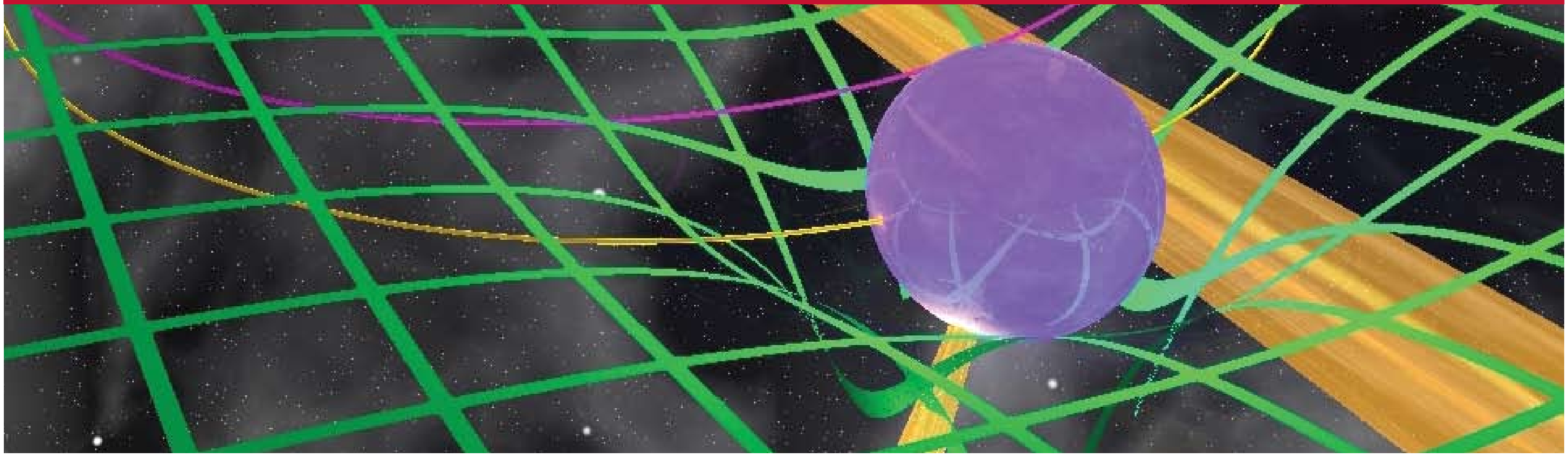
THE UNIVERSITY OF BRITISH COLUMBIA

SYNERGY » JOURNAL OF UBC SCIENCE

ISSUE 1|2007



Words from the Dean

I am pleased to introduce a new direction for *Synergy*, the journal of UBC Science. In addition to articles featuring cutting-edge research, we have expanded our coverage to highlight exciting advances in science education and bring you up to date on several Faculty of Science initiatives.

Human and scientific knowledge continue to expand rapidly, presenting both challenges and opportunities for science education. It is no longer possible (and perhaps it never was?) to teach students everything there is to know about a particular discipline. Instead, we need to focus our efforts on fundamental scientific concepts and on teaching students "how to learn." In today's Information Age, there is no shortage of information, so our students need to develop skills that allow them to distill relevant information efficiently and critically. On January 1, 2007, Nobel laureate Carl Wieman officially joined UBC to lead a major science education initiative focused on student learning (see page 12). In many ways, this is the perfect time and UBC is the perfect place for this initiative. Paralleling our advances in scientific knowledge, there have been dramatic recent advances in educational pedagogy and in understanding how the human brain "learns." UBC has a proud history of education innovation and is fortunate to have extraordinary teachers, one of whom—Shona Ellis—is profiled on page 16 of this issue.

One of *Synergy's* primary themes—interdisciplinarity—is not changing. As you read through the research articles, I hope you are struck by the connections among a wide range of disciplines. The research and teaching articles illustrate how exploring the connections between disciplines can advance our understanding of nature. Not surprisingly, sustainability is a theme running through several of the stories in this issue, including Earth & Ocean Sciences professor Greg Dipple's research on CO_2 sequestration (page 4) and Mountain Equipment Co-op's support of sustainability research projects conducted by Chemistry graduate students (page 3).

Photo: Martin Dee

Dean Simon M. Peacock

In past issues of *Synergy*, we have described a number of exciting interdisciplinary research projects focused on microbial life. I am delighted to report a generous investment by the Tula Foundation, which has allowed us to support post-doctoral scholars in the new Centre for Microbial Diversity and Evolution (page 3). Next year, we will launch a new interdisciplinary course for second-year students titled Global Issues in Arts and Science, focusing on climate change and genetically modified organisms.

At their core, universities and science are about people. I am delighted that we are telling more people stories in this issue of *Synergy*—alumni stories, faculty stories and student stories—stories about the wonderful people who make up UBC Science.

We are very interested in your feedback on *Synergy* and UBC Science, and invite you to send us your comments to synergy.science@ubc.ca.

Simon M. Peacock
Dean, UBC Faculty of Science

In the News…

UBC Gains $26M for Infrastructure
UBC media release – Nov 27, 2006

Researchers at the University of British Columbia have earned more than $26.5M from the federal Canada Foundation for Innovation to fund facilities and equipment for six projects including: The **Centre for Drug Research and Development** ($8M) will help advance early state health-related discoveries through core activities of drug discovery, design and synthesis, screening, testing, and drug formulation and evaluation. *Researcher: Prof. Robert Hancock, Microbiology & Immunology, CRC in Pathogenomics and Antimicrobials.* A **Quantum Materials Spectroscopy Centre** ($6.4M) will be located at the Canadian Light Source, for the design and exploration of novel complex materials. *Researcher: Asst. Prof. Andrea Damascelli, Physics & Astronomy, CRC in Electronic Structure of Solids.* A **Centre for Microscopy of Intermolecular and Cellular Dynamics** ($1.6M) will allow living cells to be viewed at an unprecedented level of detail, supporting discoveries in biotechnology, health and the environment. *Researcher: Prof. Geoffrey Wasteneys, Botany, CRC in Plant Cell Biology.* A **Tunable UV and Soft X-ray Laser Source for Coherent High-resolution Spectroscopy** ($375K)—an ideal tool for the most advanced photoelectron spectroscopy experiments—will be used by researchers in medicine, biology, physics, and chemistry. *Researcher: Asst. Prof. David Jones, Physics & Astronomy.*

UBC Research Major Contributor to World's First Tree Genome
UBC media release – Sep 15, 2006

An international team of scientists, including Assoc. Prof. Joerg Bohlmann from the Michael Smith Labs and Prof. Carl Douglas from Botany, has completed the world's first physical map and sequencing of a tree genome—only the third plant ever sequenced—providing important insight into the future development of alternative fuels, forest health and wood quality.

Remembering a Pioneer—Supporting Future Scientists

Back in 1961, when Vivien Srivastava discovered that cod grunt, there were questions in the British parliament, a poem in *Punch* magazine and a CBC interview with Bruno Gerussi. Srivastava's interest in animals and their behaviour created quite a stir. Against countless odds, Srivastava achieved many firsts as a woman in science: the first woman scientist to be hired by both the Fisheries Research Board of Canada and the Bedford Institute of Oceanography, and the first woman to receive a PhD in Zoology at UBC. As a mother, Srivastava was also very familiar with the challenges of balancing an academic career in science with the demands of family life. In Srivastava's memory, her family recently established the *Vivien M. Srivastava Memorial Endowment Fund*. This fund will provide assistance to female graduate and post-doctoral students experiencing financial hardship, and will support a workshop series to encourage and empower female participation in science and technology.

"I did not actively campaign for the rights of women, but was determined to be treated as someone with a job to do."
– Vivien M. Srivastava (1931-2004)

Distinguished Lecturer Maria Klawe on "Gender, Lies and Video Games"

From playing computer games to pursuing computing careers, why does the participation of females tend to be very low compared to males? Current president of Harvey Mudd College and former UBC Science dean Maria Klawe, speaking at UBC in November 2006, identified three important factors discouraging young women from majoring in computer science: they don't think it would be interesting, they don't think they would do well, and they don't think they would fit into the culture. These perceptions about studying computer science, and information technology careers more generally, are already well entrenched by the beginning of high school. Increase interest, Klawe says, by changing the image of the field—and give girls their own laptops. Initiatives to boost confidence and a sense of belonging in the field include achieving critical mass and ensuring inclusive language and images. There are many things that universities can do to increase the participation of women in computing courses and majors. These comprise outreach to high schools, offering introductory courses that stress applications, and offering joint majors that combine computer science with disciplines such as math, statistics, biology, psychology, art, theatre, music, and business. UBC has been a leader in all of these, says Klawe, and has a significantly higher percentage of women in Computer Science than many other universities in North America.

