THE UNIVERSITY OF BRITISH COLUMBIA

SYNERGY » JOURNAL OF UBC SCIENCE

ISSUE 1|2006

Words from the Dean

Synergy is about sharing creative energy. The same could be said for mentoring. Mentoring is more than good teaching—mentors guide and advise, building trusting relationships within which they share their knowledge and experience. In academia, your mentor can be your peer, your teacher, your senior colleague. One common aspect of mentoring is the transmission of not only knowledge, but of love for the subject matter and the possibilities for engagement.

My first mentor was my high school science teacher, Mrs. Sanford. She was passionate about her teaching and, through fostering my specific interests, she got me hooked on physics and math. I pursued their study at the post-secondary level.

After I had completed four years of physics and math undergraduate work, I borrowed a book about oceanography from my former college roommate. This book showed it was possible to apply the physics I had learned in the classroom to studying the dynamics of the ocean. This was a 'eureka!' moment for me, and a career-changing decision ensued.

In 1967, I became a summer student fellow at the Woods Hole Oceanographic Institute on the eastern coast of the US, working one-on-one with renowned physical oceanographic researchers Hank Stommel and Ferris Webster. They taught me research methods and how to think about problems—fundamental skills I would use throughout my career. Their dedication to research and excitement about science was contagious—they were two more mentors on my science career path.

In the fall of that year I entered MIT for my PhD degree in physical oceanography. It was a demanding program. But the rigour was balanced by all the positive aspects: the expectation of our success by the professors and the mentoring that all graduate students got from the profs. The supportive and stimulating environment I had during my graduate program gave me the confidence to tackle difficult and interesting problems.

In 1973, I was invited to join an inter-university interdisciplinary oceanographic research group. Sampling on the same ship and working together on solving research problems led me and my fellow researchers into stimulating careers, lifelong friendships, and most importantly, colleagues we could trust. Mentoring played a part in many of my interactions. In the early days, the senior scientists in our group took care of most of the administration as the younger researchers learned leadership skills for the future. Supervising graduate students was a learning experience for me, as well as for them. Our team grew, initially within Canada, then internationally, so I benefited from perspectives shared by new colleagues from around the globe.

The Faculty of Science at UBC enhances learning by linking students to exciting teachers and stimulating ideas. I am always looking for ways to increase mentoring opportunities in the classroom, the research laboratory and in field programs. Mentoring is a powerful way to nurture a learning and working environment in which independent thinkers can develop and in which students can acquire networking and other skills crucial for a successful career in any field.

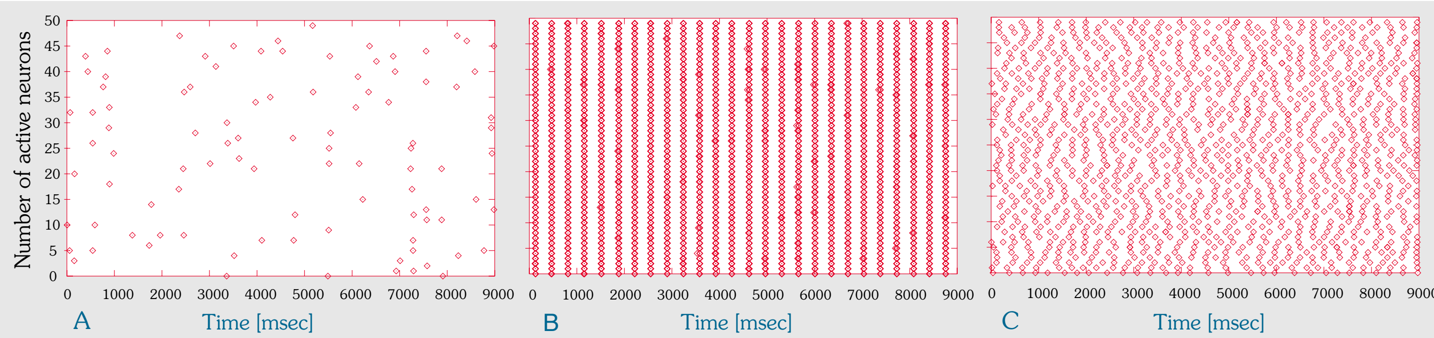
Communicating one's ideas and enthusiasm is important at all stages in academia. *Synergy* is one way we at the Faculty of Science have chosen to share science with others—and in these pages there may be a 'eureka!' moment waiting for you. But it is through two-way communication that we all learn. We welcome your comments at any time (synergy.science@ubc.ca). The exchange of ideas benefits us all.

R. Grant Ingram,
Dean *pro tem*, UBC Faculty of Science

(Photo: Janis Franklin)

Modelling Flux and Flow

Mathematical Analysis of Physical Processes



The firing of neurons, the fluid flow in hydraulic fractures, the oscillations in chemical interactions, and machine tool vibrations all comprise the dynamic flux of daily life. For mathematician Rachel Kuske, these physical processes pose compelling and often strikingly similar mathematical problems.

There is nowhere in the world that a place of absolute stillness exists—except perhaps in the mind of a highly-disciplined yogi. The human body, on the other hand, plays host to an ongoing plethora of physical processes. Everything in and around us is in a constant state of flux and flow. Rachel Kuske, Canada Research Chair in Applied Mathematics, combines various mathematical approaches to understand and predict the effects of random fluctuations, perturbations and oscillations in a wide array of disparate systems.

Chatter and Noise in Machine Tooling

Studying the mechanical flux of machine tool vibrations is one of the more practical applications of her work. Commonly known as "chatter," the vibrations caused by instabilities in machine tooling processes such as metal cutting, milling or drilling can result in machine wear or damage, poor workpiece quality, reduced productivity, and physical noise. In machine tool dynamics, particularly in high-speed machining and virtual machine tools, chatter prediction is a crucial component in the design process.

