore deposits. The technology could increase the success of exploration while at the same time making it less expensive and reduce its environmental impact.

"The underground muon sensor system is able to detect and differentiate regions of high density, from which 3D images of potentially valuable ore can be created," says Bryman, the JB Warren Chair at the University of British Columbia Department of Physics and Astronomy.

The technology is being developed by Advanced Applied Physics Solutions (AAPS), a Centre of Excellence for Commercialization and Research funded under the federal Networks of Centres of Excellence program. AAPS is the commercialization partner of TRIUMF, Canada's national laboratory for nuclear and particle physics.

"Mining is a major contributor to our resource-based economy. By investing in this project, our government is ensuring that our key sectors develop the tools necessary to grow and provide highly skilled jobs for Canadians," said the Honourable Lynne Yelich, Minister of State for Western Economic Diversification, in announcing the funding.

A New Look at a Fiery, Magnetic Planet

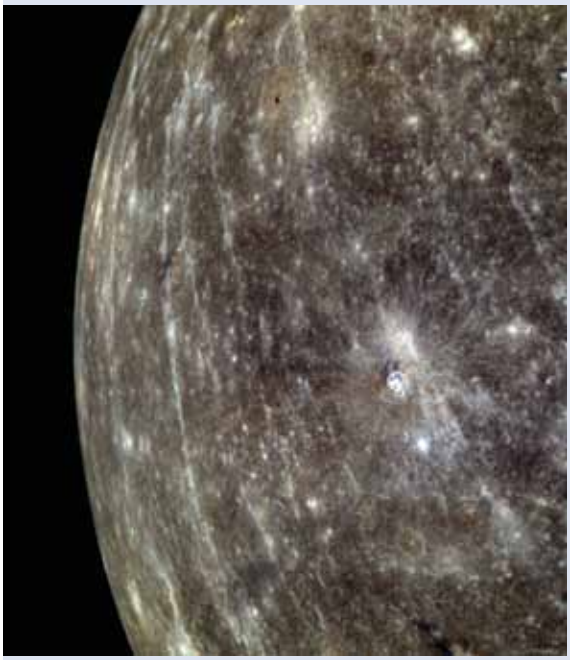


Photo: NASA/Johns Hopkins University Applied Physics Laboratory/Carnegie Institution of Washington.

UBC geophysicist Catherine Johnson is part of a NASA mission unveiling the first images of Mercury taken from the planet's orbit, and capturing new data on the tiny planet's crust, topography and geologic history.

Johnson, an expert in planetary magnetic and gravity fields, is part of NASA's MESSENGER mission's geophysics group. Along with colleagues at NASA's Goddard Space Flight Center Laboratory and the Johns Hopkins University Applied Physics Laboratory, she is analyzing the initial data collected by the spacecraft's magnetometer, which has measured Mercury's magnetic field during 10 passes near the planet since the instrument was turned on March 23.

"A team of scientists is working away on analyzing the data from MESSENGER's various instruments, all of which are now on and returning data," says Johnson. "My group at UBC is working with the magnetic field, altimetry and radio science data to try to understand the structure of Mercury's internally generated field and how it interacts with solar wind."

The spacecraft delivered its first photo of the planet in late March, after entering Mercury's orbit on March 17. MESSENGER is now in its orbital commissioning phase, during which its instruments are turned on and tested.

MESSENGER's primary mission is to collect data on the composition and structure of Mercury's crust, topography and geologic history, thin atmosphere and active magnetosphere, and makeup of core and polar materials.

"Now the focus will be on collecting results from the early data as well as getting set up for a year of data collection and analysis," says Johnson. "From what we've seen so far, it's a very dynamic environment."

"Understanding Mercury is crucial to understanding the family of inner solar system planets. The MESSENGER data will help us better understand our own planet."

EARTH SCIENCES

Oscillating 'Plug' of Magma Causes Tremors that Forecast Volcanic Eruptions

UBC geophysicists are offering a new explanation for seismic tremors accompanying volcanic eruptions—a model that could advance forecasting of explosive eruptions.

All explosive volcanic eruptions are preceded and accompanied by tremors that last from hours to weeks, and a remarkably consistent range of tremor frequencies has been observed by scientists before and during volcanic eruptions around the world.

However, the underlying mechanism for these long-lived volcanic earthquakes has never been determined. Most proposed explanations are dependent upon the shape of the volcanic conduit—the "vent" or "pipe" through which lava passes—or the gas content of the erupting magma, characteristics that vary greatly from volcano to volcano and are impossible to determine during or after volcanic activity.

"All volcanoes feature a viscous column of dense magma surrounded by a compressible and permeable sheath of magma, composed mostly of stretched gas bubbles," says lead author Mark Jellinek, an associate professor in the UBC Department of Earth and Ocean Sciences.

"In our model, we show that as the center 'plug' of dense magma rises, it simply oscillates, or 'wags,' against the cushion of gas bubbles, generating tremors at the observed frequencies."

GENOMICS

Blue Stain Fungus Evolved to Bypass Tree Defence in Pine Beetle Epidemic

The genome of the fungus that helps mountain pine beetles infect and kill lodgepole pines was decoded by UBC researchers early this year.

Also known as blue stain fungus for the stain it leaves in the wood of infected trees, Grosmannia clavigera is carried to the host trees by pine beetles and weakens the trees' natural defence system, allowing pine beetles to feed and reproduce in the tree bark. A successful beetle-fungus attack ultimately causes tree death.

Now, researchers from UBC and the BC Cancer Agency's Genome Sciences Centre have conducted a detailed genome analysis. They have identified genes in Grosmannia clavigera that are responsible for the fungus's ability to bypass the lodgepole pine's natural fungicide and use the pine as a carbon source for fungal growth.

"We found that the fungus can not only survive, but can actually thrive, when exposed to the normally fungicidal resin chemicals of pines," says co-author Joerg Bohlmann, a professor in the Michael Smith Laboratories at UBC. "In a way, it's like these genes give the fungus the ability to turn poison into nectar."

"Our study helps to clarify how the fungus has evolved to successfully infect lodgepole pine and gives us a better understanding of the intricate chemical interaction between the tree, beetle and fungus," says Bohlmann. "This new knowledge could inform strategies to prevent future outbreaks, such as selecting trees with improved resistance to pine beetles and their associated pathogens."

The current outbreak of mountain pine beetle has destroyed more than 16 million hectares of forest in BC. It has crossed the Rocky Mountains, and is now in the boreal pine forests, moving east.

MATHEMATICS

NSERC Funding Boosts UBC Math Research into Data Acquisition and Conversion

UBC mathematicians have received Natural Sciences and Engineering Research Council of Canada funding to tackle problems underlying more efficient data acquisition, conversion and processing. "Digital computers and their efficiency at processing data is one of the main driving forces behind modern technology," notes UBC mathematician and principal investigator Ozgur Yilmaz. "We're looking at some key mathematical questions around acquiring inherently analogue data like audio and images, converting them to digital and processing the data digitally for denoising and compression."