MEC and UBC Science Partner to Promote Sustainability

Mountain Equipment Co-op (MEC) is a retail co-operative and Canada's largest supplier of outdoor clothing and equipment. MEC is also committed to environmental and social reponsibility in business. The *MEC Graduate Research Fellowship in Chemistry* promotes sustainability in business and the role scientific research plays in developing sustainable products and practices. In 2006, the inaugural MEC Fellowship was awarded to PhD candidates Louisa Stanlake and Aya Sode. Aya is exploring low-cost ways to manufacture fuel cells (see photo). Louisa is researching low waste catalytic processes in the manufacture of polymers. MEC has generously renewed its $25,000 commitment for the 2007/08 academic year. MEC's investment in graduate student research builds on the UBC Science goal to explore novel practices and to reduce the consumption of non-renewable resources through new knowledge and innovation.

Investment in Basic Research—The Study of Microbial Life

Driven by curiosity, creativity and the spirit of exploration, the Tula Foundation has established the Centre for Microbial Diversity and Evolution (CMDE) at UBC with a $7 million investment in fundamental research. This increased research capacity, driven by the support of up to 40 post-doctoral fellows over ten years, will enable UBC researchers to become international leaders in microbial diversity and evolution. While the potential to learn from and even harness practical aspects of microbial biodiversity is enormous, it remains mostly just that: potential. This microbial world is not well explored, its population unknown and its dynamic poorly understood. "This is an enormous boost to future generations of researchers focused on understanding microbial diversity," says UBC Botany associate professor Patrick Keeling and CMDE principal investigator. Exploring the diversity of microbial life forms and how they evolve is crucial to the understanding of ecological systems and the process of evolution, says Keeling. The opportunity for new discoveries is immense.

Waste. Not.

Using Mine Tailings to Sequester CO_2

Ensuring a habitable Earth will require more than emission reduction and a switch to alternative energy sources. Finding ways to trap and store carbon dioxide is crucial to the future of this planet. UBC geologist Greg Dipple has discovered that mine tailings are a natural CO_2 sink, and he is working to harness and fast-track nature's mineral sequestration process.

The last place on Earth one might consider looking for a solution to global climate change is in mine tailings. These mountains of sand and fractured rock are known to leach toxic minerals and turn the landscape into a wasteland of rubble. It is difficult to imagine anything beautiful or beneficial about them. Nevertheless, UBC Earth & Ocean Sciences professor Greg Dipple has discovered that mine tailings are an enormous greenhouse gas (GHG) storehouse, with the potential to remediate thousands of tonnes of carbon dioxide (CO_2) emissions quickly and efficiently using Mother Nature's recipe for chemical weathering. "Other carbonation methods, such as increasing natural forest, soil and ocean sinks, and artificial sequestration are either short-term or low-capacity solutions," Dipple states. Mine tailings have the potential to sequester and store more CO_2 than other methods, in a more stable form. This could be achieved as part of ongoing mining processes that would also be GHG neutral.

In the natural cycle of mineral weathering and sequestration, rain falling on continents dissolves small amounts of minerals, and in the process, removes CO_2 from the atmosphere. In the subsequent recycling process, CO_2 is typically carried to the ocean and eventually becomes rebound in minerals. "This natural cycle occurs on a continental scale over millions of years," Dipple explains. "As a result, about 90 percent of the earth's carbon is bound in carbonate minerals, where it is very thermodynamically stable."

For the past decade, the US Department of Energy has been investigating mineral sequestration of CO_2 as a novel GHG sink. However, their model involves sending the CO_2 from a coal-burning power plant to a new mine opened specifically to extricate silicate minerals for carbonation. "The challenge is finding a quick, economical method that doesn't emit more CO_2 when generating the energy required for mining than you eventually store," Dipple says.

Existing mining environments provide a ready-made solution, albeit one that might seem too good to be true. "In the milling process, solid rock is ground up, thereby increasing the reactive surface of the rock a million-fold," Dipple explains. "A reaction that would normally take a million years can happen in a few years, or even months." He notes that some studies have shown the formation of carbonate crusts in mine tailings within months of their deposition. Dipple and colleagues were the first to study—and publish—how CO_2 sequestration occurs in mine tailings from existing mines.

Potential GHG Benefit

- Magnesium silicate minerals consume half their mass in CO_2 during carbonation.
- The tailing sequestration capacity of hardrock mines is five to ten times greater than their total GHG emissions.
- Using only ten percent of tailings as sinks could produce a GHG neutral mine.
- Approximately one million tonnes of CO_2 per year could be trapped and stored in a ten-million-tonne-per-year tailing operation.

Diavik diamond mine, Northwest Territories

Mechanisms of CO_2 Fixation in Tailings

With seed money from NSERC, the Yukon Geological Survey, and the BC Ministry of Energy, Mines and Petroleum Resources, and in collaboration with the Mineral Deposit Research Unit and the Pacific Centre for Isotopic and Geochemical Research at UBC, Dipple and UBC colleagues initially studied tailings in abandoned mines at Cassiar and Clinton Creek. Their work involved quantifying the rate of CO_2 uptake, examining the different processes by which CO_2 uptake occurs, and determining what was attributable to the mining process versus natural weathering.

The carbon in minerals from mine sites comes from three reservoirs: the atmosphere, bedrock and the industrial process of mining itself. Determining the source of carbon that has been trapped in the tailings is crucial to their potential use for GHG remediation. "These three sources of CO_2 tend to form carbonate minerals that are isotopically very distinct," Dipple says.

He and his research group also identified the two distinct pathways by which magnesium carbonate minerals form as a natural consequence of silicate weathering. The pathway for the minerals nesquehonite and lansfordite is abiotic, or dependent on environmental factors, such as water chemistry and pH, and weather. For the minerals dypingite and hydromagnesite, the pathway is biotic, or microbially mediated.

Mt. Keith nickel mine, Western Australia

Mineral crust, Mt. Keith tailings

Industry Acceptance Accelerates Research

Knowledge of the reaction rates, pathways and minerals formed is required to develop models and identify the processes needed for industry to use the science of mineral sequestration for tailing sinks. With funding from mining companies BHP-Billiton and Diavik, followed by matching funds from NSERC, Dipple and colleagues began studying two active mines: the Diavik diamond mine in the Northwest Territories, and the Mount Keith nickel mine in Western Australia. The group measured the difference between minerals formed by biotic and abiotic pathways, and discovered that the environment likely dictates not only the pathway, but the mineral formed and the rate of sequestration. Nesquehonite and lansfordite are commonly found in the Canadian Arctic. In contrast, dypingite and hydromagnesite were more predominant in tailings found in the Australian desert. “It seems that nesquehonite prefers a colder climate, and dypingite and hydromagnesite like the hot, wet tailing environment of the Australian mine,” says Dipple. “One would expect an abiotic pathway in the colder environment and a microbially-mediated pathway in the hot environment, but we are still in the process of figuring this out.”

Perhaps most significant of all, they found that the total CO_2 sequestration capacity in these two mines exceeds the total of their greenhouse gas production by a factor of five to ten.

Global Impact of Silicate Sequestration

The rate of chemical weathering in nature and of carbon fixation in mine residues is determined by how quickly minerals dissolve in water. Dipple and his group are working in the field and in the lab on methods to accelerate this process. They are developing a geochemical model to predict sequestration rates as a function of the environment and of accelerated processes such as increased abiotic or microbial activity (see sidebar). This work would provide a verification protocol that will allow companies to forecast and track the rate of carbon uptake in mine tailings in order to trade carbon credits on systems like the European Emissions Trading System and the Chicago and Montreal Climate Exchanges. This could, in turn, help fund site remediation in abandoned mines. “In active mines, the companies just need to tweak an ongoing process. In abandoned mines, the infrastructure is gone,” Dipple says.

With the potential of a single mine site to trap and store hundreds of thousands of tonnes of CO_2 annually, Dipple’s research could have a huge impact on global climate change remediation. He is cautious about being overly optimistic, however. Since the world’s major infrastructures—energy, electricity, transportation, economy—are all built around the fossil fuel industry, it could take at least 50 years to see the effects of both innovation and remediation. “After that time, we won’t have to deal with these issues any more, because by then we will have moved on.” ■

Accelerating Sequestration—with Bugs

Greg Dipple and colleague Gordon Southam of the University of Western Ontario are investigating various methods of accelerating CO_2 uptake by abiotic and microbially mediated pathways. They have discovered that the rate of sequestration varies by orders of magnitude between different tailing environments. The salinity and pH value of the water contribute dramatically to the rate of mineral dissolution and subsequent CO_2 uptake.