The NSERC Discovery Accelerator Supplements Program provides substantial and timely resources to outstanding researchers who have a well-established research program and are at a point in their careers where they can make, or capitalize on, a significant breakthrough. Yilmaz's work complements a multi-million-dollar project, involving researchers from the Earth and Ocean Sciences and the Computer Science departments, that is designing the next generation of seismic imaging technology.

EARTH SCIENCES

Shell GeoCanada Awards Give Students Real-World Exposure

UBC geology students Nicholas Joyce and Eric Letham, geophysics student Taylor Milne and geological engineering students Erica Lewynsky and Jake Matthews have received 2011 Shell GeoCanada Awards. The award, one of several that Shell Canada underwrites at UBC, supports student attendance at the annual Canadian Society of Petroleum Geologists Conference. "This is a significant national conference for geoscience associated with the oil and gas industry," says Greg Dipple, head of the Department of Earth and Ocean Sciences. "This type of award is critical in giving our students the opportunity to network with industry professionals and gain exposure to industry-scale science and engineering issues early in their careers." Shell Canada also supports fieldwork and mapping prizes awarded at UBC's Oliver Field School.

ACCOLADES

National Honours to UBC Researchers in New Materials, Atmospheric Aerosols

UBC Science researchers investigating new materials and atmospheric aerosols, along with a former UBC graduate student studying evolutionary adaption, were among 13 recipients of Natural Sciences and Engineering Research Council prizes this February. Rowan Barrett, who recently completed his PhD in zoology at UBC, received the NSERC Howard Alper Postdoctoral Prize. Andrea Damascelli, an associate professor of physics and astronomy, and Ruth Signorell, a professor of chemistry, received NSERC EWR Steacie Memorial Fellowships.

Alzheimer's Research, Evolutionary Biology Garner Killam Fellowships

UBC chemist Chris Orvig and evolutionary biologist Dolph Schluter have been awarded 2011 Killam Research Fellowships, one of Canada's most distinguished research awards. The funded research will focus on the preclinical discovery and testing of compounds that will slow, halt or reverse the cognitive decline associated with Alzheimer's disease, and will investigate the changes that occur during evolution in three-spined stickleback fish in British Columbia's coastal lakes.

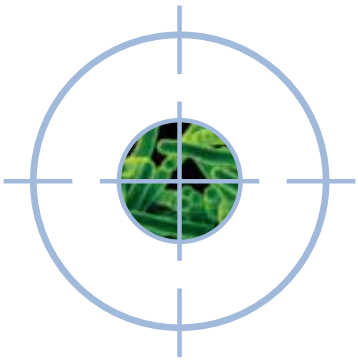
UBC Researcher Nabs Premier Applied Math Award

UBC mathematician Michael Ward has been awarded the premier research prize by the Canadian Applied and Industrial Mathematics Society. The CAIMS Research Prize recognizes innovative and exceptional research contributions in an emerging area of applied or industrial mathematics. The citation recognizes Ward's significant successful combination of singular perturbation techniques and numerical methods to analyze boundary-value problems arising in a wide range of applied fields.

Watch Andrea Damascelli and Ruth Signorell discuss their work and the support they've received from the Natural Sciences and Engineering Research Council of Canada. **science.ubc.ca/synergy**

TARGETING TUBERCULOSIS

Tuberculosis is the most devastating infectious disease worldwide after HIV. Microbiologists and immunologists at UBC's Centre for Tuberculosis Research are on the front lines of the battle against Mycobacterium tuberculosis, a pernicious, crafty bacterium that has been around for millennia and has an amazing ability to adapt its molecular defences to resist attack.



A startling **1/3 of the world's population** is infected with the bacterium, although only 10% will develop active forms of TB.

After an arsenal of antibiotics was developed in the 1950s and '60s, the Western world believed that the scourge of tuberculosis had been eradicated and that bacterial infections were no longer a serious health threat. Yet, multiple-drug-resistant TB (MDR-TB) strains have emerged that require long courses of treatment—nine to 18 months—with a combination of potent drugs that have an array of unpleasant side effects. The most deadly strains, extensively drug-resistant TB (XDR-TB), are untreatable even with the most powerful chemotherapies. Even non-drug-resistant strains require minimum treatment of six months with toxic chemotherapy, usually supervised by health officials.

"The last antibiotic to treat TB was developed almost 50 years ago. By contrast, 30 new HIV/AIDS drugs have been developed since the '80s," says UBC microbiologist and biochemist Lindsay Eltis. "We have the potential to develop new TB drugs as well, but they will come from basic research." Eltis is a member of UBC's Centre for Tuberculosis Research (CTBR), a consortium of researchers from the faculties of Science and Medicine working to develop new therapeutics to combat TB.

Each year 9.4 million cases are diagnosed and 1.7 million people die from TB. An airborne pathogen, Mycobacterium tuberculosis (Mtb) can be transmitted by coughing, sneezing or even talking. A startling one-third of the world's population is infected with the bacterium, although only 10 percent will develop active forms of TB. The pathogen normally infects the lungs, but it can also infect the spine, kidneys and brain.

Aboriginal communities have been hardest hit. Nunavut has an infection rate 62 times the Canadian average. Traditionally thought to be a disease that targets the old and infirm, more younger patients are becoming infected, which suggests TB is being actively spread.

"One reason we have these drug-resistant strains is that there is a lot of non-compliance due to side effects. People stop taking their drugs after two or three months because they feel better," says Eltis. "But patients still have bacteria in their body, including some that have acquired drug-resistance mutations."

Eltis and colleagues at the Life Sciences Institute and UBC hospitals have demonstrated that several Mtb genes are double agents, providing not only metabolic or structural roles within the bacterial cell, but often additional functions that aid virulence and antibiotic resistance. That research is providing important insights into the multiple survival mechanisms that contribute to Mtb's tenacity and persistence.

Outmanoeuvring TB's Microbial Checkmate

Perhaps most intriguing is the bacterium's ability to live inside macrophages (large host defence cells) and co-opt the body's biological mechanisms to aid its own survival. We usually think of white blood cells as the white knights of the immune system, destroying all pathogens that attempt to invade the castle. But the bricks and mortar of the body—and of the pathogen—are mostly fluid, and their molecular interplay resembles a microscopic game of chess in multiple dimensions.

The way Mtb manipulates its host cells illustrates the cunning strategy of the bacterium's molecular war game. When pathogens are first engulfed by the macrophage, vacuoles called phagosomes are formed around invaders. As the phagosomes in the 'holding cell' mature, they become acidic with digestive enzymes that destroy the pathogen. Mtb manipulates the macrophage so that phagosome maturation never occurs, creating an environment in which the pathogen can survive.