The abiotic method of the process relies on bulk changes in fluid chemistry to accelerate mineral dissolution. Dipple and Southam have found that microbes also accelerate sequestration, and their method is similar—but more subtle and sustainable. “Microbes change the chemistry of the water around their cell walls,” he explains. “So you can get the same mineralogical effect both abiotically and biotically. The difference is that microbes only change the pH value in their immediate environment, so we don’t need to change the composition of all the water in order to accelerate the precipitation rate.”

Their experiments have shown that the biological pathway produces an increased rate of precipitation, without the further environmental hazard of waste water containing high salt concentrations.

Regularity in Randomness

Using Graphs to Reveal Mathematical Relationships

To a mathematician, life is filled with geometrical symmetry, patterns and relationships—a rose, a rainbow, ripples from a stone thrown in water—and this symmetry can be described in numbers. Jozsef Solymosi uses geometry, graph theory and combinatorics in the study of patterns, combinations and relationships—and the uncanny order in randomness.

For Jozsef Solymosi, assistant professor of Mathematics at UBC, the perceived complexity of many systems is embedded with innate order; and the common coincidence of running into an acquaintance while travelling abroad can be explained mathematically. One well-known example was proved in 1930, by Frank P. Ramsey. A simple corollary of his famous theorem, which is now the foundation of an important part of mathematics, states that given any group of six people, three people out of the group will either all know each other, or all not know each other. It is a theory that still fascinates mathematicians today, and is a key problem in structural combinatorics, one focus of Solymosi's research.

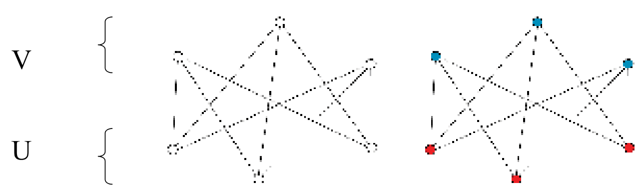
Tackling Intractable Problems with Graphs

Another famous relationship hypothesis, known as "six degrees of separation," states that anyone can be connected to any other person on Earth through a chain of acquaintances with no more than five intermediaries. Graph theory is used to solve similar combinatorial problems, and the development of algorithms based on graphs is a key focus in computer science.

Graphs allow us to visualize abstract or symbolic relationships, and they can be used to represent a ubiquitous array of problems and structures. Graph theory has been described as one of the oldest and most accessible aspects of combinatorics. It provides a representation of the binary relations of objects, and has applications in biology, chemistry, physics, and computer science. Applications include network analysis and flow, molecular analysis and route analysis.

Graph Coding and Colouring

A simple graph contains a set of objects called points or *vertices* connected by lines or *edges*. A graph is undirected when a line from point A to B is considered the same as a line from B to A. Graph colouring is the assignment of colours to certain objects in a graph. A graph is bipartite if its vertices can be divided into two subsets, U and V, so that each edge connects a vertex from U to one from V, as in the $K_{3,3}$ graph (see illustration below). This graph can be coloured so that

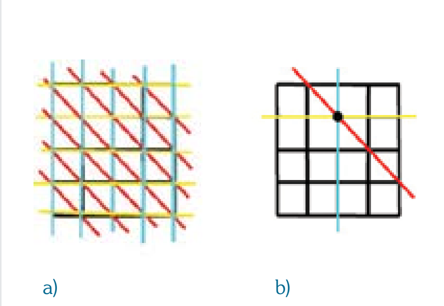


the vertices in the subset U are red, and the vertices in subset V are blue, and each edge connects to a vertex from each subset. Generally, graph colouring is assumed to be "proper" when no two adjacent, or joined vertices are assigned the same colour.

In graph theory, a subgraph is a subset of nodes and edges from a larger graph. Extremal graph theory deals with maximums and minimums, for example, what is the maximum number of edges in a six-vertex graph such that it doesn't contain a triangle as a subgraph? The $K_{3,3}$ graph is an example of an extremal graph, in that it has the maximum number of edges—nine—for a six-vertex graph not containing a triangle (see above). Graph colouring problems have many real-world examples, including scheduling, assigning frequencies to mobile radios, and pattern matching.

Randomness and Regularity in Hypergraphs

While simple graph theory is a good tool to study binary relationships, many phenomena are much more complex. Hypergraphs



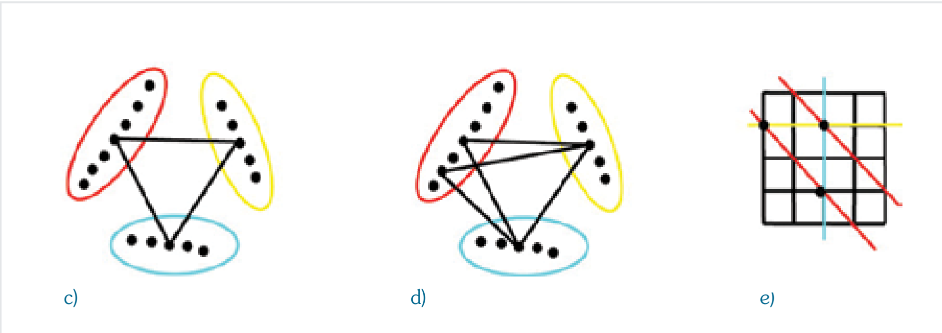
are tools used to study multiple relationships, such as a transportation network, or the Internet. "When we take the leap to hypergraphs, the question of how many edges you need in order to avoid this or that becomes out of reach," admits Solymosi. Fortunately, many theorems involving graphs also hold true for hypergraphs, such as Ramsey's theory, which says there is no such thing as complete disorder. When something is random, we would normally consider it also to be irregular; however, in extremal graph problems, regularity is a measure of randomness.

But what is a random graph? "It means that you could choose every edge by flipping a coin," explains Solymosi. The resulting graph would be a random graph that has some inherent order, in that the expected number of subgraphs can be determined.

"Szemerédi's regularity lemma says that it doesn't matter what kind of structure you have, you can arrange the vertices into groups so that the graphs between those groups, or sets of vertices, are random-like," Solymosi explains. "And then you can use the tools from probability to prove there is a structure. That's how randomness and regularity relate to Ramsey's theory."

Regularity Lemmas and Number Theory

This randomness and regularity is also a feature of number theory. A famous theorem



In this tripartite graph, the vertices of the three subgraphs are the red, yellow, and blue lines and the edges are arbitrary sets of vertices, denoted by the set S (a). Two vertices are connected by an edge if the crossing point of the corresponding lines is a point of S (b). A triangle in the graph corresponds to three lines such that any two intersect in a point of S (c, e). If two triangles share an edge, one is an isosceles equilateral triangle (d). (Source: PNAS June 7, 2005: vol. 102, no. 23, 8075–8076.)

in number theory states that every dense subset of integers contains an arbitrarily long arithmetic progression. For example, a five-term arithmetic progression can be described as (*n, n+d, n+2d, n+3d, n+4d*) where *n* represents an integer and *d* is the difference between consecutive elements. "If you choose a dense, arbitrary subset of integers, which is dense in the sense that out of every 1,000 you choose at least one, then at some point you will find complete order, or a long arithmetic progression," says Solymosi.

For a mathematician, an obvious question might be, if a hypergraph is an arbitrary graph, then how are vertices equated to integers? "Through geometry," states Solymosi. The subset of integers in a numerical progression represents order, as do subgraphs in hypergraphs. In hypergraphs, vertices become lines, where a set of yellow lines represents one set of points, blue lines another set of points, and red lines another. Every intersection of lines represents three edges. By applying the regularity lemma, every dense graph will contain a subgraph. Two triangle subgraphs form a "clique" when each graph shares a set of pairwise adjacent vertices (see illustration above).

Solymosi was one of the first mathematicians to apply the hypergraph regularity lemma in solving problems from number theory. He recently received a 2006 Alfred P. Sloan Fellowship, which is awarded annually to approximately 20 outstanding young mathematicians who received their doctorate degree from a college or university in the US or Canada less than six years ago. This year, he was the only mathematician from Canada to receive the award.