Although macrophages normally devour invading pathogens, in TB infection the roles are reversed. Mtb feeds on cholesterol that it degrades within the macrophage. In bioremediation studies on the soil bacterium Rhodococcus, which is closely related to M. tuberculosis, Eltis and UBC colleague Bill Mohn discovered similarities in the genes of these bacteria. Both have genes that encode cytochrome P450, a hemoprotein involved in degrading compounds used for cell energy and for making secondary metabolites to manipulate the host (see Synergy 2/2005). They have found 20 genes that encode P450s in Mtb. "While the function of many of these genes is still unknown, we know that two are involved in cholesterol metabolism,"

(L-R) Lindsay Eltis, Professor, Microbiology and Immunology | Charles Thompson, Professor, Microbiology and Immunology. (Not Pictured) Richard Stokes, Associate Professor, Pediatrics.

says Eltis. His group was the first to demonstrate that one of these genes, Cyp125, makes a hydroxycholesterol compound. Such compounds can alter the behaviour of the macrophage—another example of host manipulation.

"If you knock out only this gene, it isn't enough to prevent the growth of Mtb in the macrophage or in mice," Eltis says. However, researchers at the University of California in San Francisco found a sister gene, Cyp142, with a similar function and discovered that knocking out both inhibited Mtb growth.

As the disease progresses, patients develop granulomas—masses of immune cells that contain a high amount of cholesterol—in the lung. As granulomas break down, the bacteria grow very rapidly. "Mtb doesn't just use cholesterol breakdown to survive in the macrophage, it uses it throughout the progression of the disease," Eltis explains. "This is a very competitive research area. However, with approximately 80 genes involved in degrading cholesterol in Mtb, there is lots of work to be done."

The Eltis lab is also working on a group of six enzymes involved in cholesterol degradation and have found that one, HsaC, is essential for the growth of Mtb on cholesterol. Using molecular genetic approaches, they found that inactivating this enzyme impaired the survival of the pathogen in animal models.

Targeting the enzymes involved in cholesterol metabolism could be one way to fight the disease, although the research is still emerging. "There are many genes involved in cholesterol degradation, and we're just one group that is working to demonstrate the precise role of these enzymes. Many groups around the world are contributing to our understanding of how these enzymes work."

Outer Capsule Aids Molecular Mercenaries

The only way to win the fight against TB, says Richard Stokes, CTBR microbiologist and an associate professor in the Department of Microbiology and Immunology, is to develop both host- and pathogen-based lines of attack. "Bacterial pathogenesis is a double-edged sword. Immunologists tend to focus on the host response and microbiologists study bacteria. The two genomes need to be looked at together."

Stokes and colleagues are studying how Mtb invades the macrophage and have shown that different populations of these immune cells react to the bacteria in different ways. They also found that the cell envelope in mycobacteria is more complex than originally thought. The components usually associated with resistance to drugs are the lipids, or fatty parts of the cell wall common to all mycobacteria. Farther out in the cell wall there is an outer layer, or cell capsule, composed of complex carbohydrates, proteins and glycolipids. "As interactions between host and bacteria take place at the outer layer of the cell, the presence of this capsule changes the whole research hypothesis," says Stokes. His group has shown that the sugar-rich capsule modulates the interaction of Mtb with macrophages—removal of the capsule greatly increases macrophage binding.

Surprisingly, lung macrophages, the front-line defence against TB infection, have a weak capacity to bind to the bacterium, partly due to the protective capsule. "The same cells have an amazing ability to take up fungi, so this limited binding is specific to certain organisms, of which Mtb is one," says Stokes. His work suggests that Mtb controls which macrophage population it goes into—to its own advantage.

Moonlighting Chaperonins

In the 1980s, a group of 'heat-shock' proteins were discovered that protect other proteins from stress. When subjected to moderate increases in temperature above 37 C, they unfold and refold around other proteins in a protective cellular embrace. These proteins—now called chaperonins—are also involved in molecular transport in mammals, plants, fungi and bacteria. One such protein is Cpn60, found in abundance in the Mtb capsule.

"That Cpn60 is conserved across phyla is amazing. Just about every organism has a homologue for Cpn60," says Stokes. "Initially it was thought that the sole function of these chaperonins was to protect other proteins. What is becoming more obvious is that they have other functions as well."

Mtb has two chaperonins, Cpn60.1 and Cpn60.2. Stokes' group discovered that Cpn60.2 helps the bacteria bind to the host cell receptor CD43. On the host response side of his research, Stokes discovered that CD43 is important in host defence. In particular, CD43 is involved in regulating cell death to control intracellular growth of Mtb. "One of my colleagues is working on Cpn60.1, and this chaperonin has very interesting immunomodulatory functions in the host, so our work is very complementary." So, it seems, is the function of the chaperonins, which work in tandem to modulate the host's immune defences.

"Because these chaperonins

"It is really important to put a human face on the suffering caused by TB. Because it affects the poorest nations and communities, we don't see the devastation it causes."
– Charles Thompson

are conserved across phyla and have maintained their homology throughout evolution, it tells us they are incredibly important," Stokes says. "If they involved functions that could be dispensed with, that is what evolution would have selected."

Antibiotic-Induced Stress Signals Activate Resistance Gene

UBC microbiologist Charles Thompson has discovered yet another mechanism by which the M. tuberculosis bacterium foils antibiotic treatment. While all bacteria have developed cell envelopes that are difficult for antibiotics to permeate, Mtb's cell envelope is the most impermeable. As a result drugs enter very slowly, allowing the bacteria's internal systems more time to activate genes that confer resistance.

Thompson and his group have shown that the Mtb gene whiB7 and the genes it activates provide another line of defence to drugs that have penetrated the tough cell envelope. Their work indicates that antibiotics may not kill the bacteria directly, but instead disrupt normal protein synthesis leading to an alteration of physiology and accumulation of toxic metabolites that trigger a stress response. The bacteria then kicks into survival mode—called intrinsic resistance—by activating whiB7, which restores metabolic balance and clears toxic metabolites out of the cell. Most compelling of all, they found that whiB7 transcription is activated by diverse antimicrobial compounds, all with different structures and targets. This suggests that antibiotics generate a common stress signal that the bacteria recognize and respond to.

Could New Combinations of Old Drugs Hold Promise for TB Treatment?

While CTBR research shows promising new avenues for drug development, translating findings from bench to bedside is slow, laborious and costly. New drugs can take up to 14 years and $800 million to bring to market. While hundreds of drugs are available for treating other bacterial diseases, few are active against Mtb. Thompson's insight was that old drugs might still be effective if new technologies were applied to study how they might work in synergy. And since these compounds have already been approved, the cost and time it takes to translate research from bench to bedside would be greatly reduced. "We have the potential to get new drug combinations to patients for one-third of the cost and three times as fast."

Working with the Centre for Drug Research and Development at UBC, Thompson developed high-throughput synergy screening (HTSS) to test new combinations of TB therapies. Although multi-drug therapy is standard treatment for TB, no one had systematically studied how TB drugs might interact, nor investigated their synergistic interactions with non-TB antibiotics. Thompson and his lab found much more than they expected.