Using Removal Lemmas to Break Up Cliques

When we think of breaking up cliques, groups of catty high-school students comes to mind. The relationships involved in the study of cliques in graph theory are even more complex than those of teenagers, however. They raise many NP-complete (computationally intractable) problems, for example, what is the largest clique in a graph? Solymosi used a removal lemma that cracked the code of cliques. If a hypergraph contains just a few cliques, then after removing only few edges, the remaining hypergraph will not contain any cliques at all.

"That's the key to everything," exclaims Solymosi. "You can't have a few cliques nicely distributed in a hypergraph. If you do, then if you remove a few edges you destroy them all." Although mathematicians started investigating removal lemmas 15 years ago, Solymosi is credited for showing how they can be applied to number theory to solve difficult problems in mathematics. ■

Constance van Eeden: Promoting Statistical Science

Constance van Eeden's distinguished career as a mathematical statistician has spanned over five decades. Well known for her work in nonparametrics, van Eeden pioneered the field when very few women were in academia. Her career took her through a succession of academic positions, from the Netherlands to the United States to Canada.

Since her retirement from the University of Montreal in 1988, van Eeden has continued to make significant contributions in areas such as estimation in restricted parameter spaces, decision theory and selection procedures. She is a Fellow in the Institute of Mathematical Statistics and the Amercian Statistical Association, and an elected member of the International Statistical Institute.

For the past 18 years, UBC Statistics has been fortunate to have van Eeden spend each fall term in the department. Now an honorary professor, she has taught courses, supervised and mentored graduate students, conducted research, and enriched the department's learning environment in a great many ways.

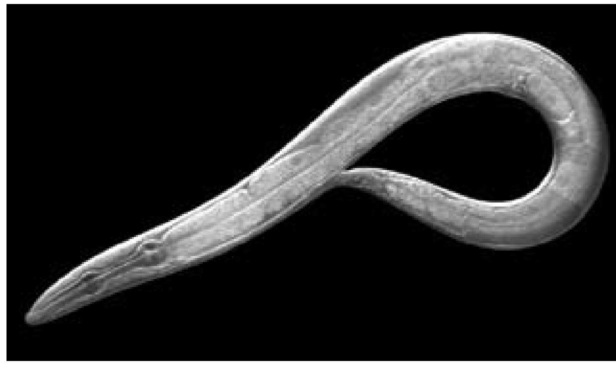
In 1998, she established the *Constance van Eeden Fund for Honouring Distinguished Achievement in Statistics* at UBC. Since its inception, this fund has supported activities such as the Statistician in Residence program, a lecture program, a summer school program, and admissions awards. These promote learning in statistical science, recognize distinguished statistical scholars and celebrate extraordinary achievement in the discipline.

Nematode Knockout

Mapping the Genetics of "Elegant Worms"

Photo: A. Rogula

Zoology professor Don Moerman and his lab grow and study mutant worms to try to decode the intricacies of cellular development. Moerman is director of the Michael Smith Laboratories C. elegans Reverse Genetics Core Facility, which supplies scientists around the world with mutants of this important model organism.



Caenorhabditis elegans—*a one-millimetre-long adult worm seen through a differential interference contrast microscope. (Photo: John Tyson)*

As a biological model for studying gene function—worms rule. *Caenorhabditis elegans* may be a simple nematode, but it has more than 7,000 genes in common with humans. Genes are specific segments of deoxyribonucleic acid (DNA) that are encoded to make ribonucleic acid (RNA) molecules, which form the proteins that regulate cell growth and behaviour. This cascade of molecular interactions allows cells to turn genes "on" and "off" and thus adapt to a changing environment or perform specialized functions in an organism. Research has indicated that malfunction of some of these genes in humans can lead to inherited diseases, susceptibility to cancers or other health problems. "Many of these genes are also found in the worm, and understanding their basic biological function could provide valuable knowledge for medical diagnosis and treatment of human disease," says UBC Zoology professor Don Moerman.

Providing Mutant Worms for Worldwide Research

Moerman is director of the Michael Smith Laboratories *C. elegans* Reverse Genetics Core Facility, which is funded by Genome Canada, the Canadian Institutes of Health Research, and the Canada Foundation for Innovation. In collaboration with an international consortium of *C. elegans* genomics laboratories, Moerman's lab has already identified close to 5,000 deletion mutations (in which a gene is "knocked out," or removed, in order to determine its function in an organism). However, 15,000 genes still remain unexamined. The goal of the current *C. elegans* knockout project is to provide the global research community with another 4,000 mutant strains of relevance to biomedical research and agricultural sciences. In particular, some nematode species are agricultural pests and others cause many human diseases (e.g. river blindness). Moerman's lab is also targeting worm-specific genes to help determine the best potential targets for the development of nematicides. All mutant strains derived from this project are placed in a central repository where they are available for ongoing research. "One important aspect of Genome Canada sponsored projects is to ensure the research remains in the public domain," states Moerman. "We provide deletion mutations to the global community, and this drives various types of experiments."

SAGE, GFP and other "Hi-Techniques"

Moerman's work on gene expression profiling involves an array of techniques and instrumentation to examine when, where and how genes are expressed during *C. elegans* development. For example, transgenic worms are tagged with green fluorescent protein (GFP), which lights up individual cells so researchers can determine the time and tissue expression pattern of the promoter (the DNA sequence that permits the proper activation or repression of the gene it controls). Since GFP can detect gene expression at the resolution of a single cell, it is an extremely powerful tool.

In addition, serial analysis of gene expression (SAGE) gives scientists

Advantages of Working with Worms

Nematodes are one of the most abundant organisms on the planet; there are roughly one billion nematodes in the first two centimetres of an acre of topsoil. The microscopic *C. elegans*, a common nematode, has one of the smallest genomes sequenced. With 20,000 genes and less than 1,000 somatic cells—which form the tissues, organs and body of an organism—the tiny, transparent worm is ideal for studying cell, tissue and organ function and development. The first multicellular organism to have its complete genome sequenced, *C. elegans* is the only organism that has a fully documented cell lineage. "We can trace the cellular development from division of the first cell to the formation of the organism," says Moerman, whose lab uses the nematode for a variety of projects.

The worm's short generation time of three days and lifespan of two weeks means that experimental procedures are also shorter, more flexible and more cost-effective than mouse or zebra fish models. And unlike the fruit fly models, nematodes can be frozen so that mutant strains can be used in future research. "*C. elegans* are hermaphrodites, and each animal will produce 250 to 300 progeny in three days," Moerman notes. "From a genetic standpoint, that's another big advantage, and from a biochemistry standpoint, it is easy to get a lot of material to work with."

For more information visit www.zoology.ubc.ca/~alorch/homepage.php an overview of a cell's complete gene activity and allows them to examine the expression of *C. elegans* genes in the whole organism. It works by capturing, identifying and counting RNA molecules. Using SAGE, more than 5,000 genes can be monitored simultaneously from a single cell type. Moerman, and his collaborators at the Michael Smith Genome Sciences Centre, have contributed a vast library of SAGE data to the public domain (see http://elegans.bcgsc.bc.ca). They are now exploring new methods of mining and presenting this data in order to gather more information on gene regulation and gene pathways.

C. elegans has 20,000 genes, of which 1,000 are transcription factors involved in regulating how genes are expressed. "Five percent of the genome is involved in directly regulating the other 95 percent," states Moerman. "Now that we have completed our SAGE program, we know that many of the key transcription factor regulators are actually expressed in a variety of different cells, but at a higher level in the cell in which they are thought to be a key regulator." As yet, the complete logic of these interactions still eludes researchers, and solving the puzzle of gene regulation is one of the holy grails of current research in developmental biology. By combining the data from GFP and SAGE analyses, Moerman hopes to obtain a more complete profile of where and when genes are expressed in *C. elegans* in order to determine the logic of transcription circuits.

Early Cell Migration and Muscle Morphogenesis

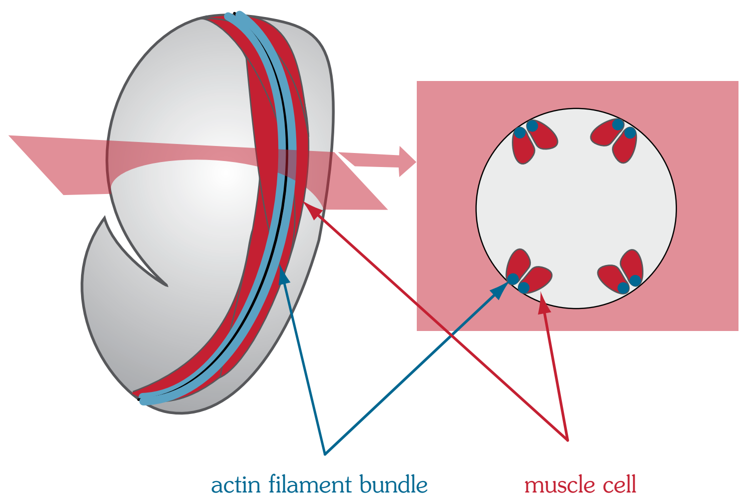
Despite advanced genetic and molecular biology research, scientists still do not know how cells in a developing embryo in any organism make their way to their final destination. Again, the simple worm is providing important clues to understanding early cell migration. In *C. elegans*, muscle precursor cells migrate to four distinct quadrants underlying the hypodermis, which forms the outer structure, or skin, of the organism. The process begins during early cell division and continues even into the early stages of elongation. In a sort of cellular square dance, the anterior daughter cell of a myoblast (a type of stem cell in muscles) moves toward the ventral quadrant of the emerging organism, and the posterior daughter cell migrates to the dorsal quadrant. (Daughter cells are the offspring of cell division.) Moerman's master's student Ryan Viveiros is using RNA interference and deletion mutations to determine which gene causes the precursor cells to misstep and migrate to the wrong place (see illustration below).

"We had no idea that these particular genes were involved in muscle migration," says Moerman. Muscle formation and development in *C. elegans* has been a lifelong focus of his research. In particular, Moerman has been studying the assembly of muscle sarcomeres, multi-protein complexes composed of different types of filaments, which are essential for muscle contraction and relaxation and thereby control all movement.

As with cell migration, muscle cell assembly is a highly choreographed affair. Thick myofilaments are composed of the protein myosin, and thin filaments are primarily composed of the protein actin. Although many components are the same, the orientation and length of these myofilaments vary within different types of muscle (such as heart or skeletal muscle), and within individuals (a marathon runner versus a sprinter), and between species.

Moerman's studies have shown that in initial sarcomere assembly, proteins outside of the cell attach to the transmembrane protein integrin, which in turn acts as an anchor for the assembly of the intracellular proteins of the sarcomere. His group has identified over 100 genes that encode structural proteins, which affect sarcomere organization and stability. Most of these newly identified proteins have human homologs and in most instances nothing is known about their function in humans. Moerman's lab continues to identify new proteins crucial to these processes and are working to determine just how these proteins participate in the structural dance of muscle development.

Discovering what genes and proteins are involved is only the first step, however. Moerman notes that the gene encoding the protein dystrophin was discovered in 1987, but there is still no treatment for muscular dystrophy—a devastating disease caused by a mutation in the dystrophin gene, which leads to the loss of dystrophin. "To understand this protein's role in muscular dystrophy, we must first understand how it interacts with other proteins, both during sarcomere formation and later on in development to maintain sarcomere stability," Moerman says. "Once we understand the function and interaction of these proteins, there is hope of developing a treatment." ■



Testing Relativity
Rare Binary Pulsars Show Einstein Right — Again

Astrophysicist Ingrid Stairs has built her career around stargazing. As key collaborator on astronomical surveys at renowned observatories around the globe, she is among an elite group who are discovering and tracking rare binary systems and other stellar phenomena.

Einstein's theory of general relativity (GR) postulates that an accelerating mass should emit gravitational radiation, or waves. GR is conceptually mind-boggling and mathematically brilliant, but tests of its predictions are difficult to perform. The discovery of the binary pulsar J0737-3039 by an international team has enabled stringent new testing of Einstein's theories—showing that he was probably right, as usual.

For Ingrid Stairs, assistant professor of Physics & Astronomy, binary pulsars provide the perfect timing mechanism with which to study GR and other theories of gravity. A pulsar is a neutron star, formed by the collapse of a massive star after a supernova explosion. It emits electromagnetic radiation in the form of radio waves that can be tracked and measured. The radiation intensity varies with a regular period, believed to correspond to the rotation period of the star. A binary pulsar is one that orbits around another star, and these are occasionally observed as double-neutron-star (DNS) systems. "Think of a pulsar as a lighthouse," explains Stairs. "Every time the star spins around, you get a blip of radiation." The regularity of these stellar "pulses" provides a precise astronomical clock, and binary systems allow astrophysicists to measure the relative effects of one star on another, providing the experimental means to test GR.

Tracking the Elusive Double Pulsar

With their discovery of the first binary pulsar system by Hulse and Taylor in 1974, the two scientists were the first to confirm Einstein's theory of GR using binary pulsars. For this work they later received the 1993 Nobel Prize in Physics. In the Hulse-Taylor system, the pulsar is locked in a tight orbit with another non-pulsar neutron star around a common centre of mass.

In the Milky Way, eight DNS systems have been discovered to date, and J0737-3039 is the only one that has been observed as a double pulsar. Its discovery in 2003 was all the more exciting for several reasons. Not only were both stars pulsars (called "A" and "B"), but they have a much tighter orbit than the Hulse-Taylor pulsar (2.4 hours compared to eight hours), and the stars are comparatively close together for binaries (900,000 kilometres apart). "That's the reason the relativistic effects are so big," explains Stairs. Her and colleagues' subsequent studies, led by Michael Kramer of the University of Manchester, have provided the most thorough and precise testing of GR in strong gravitational fields to date.

Along with other types of pulsars, DNS systems are discovered in large-scale sky surveys. During her first post-doctoral fellowship at Jodrell Bank Observatory in the UK, Stairs was part of a very successful multi-beam survey at the 64-metre Parkes telescope in Australia, which discovered nearly 700 new pulsars. It was in an offshoot of this survey that colleagues discovered the double pulsar.

By that point, Stairs' second post-doctoral experience at the US National Radio Astronomy Observatory had given her expertise with the 100-metre Green Bank Telescope in West Virginia—the ideal telescope to use for the double pulsar. As a result, Stairs and one of her students became involved in data collection, analysis and GR tests of the J0737-3039 binary system, using a precision instrument they developed in collaboration with UC Berkeley and Bryn Mawr. Meanwhile, Stairs and other members of her research group have been heavily involved in a new multi-beam survey using the 300-metre Arecibo telescope in Puerto Rico (see sidebar), hoping to find still more exotic binary systems.

Arecibo Pulsar Survey

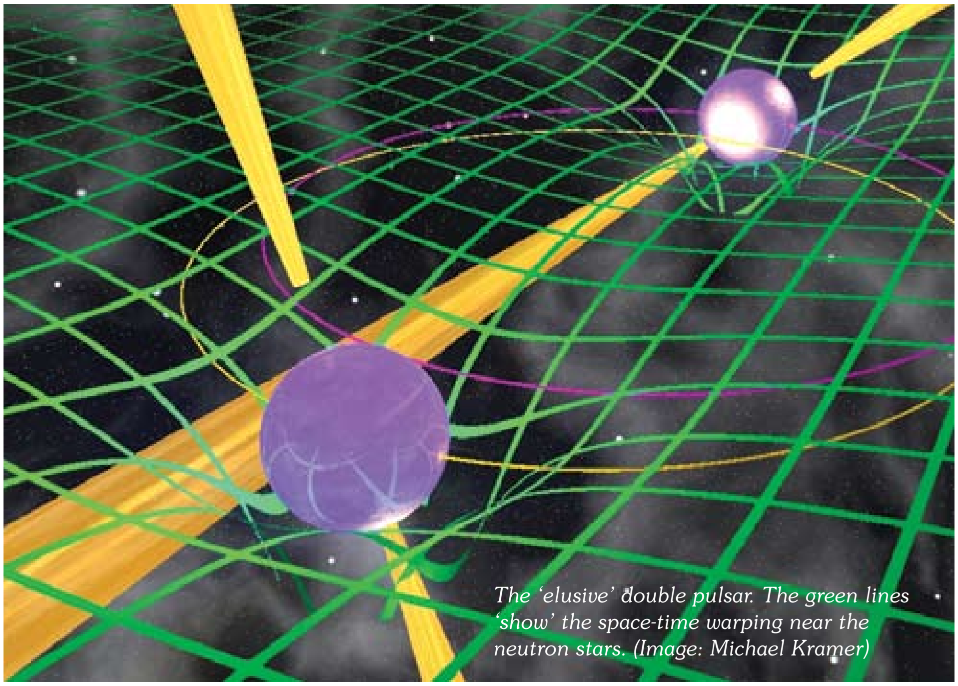
Stairs and her research group are involved in a large-scale pulsar survey using the Arecibo telescope in Puerto Rico, with the aim of discovering more and different types of pulsars to shed more light on their numbers and statistics. The large, 300-metre telescope is extremely sensitive, allowing researchers to detect different types of pulsars at much greater distances. They expect to discover between 500 and 1,000 pulsars in the survey.