They screened 3,600 different compounds, including 200 antibiotics, and identified several that worked synergistically with spectinomycin, an older antibiotic that was abandoned because it wasn't effective against most bacterial pathogens. Many of these combinations were synergistic, and every compound that acted in synergy with spectinomycin generated its own specific pattern of sensitivity to other drugs.

"We don't understand how they work together synergistically, and each one of these combinations could be a PhD thesis in itself," states Thompson. "We found that most hits were with other antibiotics, so now we're doing a more targeted study of 500 known antibiotics against a selective group of six or seven front-line TB drugs." As yet unpublished, these studies promise even more remarkable results.

Thompson's work underscores the complex interplay of molecular mechanisms at work in bacterial infection and drug interactions. The high proportion of synergistic interactions also illustrates the need for this type of screening for all bacterial pathogens.

"Enzymes and transporters inside living systems aren't as specific as we may think, and any compound will affect many different targets, not just the desired one," Thompson says. "All of these so-called drug-resistant genes are really just normal parts of the cell's physiology that have been adapted to another purpose."

Thompson emphasizes the need to put a human face on TB. Africa has the highest rate of infection—29 percent of new cases worldwide—often associated with HIV/AIDS. His group has attracted the interest of doctors at a leading clinic in South Africa who want to test new drug combinations on MDR-TB and XDR-TB patients. However, Thompson first must test the combinations in mice. "We need funding partners to move this research from the lab into clinics like the one in Africa. A fairly modest research investment could potentially save hundreds of thousands of lives."

Research cited in this article is funded by the Canadian Institutes of Health Research, the Natural Sciences and Engineering Research Council of Canada, the Michael Smith Foundation for Health Research, the British Columbia Lung Association, and the TB Vets Charitable Foundation.

The Graphene Road to a Nobel Prize

In 1984, UBC mathematical physicist Gordon Semenoff predicted the astonishing properties of graphene, a material that wouldn't be isolated and fabricated until a quarter century later. His work paved the way for the 2010 Nobel Prize and a brave new field in materials science that envisions foldable touch screens, super-fast electronics and single-molecule detectors.

The history of graphene reads like a sci-fi novel with a uniquely Canadian twist. The super-material is stronger than steel by a factor of 100, yet bendable and foldable like rubber. A one-atom-thick layer of graphite, graphene is transparent and is the best electrical conductor ever discovered—able to carry current densities a million times that of copper with no electrical resistance. The Canadian twist? Graphene's amazing properties were envisioned nearly three decades ago by UBC string theorist Gordon Semenoff.

Nobel's Canadian Connections

While no material was yet known to exist that had these properties, Semenoff was told about graphite (commonly associated with pencils) by former head of UBC Physics and Astronomy, Rudy Haering, an expert on the semi-metal. "We now know that when we write with a pencil we often peel off layers of graphene, but back then we had no way of isolating or measuring single layers," Semenoff explains.

"What Gordon did was predict almost all the important features of a material that did not exist, and he had the insight to predict what kind of system experimental physicists should study," explains Philip Stamp, director of the Pacific Institute for Theoretical Physics (PITP) at UBC.

Graphite research has a long history in Canada and dates back to noted McGill theorist Philip Wallace's work at Chalk River in 1948. Wallace studied the electronic properties of graphite because it was used as a moderator in Canada's nuclear reactors.

Semenoff's groundbreaking paper, published in 1984, described the unusual properties of electrons on a two-dimensional hexagonal lattice. He established that the electron energy in a single graphene sheet would be proportional to its momentum, which means that graphene electrons, like light, would move at a constant velocity no matter at what energy they were created. They also behave like massless neutrinos, travelling undeterred and without deflection through any impurities or imperfections in the graphene. "That's the key prediction," states Semenoff. "The electrons live inside this sub-atomic 2D surface, and they behave like relativistic neutrinos that have zero mass."

In 2004, Semenoff's predictions were finally verified by experimental physicists. In 2010, the Nobel Prize in Physics was awarded to Konstantin Novoselov and Andre Geim from the University of Manchester. In 2004, they isolated a single atomic layer of graphite by peeling it off a lump of graphite with Scotch Tape and measuring its electrical properties. They confirmed that the electrons in graphene indeed behaved as if they were zero mass relativistic neutrinos, not like electrons in regular metals.

"Their method was amazingly low-tech," says Semenoff. "Their real advance was learning how to identify what they had." Using ordinary light through a microscope, the Nobel team saw that a single layer of graphene is a different colour from graphite.

Graphene's Path of No Resistance

Semenoff was awarded the Brockhouse Medal from the Canadian Association of Physicists in 2010 for his 1984 research, which laid the groundwork for understanding the physical properties of graphene. "Carbon atoms have four electrons, and three are involved in stable electron bonds with their

(L-R) Gordon Semenoff, Professor, Physics and Astronomy • Philip Stamp, Professor, Physics and Astronomy • JS Diggens, Chair, Advisory Panel, Pacific Institute of Theoretical Physics.

neighbours, but the fourth electron is free to wander and it determines the properties of graphene," he explains. "That extra electron moves around on the lattice. It follows principles of quantum dynamics, so it behaves like a wave. The way the energy of these waves depends on momentum can be plotted on a graph that looks like a Dirac cone."

When graphed, six double Dirac cones illustrate how the energy of the electrons in graphene depends on their momentum. The electrons fill up all allowed quantum states on the surfaces of the cones, up to the Fermi level, which is at the apexes of the cones, or the Dirac points.

In solids, electrons all pack into the lowest available energy states, called a Fermi sea. The Fermi level fixes the surface of that sea at absolute zero—no electrons have enough energy to rise above this Fermi surface. In graphene, the Fermi sea states are all on the surfaces of the Dirac cones, and the Fermi level is at the apex points where the cones meet, so the Fermi surface collapses to these Dirac points. The electrons thus fill up the surfaces of the bottom cones until they are all full, careful that none of them occupy the same state—the top cones are empty. Near the Dirac points, the energy of the electrons is proportional to their momentum, which corresponds to the electrons having zero effective mass, even at room temperature.

Curbing Electron Enthusiasm to Create an Ultra-Conductor

The amazing ability of graphene electrons to barge ballistically through any impurity or barrier unchecked makes graphene an extremely promising electrical conductor. However, this mobility also poses a problem for electronic applications, because in order to make a transistor, you need to be able to regulate the flow of current. In his early work, Semenoff also predicted a method for regulating the flow of graphene electrons. He proposed a mechanism for generating a gap in the electron wave spectrum, called the Semenoff mass.

"In theory, we can create a gap between the Dirac cones by splitting them apart and rounding out the bottom, thereby stopping the flow of current." Semenoff adds that roughly half of the research on graphene today involves looking for a way to induce Semenoff mass in the graphene spectrum.