One of the first finds in the Arecibo pulsar survey turned out to be a new relativistic binary. Led by Duncan Lorimer from the University of Manchester, Stairs and an international research group discovered the young binary pulsar J1906+0746. "We found the pulsar in September of 2004 and at first it looked quite ordinary," Stairs admits. "In May the next year we realized it was a binary." They have yet to determine exactly what the companion star is, but theories include a white dwarf and a recycled neutron star—the most likely candidate. "This pulsar is by far the youngest that we have seen in any binary system," notes Stairs. "The odds of observing one so early in its lifetime are small, so the fact that we discovered it at all indicates there are probably more than previously thought."

"The double pulsar is also fairly young compared to other DNS systems, and quite nearby," says Stairs. "This probably means that there is a fairly large number of these systems compared to what we thought before."

Applying New Pulsar Parameters

To test the relativistic effects of binary pulsars—or the distortion of their elliptical orbits—Stairs and colleagues measure the "Post-Keplerian" (PK) parameters, which are phenomenological corrections or additions to the simple Keplerian description of binary motion. They then compare PK parameters to the GR predictions. One PK parameter is the shift in the pulsars' elliptical orbits, which shows the extent of the space-warping



The 'elusive' double pulsar. The green lines 'show' the space-time warping near the neutron stars. (Image: Michael Kramer)

The Puzzle of Pulsars

With radii of roughly ten kilometres (the size of a small city) and masses about 1.5 times the mass of the sun (solar mass), radio pulsars are extremely dense. They also rotate at breakneck speeds, with spin rates less than 1.5 milliseconds to nearly ten seconds. Astrophysicists still don't know how pulsars emit radio radiation, although they surmise that the electric fields produced by these swiftly spinning magnets accelerate large numbers of particles, which emit radio waves coherently and simultaneously.

effects of GR. In J0737-3039, the point in the orbital motion of the system where the two stars are closest together (periastron) advances 17 degrees per year. This is four times higher than the rate in the Hulse-Taylor system.

Another astounding prediction of GR is that massive bodies slow down the passage of time. Measuring this slowing of time (time dilation) and the gravitational redshift, where light loses energy and shifts toward the red end of the spectrum when it moves away from a massive body, confirms Einstein's prediction that time slows down near massive objects. In J0737-3039, the combined effects of these phenomena delay the pulse signal by nearly 0.4 milliseconds.

Stairs and colleagues also measure two parameters in the Shapiro delay effect, in which light signals, when passing near a massive object, take slightly longer to travel to a target than if the object wasn't there. As well, they measured orbital decay, which corresponds to shrinkage of the pulsars' separation at a rate of seven millimetres per day.

Altogether, the researchers have observed six different parameters—including the mass ratio R of the two stars—that connect the two unknown masses of pulsars A and B. "By solving for the two masses using R and one PK parameter, we can then use each further PK parameter to compare its observed value with that predicted by GR," states Stairs. This method provides four separate tests for general relativity with the best having an uncertainty of 0.05 percent. In comparison, the Hulse-Taylor system was much less precise, confirming GR at the 0.2 percent level. The double pulsar test, taking advantage of the strong gravitational fields near the neutron stars, is an important complement to the GR tests available in the weak gravitational field of the Solar System.

Evolution of Double Pulsars

The discovery of the first observable double pulsar not only allowed Stairs and her collaborators to perform more stringent testing of GR, but it also led to new insights into the formation of DNS systems. These systems are formed when two massive stars undergo supernova explosions but still manage to stay gravitationally bound to each other. In J0737-3039, the first explosion formed the older A pulsar. When B's progenitor evolved, it transferred mass and angular momentum onto A, resulting in A being "spun-up" or "recycled" in a tight orbit around B's progenitor (the core of the star prior to undergoing supernova).

"Standard ideas about the formation of DNS systems would have insisted that the core of the progenitor star should have been at least 2.1 solar masses in order for it to undergo a supernova explosion at all," Stairs explains. The asymmetry observed in supernova explosions causes a recoil effect, or kick, that sends the neutron star off in some direction. As a result of their calculations of mass for A and B, and their more accurate measurements of the transverse velocity at 10 km/sec (the speed at which the entire system is moving in the plane of the sky), Stairs and collaborators have shown that the progenitor was probably much lighter than previously thought, settling a "weighty" debate in the astronomical community. "It possibly underwent a different type of supernova explosion altogether," says Stairs. ■

CWSEI: Carl Wieman Science Education Initiative

On January 1, 2007, Nobel laureate Carl E. Wieman officially joined UBC and the Department of Physics & Astronomy to lead an exciting $12 million science education initiative.

Over the past two decades, our understanding of how students learn has advanced considerably. Science education research has shown that for many students in "traditional" science lectures, learning equates to memorization of facts and problem-solving recipes, not useful understanding. For many, learning science is viewed as boring, irrelevant and unrelated to the world around them. Fortunately, there have been an increasing number of rigorous research results that suggest better ways of teaching and, more importantly, student learning.

Many UBC science faculty members are innovative teachers and have already embraced new approaches to student learning—a fact that formed a critical part of Prof. Wieman's decision to join UBC. One proven approach employs interactive computer simulations that enhance student learning of challenging concepts such as electrical circuits and electromagnetic waves. Simulations developed as part of Wieman's Physics Education Technology (PhET) project can be viewed on the Web at phet.colorado.edu.

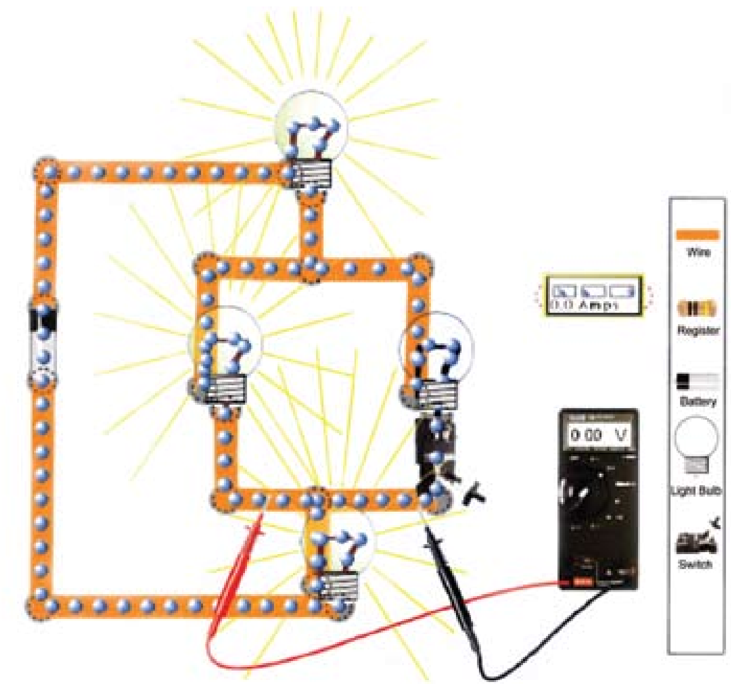
The primary mission of the Carl Wieman Science Education Initiative (CWSEI) is to support science departments in their efforts to provide an unrivalled education for all undergraduate students enrolled in their classes. The CWSEI seeks to transform the way the science departments approach teaching. This means working collaboratively with the departments to find ways to improve student education, without placing additional burdens on the faculty.

The CWSEI will pursue this goal primarily by supporting the exploration of useful and efficient ways to incorporate research on learning science—and on measuring the learning of science—into the standard educational practices of departments and faculty. It will also find ways to utilize—and develop as needed—effective, reliable and easily used educational technology.

In order to maximize educational effectiveness and efficiency, focus will be on three interconnected components: what students should learn, what students actually are learning, and improving student learning. Basically, the goal of the CWSEI is to make it possible for a department to establish the materials, structures and systems to ensure that these three components inform how every undergraduate course is taught, on a permanent basis. This is a major endeavour, but it is primarily a one-time effort with one-time costs—and with significant long-term payoffs.

Two science programs—Biology and Earth & Ocean Sciences—have been selected, on the basis of competitive proposals, to be the first departments to benefit from the new CWSEI teaching–learning innovations. Additional departments will be added in the coming year.