"The fact that the material is immune to impurities is incredible," says Stamp. "Literally trillions of dollars have been spent on purifying silicon, which represents a major part of the cost of the electronic devices you have in your home."

Graphene's Futuristic Applications

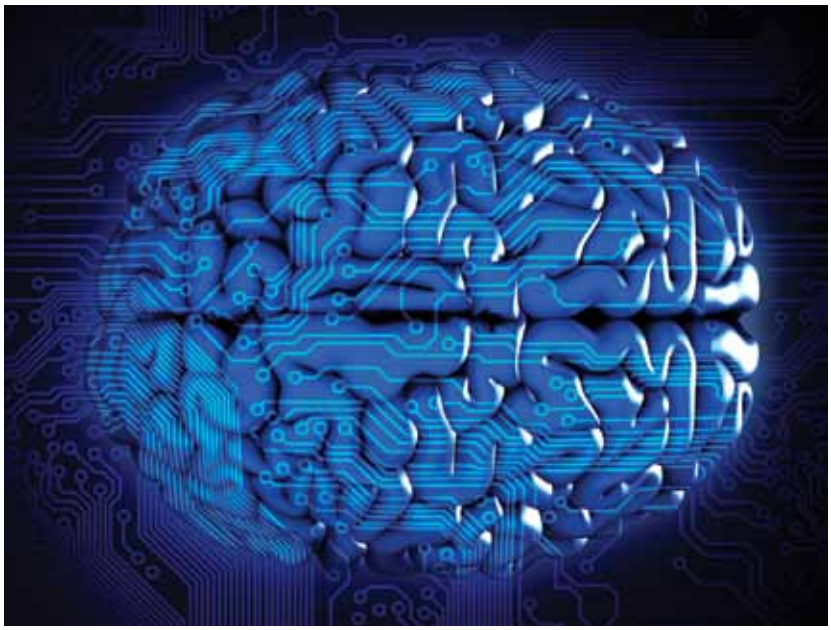
Today, companies like Samsung are actually producing graphene in 30-inch sheets and promising a host of futuristic applications, including transparent touch-screen devices that you can fold up and put in your pocket. Other potential applications include flexible solar cells, ultra-fast electronics, stretchable electrodes and composite materials that would be strong, light, heat-resistant and mechanically robust. Since graphene is able to trap single molecules, it could be used in biological devices to detect molecular precursors to disease, or for super-accurate breathalyzing or drug tests.

"Graphene has gone from being the most expensive material on earth to something close to commercial," notes Semenoff. And since it is made from carbon, it is one of the cheapest and most readily available of all materials. After years of obscurity, his research has emerged at the front lines of graphene's brave new two-dimensional world.

In the rush to get on the graphene bandwagon, companies and experimentalists will need theorists to guide them through the quantum minefield of graphene's puzzling properties. As a result, the PITP is launching a new international research network centred on the theme of graphene and related work in topological quantum states in condensed matter systems.

"One of the main goals of the PITP is to bring together a critical mass of theorists to brainstorm, share ideas and collaborate with experimentalists," says Stamp. "This multidisciplinary approach is now important for science at UBC, and for the Department of Physics. The road to graphene is a great example."

Watch UBC string theorist Gordon Semenoff discuss Graphene in a 2011 Pacific Institute for Theoretical Physics lecture, Graphene: The Idea, the Material and the Future. **science.ubc.ca/synergy**



What If Machines Could Learn?

UBC computer scientist Nando de Freitas argues that we won't always be able to program machines to undertake complex tasks—life is just too complicated to program. We'll have to teach machines how to learn for themselves.

From the second they are born, humans begin a long journey of learning. During this journey, they learn to understand the shape of objects, to associate smells with taste, to walk, to communicate, to make ethical decisions.

To many, learning is at the core of what defines us as human. Without this cognitive capacity, we would cease to exist.

However, learning is not unique to us: it's essential to the survival of all other species. Understanding learning is a big part of understanding life itself. For this important reason, I've spent most of my life trying to understand the neural mechanisms of learning.

A computational theory of learning will reveal a great deal about how the brain works—a necessary step toward the design of drugs and treatments to help people with mental disorders such as schizophrenia. A theory of how neural circuits responsible for perception and motor control develop and learn could also enable us to tap into them directly with microprocessors. Paraplegics could then use these processors—connected to robotic legs—to walk. These would be achievements of biblical proportions.

My research, however, asks another important question: what if machines could learn? Then, I argue, machines with the appropriate sensors would be able to learn to see and understand what they are seeing. The same would apply to other senses. Learning is essential here, because the process of seeing is so complex that no team of programmers could ever sit down and code the rules of seeing. We will not be able to tell machines how to see. Machines will have to learn how to see. Our task will be to tell them how to learn—at least to some extent.

So if machines could learn to see, let's imagine that they could also learn to move and control objects. Then a machine that could see and control, say a steering wheel and an accelerator, would be able to drive automatically. In the United States of America about 40,000 people die each year in car accidents. Imagine getting into your car after a late night at the office and being able to press a button that would let your car drive you safely home.

If machines could learn, they would understand other signals too—weather forecasts, temperature sensors, building occupancy levels. Then they would be able to regulate heating appropriately and improve energy efficiency. They would also be able to predict many environmental hazards, such as water contaminants, ahead of time.

If machines could learn, they would be able to use medical data such as x-rays, mammograms, ultrasound videos and gene measurements to diagnose and predict diseases with more efficiency and accuracy than any surgeon. This improvement in health care would be accompanied by huge reductions in cost.

Learning machines are already being widely deployed. They play a central role in bioinformatics, search engines such as Bing and Google, and recommender systems like Netflix and Amazon. The successful Zite iPad application—spun off research conducted at the Laboratory for Computational Intelligence at

"Imagine getting into your car after a late night at the office and being able to press a button that would let your car drive you safely home." – Nando de Freitas

UBC—is a very sophisticated web-scale machine learning system for the semantic analysis of documents and personalized recommendations. The system helps filter information in social networks such as Twitter and Facebook, but more importantly, it understands what a document is about and learns what users are interested in at a particular time. It is an artificial intelligence system that learns from vast quantities of dynamically changing data. It learns to know you.

Learning machines are also becoming ubiquitous in electronic devices. For example, learning methods are used to build the face-recognition systems used by most cameras. They also play a central role in the development of robots for civilian and military applications.

It is important to be aware of these learning machines. They will change our lives very profoundly.

Photo courtesy Illinois National History Museum

Government Leadership Needed to Bolster Taxonomy Capacity

Wayne Maddison, professor and Canada Research Chair in Biodiversity and Systematics, is scientific director of the UBC Beaty Biodiversity Museum. Sarah Otto is a professor and the director of the Biodiversity Research Centre, University of British Columbia. Both were members of the 2010 Council of Canadian Academies Expert Panel on Biodiversity Science.

The threat of invasive species entering Great Lakes waterways—Asian carp in particular—set off alarm bells this March. Reports called for the establishment of emergency response plans, and experts gathered at simulated invasive-species emergency war rooms in Ontario to pre-emptively deal with the prospect of alien invasions.

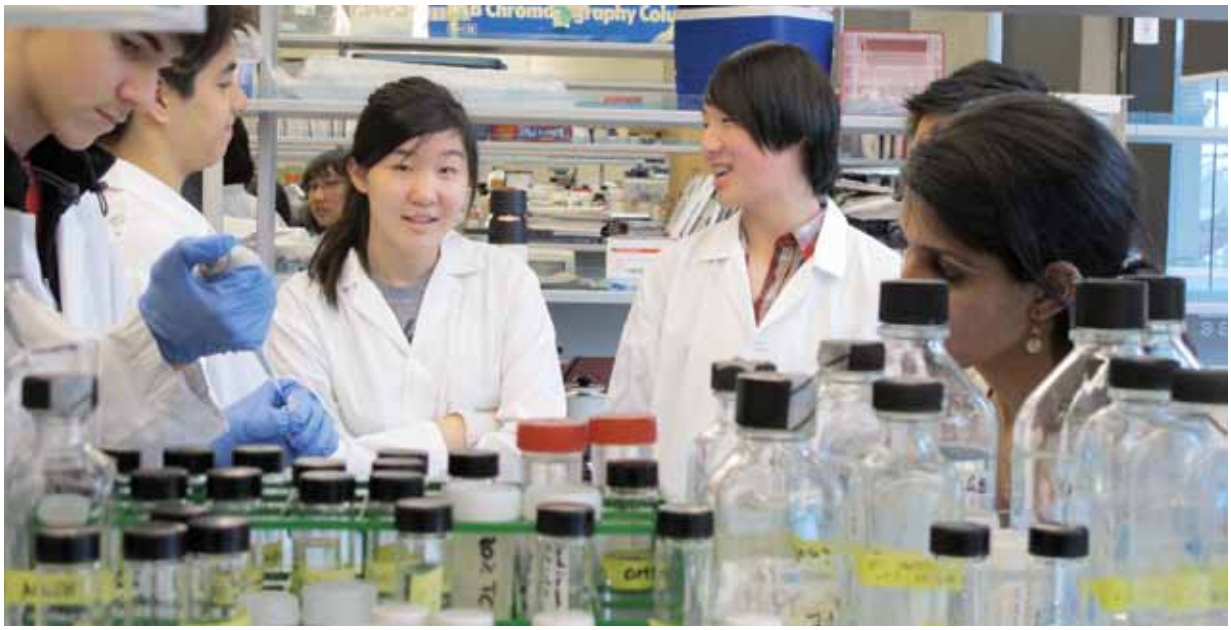
One essential ingredient to addressing the impact of environmental challenges such as these is taxonomic expertise—the ability to identify, properly classify and document living things.

Unfortunately, our recent work with colleagues across Canada and the United States indicates that Canada is falling behind in its taxonomic capacity—and, consequently, its ability to intercept and eradicate alien species like the Asian carp.

While Canada continues to have world-class researchers and strong student interest in taxonomy, the number of labs that train students is dwindling, leading to a loss of breadth in taxonomic expertise. Training and job opportunities are limited and research funding has stagnated. As a result, Canada's international contribution to new species descriptions declined from sixth in the 1980s to 14th in the 2000s.

Perhaps even more surprisingly, approximately 80 percent of Canada's online biodiversity information is held outside Canada. While there is some good news—Canada's physical natural history and biodiversity collections house over 50 million specimens—inadequate curatorial capacity and the lack of a national strategy or standards have placed Canada at risk of losing long-term records essential to understanding changes in biodiversity.

Taxonomic expertise and collections are critical for making informed policy and management decisions on changes to Canadian biodiversity, whether it be the loss of our native species or the unwelcome arrival of invasive species.



Adding a Criminal Element to Science Outreach

A researcher is found dead hunched over her lab bench, and seven suspects are in custody. Now it's up to 30 high school students to determine who killed her.

That's the premise for an innovative science outreach program hosted by the Graduate Student Association (GSA) at UBC's Life Sciences Institute (LSI). The one-day, hands-on lab is aimed at grade 10, 11 and 12 students in the hopes of sparking their interest in science as a career.

As a UBC graduate student, Caylib Durand, along with post-doctoral fellow Santiago Ramon-Garcia and the first Executive Committee of the LSI-GSA, saw an opportunity to invite students to participate in a fun and interesting event that would afford them an inside look at a professional and active scientific environment.

Durand, Ramon-Garcia and fellow graduate students based the lab on the popular Crime Scene Investigation (CSI) television franchise, dubbing it 'CSI at the LSI'. They scripted their own murder mystery, providing students with a list of suspects complete with mug shots, motives and analysis of prepared evidence samples of blood, saliva, hair and skin.

"We wanted to introduce students to basic science techniques in an entertaining and interactive way," says Ramon-Garcia. "We came up with a pretty elaborate story line, but it allows students to have fun with it."

Now in its third year, the outreach event was initially designed as part of Celebrate Research, a week-long UBC event that highlights key areas of research taking place on campus. The program has become popular with students and teachers, and has received attention from academia and government funders.

The program's methodology was published in the December issue of the Journal of Microbiology and Biology Education, and was recently awarded $14,500 from the Year of Science, a provincial initiative that encourages youth to explore the world of science.

The grant will allow LSI to host an extended, two-day version of the program for schools outside the greater Vancouver area. The program will cover the cost of meals, transportation and overnight accommodation for students, teachers, and chaperones, as well as an expanded number of hands-on activities.

The extended program will also build in more time for students to spend with graduate students and post-doctoral fellows, as well as a panel session with members of the LSI who will share their educational experiences.

"There is so much incredible research happening at the Life Sciences Institute, but there's limited public access," says Durand. "We felt we had a unique opportunity to give back to the community through education."

"Our goal was to give students hands-on training, mentorship and an opportunity to experience and ask questions about research as a possible career choice."

The latest class of crime busters to tour the facility, made up of grade 10 and 11 students from Eric Hamber Secondary School in Vancouver, was given an orientation on the institute's safety procedures.

"...being part of CSI at the LSI was a real eye-opener. I could see the passion and excitement in their eyes while they were doing the workshops." – Brenda Dowle

Students from Eric Hamber Senior Secondary take a stab at DNA analysis, fluorescence imaging and classic microbiology procedures at UBC's Life Sciences Institute.

Graduate students and post-docs then set the scene: a female graduate student has been found dead at her bench, and the students must use basic scientific techniques to test evidence collected from the scene and find her killer.

The students were broken up into four groups and assigned a workshop where one of four samples was evaluated using DNA analysis, protein analysis, fluorescence imaging techniques or classical microbiology procedures. They were also given tours of the mass spectroscopy and electron microscopy facilities.