For more information on the Carl Wieman Science Education Initiative, visit www.vpacademic.ubc.ca/CarlWieman.



"Science education is a science in itself, and a scientific approach can be applied to optimize its delivery and impact."
– Carl E. Wieman

Carl E. Wieman—Highly Recognized Researcher and Teacher

Professor Wieman and his colleague Eric Cornell were awarded the Nobel Prize in Physics in 2001 for creating the world's first Bose-Einstein condensate, an unusual quantum state of matter that forms only at temperatures very close to absolute zero. In addition to the Nobel prize, Wieman has received numerous awards for teaching excellence, including the National Science Foundation Distinguished Teaching Scholar Award (2001) and the Carnegie Foundation's US University Professor of the Year (2004). He currently chairs the National Academy of Sciences' Board on Science Education.

Faculty of Science: Kudos

Congratulations to our faculty members on having been awarded these prestigious and well-deserved honours this past year!

Andrea Bunt, PhD student, Cristina Conati, Assoc. Prof., and Joanna McGrenere, Asst. Prof., Computer Science
- IUI Best Paper Award, Conference on Intelligent User Interface

Anthony Farrell, Prof., Zoology
- Award for Excellence in Fish Physiology, American Fisheries Society

Joel Feldman, Prof., Mathematics
- CRM-Fields-PIMS Research Prize, Centre de recherches mathématiques, Fields Institute, and Pacific Institute for the Mathematical Sciences

Bob Hancock, Prof., Microbiology & Immunology
- Canada's Health Researcher of the Year, CIHR Michael Smith Prize in Health Research, Canadian Institutes of Health Research

Phil Hieter, Director, Michael Smith Laboratories
- Fellowship, Royal Society of Canada
- Fellowship, American Association for the Advancement of Science
- International Research Scholar, Howard Hughes Medical Institute

Ander Holroyd, Assoc. Prof., Mathematics
- The Andre Aisenstadt Mathematics Prize, Centre de recherches mathématiques, Fields Institute and Pacific Institute for the Mathematical Sciences

Holger H. Hoos, Assoc. Prof., and Dave Tompkins, PhD candidate, Computer Science
- Canadian AI-2006 Best Paper Award, Canadian Conference on Artificial Intelligence

James Kronstad, Prof., Michael Smith Laboratories and Microbiology & Immunology
- Fellowship, American Association for the Advancement of Science

Joseph Luk, Sessional Lecturer, Computer Science (Karon MacLean's lab), et al.
- CHI Best Paper Award, 2006 Conference on Human Factors in Computing Systems

Andre Marziali, Assoc. Prof., Physics & Astronomy
- ALA Innovation Award, Association for Laboratory Automation

Robert Miura, Prof., Mathematics
- Leroy P. Steele Prize, American Mathematical Society

Don Moerman, Prof., Zoology
- Fellow, Canadian Institute of Advanced Research

Doug Oldenburg, Prof., Earth & Ocean Sciences
- AME BC Special Tribute, Association for Mineral Exploration BC

Moshe Shapiro, Prof., Chemistry
- The Willis E. Lamb Award for Laser Science and Quantum Optics 2007, Physics of Quantum Electronics

Alan Wagner, Assoc. Prof., Computer Science
- Cisco University Research Award, Cisco Academic Research and Technology Initiatives

Chris Waltham, Prof., and Scott Oser, Asst. Prof., Physics & Astronomy
- John C. Polanyi Award, Natural Sciences and Engineering Research Council

Alex Wang, Asst. Prof., Chemistry
- Young Investigator Award 2007, International Journal of Quantum Chemistry and John Wiley & Sons

Erich Vogt — Teacher, Mentor, Scientist

Erich Vogt recently added to his long list of honours and distinctions. In 2006, he was appointed to the Order of British Columbia. He also received the UBC Faculty of Science Achievement Award for Teaching.

Ever since joining UBC in 1965, Vogt has shared his contagious passion for the wonders of science with thousands of undergraduate and graduate students. Though he officially retired in 1994, he has remained a cherished fixture in UBC's first-year physics classrooms.

A top researcher in the field of nuclear physics, Vogt has published widely on theoretical physics. He has been a founder and prime mover behind TRIUMF, Canada's national laboratory for particle and nuclear physics based at UBC. He has also served on many nuclear and accelerator science advisory committees in various world-class institutes.

Professor Emeritus Vogt became a Fellow of the Royal Society of Canada in 1970, and an Officer of the Order of Canada in 1976.

Photo: Janis Franklin

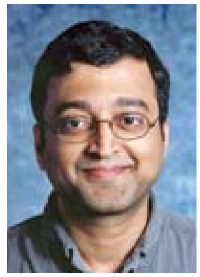
New Masterminds: Brain Gains at Science

Photo: Martin Dee


Chen


Gay


Harder


Pai


Pramanik


Rechnitzer


Wieman

The Faculty of Science welcomes our new faculty members in the nine departments.

Jiahua Chen, Prof., Dept. of Statistics; Canada Research Chair in Statistical Genetics; BSc Mathematics, University of Science and Technology of China, Hefei, Anhui, China; MSc Statistics, Institute of Systems Science, Academia Sinica, Beijing, China; PhD Statistics, University of Wisconsin-Madison, WI, US. Prior appointment: Full professor, Dept. of Statistics and Actuarial Science, University of Waterloo, ON, Canada. *Research:* A population of living organisms is often made up of non-uniform individuals possessing distinctive features that we cannot directly observe, such as different genes. My group studies and develops statistical models for analyzing data of non-homogeneous populations.
www.stat.ubc.ca/People/

Colin Gay, Assoc. Prof., Dept. of Physics & Astronomy; BSc Mathematics and Physics, MSc and PhD Particle Physics, University of Toronto, ON, Canada. Prior appointment: Assoc. Prof., Yale University, US. *Research:* My lab studies the basic particles and forces in nature at the highest energy levels available. My current project, the ATLAS experiment, is located at the Large Hadron Collider in Geneva, Switzerland.
www.phas.ubc.ca

Kenneth W. Harder, Asst. Prof., Dept. of Microbiology & Immunology; BSc Cellular & Molecular Biology, Simon Fraser University, Vancouver, BC, Canada; PhD Genetics, The Biomedical Research Centre, University of British Columbia, Vancouver, BC, Canada. Prior appointment: Research Associate, The Ludwig Institute for Cancer Research, Melbourne, Australia. *Research:* Based on rodent models of infection and cancer, we investigate key gene products and signalling pathways that control cells of the immune system. Ultimately, we hope to identify causes of inappropriate immune responses and to help enhance resistance to pathogens and tumours.
www.microbiology.ubc.ca/kharder.htm

Dinesh K. Pai, Canada Research Chair in Sensorimotor Computation and Prof., Dept. of Computer Science; BTech Indian Institute of Technology, Madras, India; MS and PhD Cornell University, Ithaca, NY, US. Prior appointment: Professor, Rutgers University, NJ, US. *Research:* I am interested in the principles that enable humans and robots to move and interact with their environment using sensory information. My work involves computational and physical modelling, with applications to computer graphics, biomechanics, haptic interfaces, and auditory displays.
www.cs.ubc.ca/~pai

Malabika Pramanik, Asst. Prof., Dept. of Mathematics; BStat, Indian Statistical Institute, Kolkata, India; MStat, Indian Statistical Institute, Bangalore, India; PhD Mathematics, University of California, Berkeley, CA, US. Prior appointment: Fairchild Senior Research Fellow, California Institute of Technology, Pasadena, CA, US. *Research:* My research area is harmonic analysis. We study mathematical objects by breaking them into simpler pieces and analyzing how the properties of the pieces are reflected in the original objects. This research has implications for math and physics applications, in seismic/medical imaging and signal processing.
www.math.ubc.ca/~malabika

Andrew D. Rechnitzer, Asst. Prof., Dept. of Mathematics; BSc and PhD Mathematics, University of Melbourne, Australia. Prior appointment: ARC Post-doctoral Fellow, University of Melbourne, Australia. *Research:* There are many problems in mathematics that boil down to a question of counting discrete objects. I use techniques from this area of mathematics to study problems in theoretical chemistry and statistical physics.
www.math.ubc.ca/~andrewr

Carl E. Wieman, Director, Carl Wieman Science Education Initiative (CWSEI); BSc Physics, MIT, Cambridge, MA, US; PhD Physics, Stanford University, Palo Alto, CA, US; Doctorate of Science (Honorary), University of Chicago, IL, US. Prior appointment: Distinguished Professor of Physics, Director of the CU Science Education Initiative, University of Colorado, US. *Research:* The CWSEI is an effort to work collaboratively with UBC departments on finding ways to improve student education in science. The CWSEI's focus will be on achieving sustained departmental-wide change, and will rely on the use of relevant science education research results and technology to achieve these goals.
www.vpacademic.ubc.ca/CarlWieman

Portrait: The Department of Chemistry

Since its start with the founding of the university, Chemistry on the Point Grey campus has grown to occupy more than 150,000 square feet of teaching and research space in the heritage-designated Centre Block and four adjacent buildings. There, 46 professors direct the research programs of 211 graduate students, 47 post-doctoral fellows and many undergraduates.