After completing their workshop module, students reconvened to share their results and use deductive reasoning to rule out suspects one by one.

"It was a lot more interesting than I thought it would be," one student from Eric Hamber Senior Secondary said in his post-workshop feedback. "It was cool to see how the electron microscope worked."

"Everyone was really helpful," said another. "We learned how to use a pipette and how bacterial cultures are grown. It was great to do the experiments ourselves in a real lab."

"These students are a motivated bunch," says their teacher Brenda Dowle, head of the science department at Eric Hamber. "Still, being part of CSI at the LSI was a real eye-opener. I could see the passion and excitement in their eyes while they were doing the workshops."

"We wanted all of the students to get the chance to participate in the experiments," says Ramon-Garcia. "It's great to see them collaborate and share what they've learned."

"At the end of the day, the students gather to use the results from the workshops to determine the killer. We bring the killer into the lab, and when the students make their announcement, a security guard comes and takes the killer away. It's a really fun way to get students interested in science."

Students and teacher take home worksheets and a memory stick of materials, so they're able to revisit and build on what they've learned during their time in the various workshop labs.

Durand and Ramon-Garcia say that the program is just as popular with the grad students and post-docs as it is with its high school participants.

"When we started this program three years ago, we had no idea it would take off like it has," says Durand. "It's a rewarding experience. Maybe more rewarding for us than it is for them!"

See more photos from the last iteration of UBC's Life Sciences Institute CSI at the LSI program. **science.ubc.ca/synergy**

Hero Worship Spurs Student Biotechnology Network

Photo: Ali Tehrani, Student Biotechnology Network and Zymeworks.

CLASS NOTES

1970s

Olympic Glory Is All Relative

Nancy Ricker (PhD Botany, 1971) basked in reflected glory when her daughter Maëlle won the 2010 Winter Olympics Gold Medal for snowboard cross at Vancouver's Cypress Bowl.

More Than Fish in the Ocean

Curtis Suttle (BSc Zoology, 1978 | PhD Botany, 1987) was awarded the 2010 AG Huntsman Award for Biological Oceanography and Fisheries Science in recognition of his extensive contribution to the field of marine sciences. Curtis, one of the world's leading marine virologists, is among a small group of researchers credited with launching the field of marine virology nearly 20 years ago. His contributions cross over many fields, including biological oceanography, environmental microbiology, microbial ecology, virology and phycology.

1980s

Diamond-Sharp Drafting Skills

Since graduation, Royanna Wild (BSc Geology, 1989) hasn't strayed far from the minerals exploration community, although she left fieldwork early on and became more involved in the office end of the industry. "While working in Vancouver, I met my husband, started a family and eventually we began working for ourselves by starting Wildrock Resources Consulting and Drafting. I still enjoy contracting to industry in GIS and drafting, as well as volunteering and sharing my enthusiasm for rocks and the mining industry with anyone who will listen!"

Balancing Health and Family

After a nine-month sabbatical to re-energize, reflect and plan, Jennifer Scrubb (BSc Biology, 1988 | MSc Human Kinetics, 1994) has worked to develop a career as a consultant in health promotion and education. "I'm thrilled with my decision and thoroughly enjoy the work I do! I am a proud mother who lives a balanced and full life by enjoying local and international travel, volunteering and remaining active."

A recent Beyond the BSc volunteer speaker, Scrubb relished the opportunity to motivate science students to explore non-traditional

"We kept hearing this word biotechnology thrown around," recalls Ali Tehrani of his last years of graduate work in Microbiology and Immunology at UBC. "And we had these amazing examples of professors at UBC who were applying their research beyond the lab. It was inspiring to see heroes like Julian Davies, Bob Hancock and Brett Finlay, who made names for themselves in the biotechnology sector, but the links and networks to help students apply their knowledge outside laboratory work just weren't there."

That gap inspired Tehrani (PhD Microbiology, 2004) to co-found the Student Biotechnology Network (SBN), which connects students with industry professionals through networking events and mentorship programs. With support, largely from the UBC community, it took two years to put the network on a firm footing after its founding in 2001. Ten years later, SBN is the largest student-based life sciences organization in Western Canada.

"The network really strives to connect students with the right people and help them translate the skills they developed during their studies," says Tehrani, who true to form, launched the computational biotechnology company Zymeworks six months before graduating from UBC. And that was only possible, he says, because he met the right people at the right time.

career and educational options after graduation. "I think it's important to remain involved, as my own time at UBC enabled me to solidify my passion for health promotion and shape my future."

1990s

Japan Bound

Now an associate professor at the University of the Ryukyus in Okinawa, James Reimer (BSc Biology and Ecology, 1995) was Japan bound right after graduation. After teaching English from 1995 to 1998, he studied Japanese at a language school and entered graduate school at Kagoshima University. "Coming from a Western background, I've been able to relate well with students and younger academics here. Japan is a more traditionally stratified culture, but currently there is a big focus on diversity and internationalization, and I'm well positioned to take advantage of this." Reimer's current research focus is the biodiversity of coral reef organisms.

2000s

Good Communications Key to Good Chemistry

After wrapping up a research position at the UBC School of Journalism, Eric Jandciu (MSc Chemistry, 2000 | MJ Journalism, 2002) is coordinating UBC Science's brand new Communicating Science course (SCIE 300). "Going to UBC helped me gain access into my desired industry. I wouldn't be working in the field or teaching science communication without both my science and journalism credentials."

Botany Graduates Are Patent Pending

Lee Johnson (PhD Botany, 2006) is now a patent lawyer with Gowling Lafleur Henderson LLP, whose offices reside on the 37th floor of Place Ville Marie, the tallest office building in Montreal. Johnson—and Mark Pidkowich (PhD Botany, 2001) who is practising patent law with Smart & Biggar in Vancouver—is training to become a Canadian patent agent. It seems that doctoral research in botany opens unexpected doors!

Academic Pursuits

Ben Gilbert (PhD Botany, 2008) is now an assistant professor at the University of Toronto.

Top 40 Under 40

David Vocadlo (BSc Biochemistry, 1994 | PhD Chemistry, 2002) was named to Canada's Top 40 Under 40 this April. Currently an assistant professor at Simon Fraser University and Canada Research Chair in Chemical Biology, Vocadlo is co-founder and Chief Scientific Officer of Alectos Therapeutics. Alectos is a biopharmaceutical company dedicated to the discovery and development of innovative small-molecule therapeutics.

2010s

Province Honours Freshly Minted Alumni

Alia Dharamsi (BSc Integrated Sciences, 2010) and June Lam (BSc Pharmacology, 2010) are among 36 recipients of the eighth annual BC Community Achievement Awards. Dharamsi was recognized for volunteer service at Canuck Place, tutoring and mentoring high school students, and developing a wellness conference for inner city youth. Lam was cited for leadership and initiative, particularly for his outreach work with UBC Science's peer coaching team and Let's Talk Science. The awards were presented in March by Premier Christy Clark and Keith Mitchell, chair of the British Columbia Achievement Foundation.

(L) More than 200 alumni and students network at the second annual UBC Geological Sciences and Engineering Alumni Reception at the Vancouver Westin Bayshore this January. (R) Science students gather to hear Elizabeth Croft deliver the keynote address at a UBC Vancouver Women in Science and Engineering gathering this March.

EVENTS

Alumni Gathering at PDAC Shows Good Prospects

Science alumni helped launch UBC's first annual alumni reception at the Prospectors and Developers Association of Canada (PDAC) convention this March in Toronto. The convention, which includes trade and mining investment shows, attracts exploration and mining professionals from around the world. Attendance at this year's conference surpassed 25,000.

Greg Dipple, head of the Department of Earth and Ocean Sciences, welcomed alumni with an update on the construction of the new Earth Sciences Building at UBC and on the exciting developments underway within the department. Be sure to come to next year's UBC PDAC alumni event and visit the UBC Science and Earth and Ocean Sciences booth at the conference trade show.

Geological Sciences Alumni 'Rap' at Roundup

More than 200 alumni geologists, environmentalists, corporate representatives, academics and science students gathered at the second annual UBC Geological Sciences and Engineering Alumni Reception at the Vancouver Westin Bayshore this January. Held in conjunction with the Association for Mineral Exploration British Columbia Roundup conference, this year's theme of Exploring Today for Tomorrow's Resources was a perfect backdrop for networking, fun and drinks. Earth and Ocean Sciences department head Greg Dipple brought everyone up to speed on UBC's Earth Sciences Building project, the Geological Field Work initiative and geochemistry at UBC, as well as the department's latest accolades and accomplishments.

Science Alumni Get WISE

Science students gathered to hear Elizabeth Croft deliver the keynote address at a UBC Vancouver Women in Science and Engineering gathering this March at UBC's Asian Centre. The annual event gives female science and engineering undergraduates the opportunity to meet, mingle and network in a small group setting. Many thanks to all the accomplished alumni from both disciplines who participated—you truly make a difference in the lives of female science and engineering students at UBC. If you'd like to participate in next year's WISE event, contact Kim Duffell, UBC Science alumni relations manager, at kim.duffell@ubc.ca or visit science.ubc.ca.

Alumni Weekend 2011 Recap: Missed the Party at the Point?

A big thank-you to our alumni, families, friends and staff who attended UBC Alumni Weekend this May. Highlights included tours of UBC's amazing attractions (including the Beaty Biodiversity Museum and the UBC Botanical Garden), classes without quizzes, reunions, spectacular magic chemistry shows, circus acts, games and much more.

Spring Graduation Congratulations!

On Monday, May 30, 2011, UBC Science welcomed its newest graduates into our alumni community. Family, friends, faculty and staff gathered at the Chan Centre for Performing Arts to mark the occasion and to celebrate the accomplishments, determination and commitment of our latest graduates. Congratulations and Tuum Est!

Are You Gold, Silver or Aluminium?

Did you graduate in 1961, 1987 or 2002? If so, you'll be marking an important milestone in 2012: either your gold, silver or aluminium anniversary from UBC. Why not celebrate the occasion with a reunion! Enthusiastic and dedicated alumni volunteers are the key to success. If you'd like to be the lead in your next reunion—or even play a supporting role—contact Kim Duffell, UBC Science alumni relations manager, at kim.duffell@ubc.ca or visit science.ubc.ca.

Connect, Grow and Contribute

Whether you're working in industry, academia, government or business, you can partner with UBC Science to make a difference. The opportunities to engage—as an advocate, employer, leader, mentor or speaker—are as diverse as the breadth of activity and discovery happening every day at UBC. You develop valuable contacts, gain new skills and meet interesting people, and your involvement contributes significantly to student well-being and to the long-term strength of the UBC Science alumni community.

Living outside of the Lower Mainland? Working on a field study in Cape Town, South Africa? Working in the mining sector in the Yukon? No problem. You can still be involved. Contact Kim Duffell, UBC Science alumni relations manager, at kim.duffell@ubc.ca or visit science.ubc.ca to find out how.

Reach Out

If you have a suggestion for an alumni event, or if you'd like to help organize one, contact Kim Duffell, UBC Science alumni relations manager, at kim.duffell@ubc.ca or visit science.ubc.ca.

Stay Connected with 32,000 Science Alumni

Drop us a line about recent accolades, professional successes, family developments or interesting world travel. It's a fun, quick way to share stories, discoveries or innovations with fellow alumni. We'll publish your submission right here in Synergy, in the UBC Science Connect eletter, or make you famous by featuring your submission on the UBC Science website! You can also go online to science.ubc.ca to see more updates. To submit notes, contact Kim Duffell, UBC Science alumni relations manager, at kim.duffell@ubc.ca or visit science.ubc.ca. Updates will be edited for clarity and brevity.

Calling Lost Alumni

Many thanks to the hundreds of alumni who updated their coordinates as part of last issue's "Do We Have Your Current Email?" iPod giveaway. Congratulations to Tom Balabanov (BSc Biology, 1974) and Dan Davies (BSc Chemistry, 1977) who are now enjoying the latest music-enlivening technology from our favourite California-based technology and design company.

science.ubc.ca/update

Watch Elizabeth Croft, Natural Sciences and Engineering Research Council Chair for Women in Science and Engineering for BC and the Yukon, deliver the keynote address at a UBC Vancouver Women in Science and Engineering gathering this March. **science.ubc.ca/synergy**

EDITOR Chris Balma WRITING Mari-Lou Rowley: Pro-Textual Communications, Chris Balma, Ashley Turk, Brian Lin COPY EDITING/ PROOFREADING Vicki McCullough DESIGN/LAYOUT www.mediagroup.ubc.ca PHOTOS Provided by UBC Science or as indicated, all rights reserved. COVER ARTWORK Claire Roan CIRCULATION 32,000 (twice a year) PUBLISHED BY The Faculty of Science, University of British Columbia, www.science.ubc.ca, synergy@science.ubc.ca

Printed in BC, Canada, on a Forest Stewardship Council® certified paper that is manufactured using 100% post consumer waste. 79 fully grown trees, 136,812 litres of water, 33 million BTU's of energy, 1,041 kilograms of solid waste and 3,643 kilograms of greenhouse gases were saved by using this paper. A total of 183 kilograms of greenhouse gases (GHGs) were emitted during the transportation of of the paper. These GHG emissions together with GHGs emitted during the printing process of Synergy will be offset through investments in energy and efficiency and non-fossil fuel technologies.

FSC RECYCLED Paper FSC® C014956

zero 100% carbon neutral by Hemlock Printers www.hemlock.com/zero

Return undeliverable Canadian addresses to: UBC Science (Synergy)
1505 – 6270 University Boulevard, Vancouver, BC Canada V6T 1Z4

www.science.ubc.ca