UBC Chemistry faculty and students study the molecular properties of matter under an incredible range of conditions—from molecular beams and ultra-cold condensates to living systems. Our researchers have developed atom-efficient catalysts for the synthesis of novel polymers, controlled the architecture of complex organic molecules to confer anti-cancer properties, built nanostructures with unique sensing and gas storage capabilities, devised new fuel-cell strategies, invented next-generation instruments and techniques for chemical analysis, advanced our understanding of enzymes and other protein systems, identified new agents of climate change, and, through experiment and theory, explained the dynamics of chemical reactions at a fundamental level.

Students and faculty in Chemistry have won recognition for their scholarship and academic accomplishments. Among 211 current graduate students, 39 have earned NSERC Graduate Research Fellowships. Another 25 hold University Graduate Fellowships, and this year, two of our students won the inaugural MEC Graduate Research Fellowship in Sustainability. Eighteen faculty members are Fellows of the Royal Society of Canada. Nine have received Canada Council Killam Fellowships and 27 have won at least one national or international award. The department is home to five Canada Research Chairs and two NSERC Industrial Chairs. In a typical year, our faculty publishes 400 papers and files more than a dozen invention disclosures.

Discoveries in our department have led to such advances as Visudyne, a widely used drug for the treatment of macular degeneration, and Fourier transform ion cyclotron resonance spectroscopy, the world's highest resolution form of mass spectrometry. UBC Chemistry has attained international historical landmark status for discovery of the first compounds of the Noble Gases.

Departmental researchers come together with cross-campus collaborators in centres funded by the Canada Foundation for Innovation. The Laboratory for Molecular Biophysics, for instance, provides a forum for inter-faculty research and advanced instrument development for the chemical analysis of living systems. Researchers in the Centre of Higher-Order Structure Elucidation work together to integrate a computational and theoretical understanding of the form, function and fluctuation of complex molecules towards more effective design and synthesis. The Laboratory for Advanced Spectroscopy and Imaging Research targets four key research areas, including laser chemistry and spectroscopy, new materials, environmental science, and catalysis. Efforts originating in our department are spurring the development of a UBC centre for science in sustainability.

In addition to its research presence, Chemistry plays an enormous role in science education on campus. Academic majors in a wide range of disciplines—including physics, biology, engineering, agriculture, and the arts—require instruction in chemistry. Each year, more than 12,000 students are enrolled in the department's 50 undergraduate courses, 21 of which include laboratory work. Our faculty members pursue this mission with a zeal recognized by numerous university and national teaching awards.

By virtue of its Chemistry department, UBC has built a world-class research presence in a central science. With its commitments to excellence in teaching and to progress in achieving a healthy, prosperous and sustainable society, the department eagerly embraces its role in serving the citizens of British Columbia, Canada and the world. www.chem.ubc.ca

Shells—Hebb Killam Gift to the Beaty Biodiversity Museum

The UBC Beaty Biodiversity Museum, scheduled to open in 2009, has received an impressive donation—an extensive shell collection and a library of associated literature. This unique collection—representing over 40 years of work—belonged to Mrs. Evelyn Hebb Killam, who had a great appreciation for conchology. Throughout her lifetime, Mrs. Killam enthusiastically collected, meticulously identified and catalogued over 42,000 shells from around the world. This historically significant collection will be publicly displayed in the new museum. It will also serve as an invaluable research and teaching resource, providing observations on evolution, ecology and population biology. The *Evelyn Hebb Killam Shell Collection* is a valuable addition to UBC Science's marine invertebrate collection and will complement the existing insect, terrestrial vertebrate, fish, fossil, and plant collections—all to be featured in the new Beaty Biodiversity Museum.

Photo: Courtesy Trek Magazine

People at UBC Science

Shona Ellis: Walk on the Green Side

Photo: Elaine Simons

Perhaps growing up in the forested hinterlands of Ocean Falls, BC, inspired Shona Ellis to become a master teacher of all things green and growing. Her germination in Botany and flowering in Plant Physiology were nurtured at UBC, where she has matured into a talented lecturer, lab instructor and course coordinator in the Department of Botany, the Biology Program and the Faculty of Science.

Science students have repeatedly nominated her for the Faculty's Killam Teaching Award, which she has won twice. She has also twice received the Just Desserts award from the Science Undergraduate Society for service to the student body. Students in the 21 courses she has taught since 1998 have given her an extraordinarily high mean score of 4.88 out of five on quantitative teaching evaluations.

Ellis has a passionate and interactive teaching style. She ensures that her students are directly involved with living organisms, in the lab and in the field—you'll find students digging in the UBC Farm gardens, or searching for the "elusive" Takakia moss on Jervis Inlet. She stimulates student curiosity and fascination with the importance of plants to humans and to the environment.

A green ambassador beyond UBC, Ellis shares her special fascination with mosses and liverworts, and with bog ecosystems, at various community events. She mentors high school students in her labs and leads activities for Greater Vancouver Regional Science Fair participants. She also is involved with UBC Connect and Aboriginal summer science camps such as the CEDAR project, programs to attract grade school students to post-secondary education, and with Science 101, a program for Downtown Eastside residents. This past summer, the Science 101 students selected Ellis to speak at their graduation.

You can find a link to Shona Ellis' teaching e-portfolio at www.botany.ubc.ca/people/shona.htm.

Pacific Museum of the Earth—Treasures for Public View

The new display vault at the Pacific Museum of the Earth (PME) at UBC is complete. The vault displays the museum's gem and precious metal treasures—exhibits not previously available for public viewing. A partnership between the university, the Pacific Mineral Museum Society and industry supporters, the PME exhibits diverse wonders of the earth, from the core to the stratosphere, including minerals, rocks, fossils, and even a dinosaur skeleton. With its commitment to educational outreach, the museum is a valuable resource for the university, the community, and local elementary and secondary schools. Student visitors enjoy interactive experiences. And the PME Teacher's Resource Centre provides teachers with reference materials that complement BC's science curriculum. For more information or to schedule a tour, call 604-822-6992 or visit www.eos.ubc.ca/public/museum.

With Thanks!

Over the past several years, the UBC Faculty of Science has been fortunate to have the loyal support of alumni, friends and community-minded companies and organizations. The current academic year is no exception.This significant philanthropy helps us provide premier experiences for students, attract and retain talented faculty, and develop programs that fuel discoveries and train the next generation of scientists. Whether supporting an exceptional student, a research scientist on the brink of discovery, or the tools of innovation, your generosity to UBC Science enables us to excel and advance at all levels. If you would like to learn more about supporting UBC Science, contact André Zandstra, director of Development, at 604-822-8686 or andre.zandstra@ubc.ca.

Printed with UV inks (emit no VOCs) on 100% post-consumer recycled paper (no new trees used). Based on the choice of this paper, the following natural resources were saved: **Trees saved.** 34. **Wood saved.** 8,805 kilograms. **Water saved.** 108,047 litres. **Landfill reduced.** 1,373 kilograms. **Greenhouse emissions reduced.** 2,663 kilograms. **Energy reduced.** 40,765 megajoules.

CANADA POST POSTES CANADA
Postage paid Port payé
Publications Mail Poste-publications
40589566

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

SYNERGY » JOURNAL OF UBC SCIENCE
Published by the Faculty of Science, The University of British Columbia (UBC)
Web. www.science.ubc.ca
Fax. 604.822.5558
E-mail. synergy.science@ubc.ca
Editor. Carola Hibsch-Jetter, UBC Science
Writers. Mari-Lou Rowley, Pro-Textual Communications (research articles); Ed Grant (Chemistry portrait)
Circulation. 30,000 (two issues per year)
Layout/Artwork. www.mediagroup.ubc.ca
Photos. Provided by UBC Faculty of Science or as indicated.
Printed in Canada on recycled paper.