An initial step in designing mathematical models that describe chatter requires answers to the questions: what is the most detrimental way in which noise could affect the machining process and where is it likely to occur? Variations in material properties, the speed of a system, and cutting or drilling geometry can all cause instability and chatter. To date, most analytical and computational studies have focused on these deterministic dynamics.

Kuske's work has taken the analytical process a step further, by considering the effect of the noise from the process or materials on the chatter. When noise is included, the deterministic methods for studying machine tool models break down. A typical feature for these models is variations in cut depth from previous rotations, which can feed back into the system to excite further vibrations, causing a phenomenon called "regenerative chatter." "Mathematical methods are typically less well-developed for complex models with memory than for those without," explains Kuske. Including memory into the model, which takes into account the time delay between cuts, adds another dimension to the problem.

Kuske and colleagues have developed a stochastic model that considers the effect of random variations in material properties in order to better predict behaviour in machining processes. What they discovered was surprising. For example, one would expect random fluctuations in cutting processes to produce rough and irregular pieces. However, Kuske and colleagues discovered

Synchronizing the activity of nerve cells plays a very important role for information processing in our neural network. Mathematical models can help to capture the basic behaviour of neurons jumping from a silent into an active phase, and to analyze how many (active) neurons are needed to activate the entire neural network. An ideal level of noise, or the effects of randomness in this system's behaviour, yields synchronization represented by regular bands (B). This indicates that all neurons are active at the same time, while too little (A) or too much noise (C) induces erratic activity where the different neurons are active at different times. (Source: Bulletin of Mathematical Biology, 2006; reproduced with permission of the Society of Mathematical Biology) that the resonance effect of the noise actually produces periodic behaviour in the tooling process that looks as if it is regular (i.e., a flaw in a piece of lumber appears at equal intervals). The noise, in effect, amplifies oscillations that should normally die out.

"It is like a mutual amplification; you can either view it as the noise being amplified or the periodic behaviour being amplified," says Kuske. "And if you run a simulation, how do you know that this regular-looking oscillation is coming from noise or from something else? This is part of what we are trying to explain—why a noisy, irregular event can cause something that looks very regular."

Noise Sensitivity and Neuronal Bursting

Many physical systems can be described by interacting, or coupled, oscillations, such as timing or reaction mechanisms in chemical and biological processes, or interactive lasers in communications and optics. Kuske has studied the phenomenon of "localization," where the oscillations of one component are small compared to the oscillations of another component. Localization can limit the propagation of an electrical impulse, the power of a laser array or the life of an engineering structure. In recent research on cellular neurobiology systems, Kuske combines analytical methods involving both localization and noise.

"Neuronal bursting" refers to the periodic pattern of electrical activity in individual nerve cells and neuronal networks as well as in secretory and muscle tissue. In excitable cells, the pattern alternates between an active phase of rapid oscillations and a silent phase of slowly changing membrane potential. Neuronal bursting involves an interplay between fast oscillations that occur during the active phase of a nerve cell, and small modulations that are associated with its silent phase.

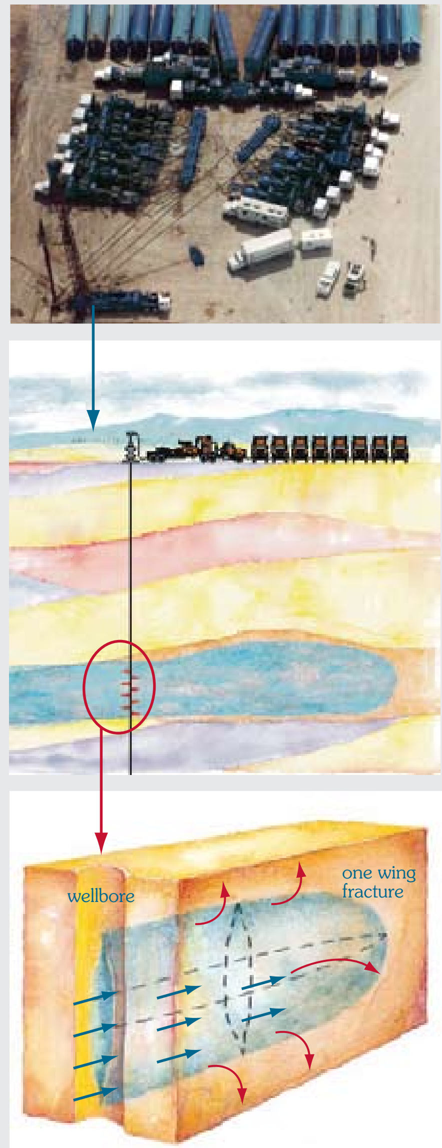
Cellular neurobiologists are trying to determine whether the activity of a neuronal network depends upon the size of dendritic spines—small bulbous extensions on individual dendrite fibres—and whether dendrite growth is related to spending more time in the active phase. Elliptic bursting is one type of neuronal bursting in which small oscillations are found in the silent phase and where oscillations in the active phase have a particular structure. Kuske developed a simple stochastic model to study elliptic bursting in single dendrites using a combination of asymptotic approaches (methods of classifying limiting behaviour by concentrating on a specific trend).

Previous methods used numerical simulations to examine random behaviour. Kuske borrowed concepts from the machine tool problem to study how biological noise might amplify neuronal oscillations and catalyze the transition from one state to another. Here, "noise" refers to synaptic vibrations from various types of neural activity and thermic noise associated with blood flow and other cellular processes. Her methods have shown that noise—or the input a particular dendrite spine is feeling from all of the other cellular activity—can affect the amount of time a system spends in the active phase. "There is a big difference between how much noise affects the transition from active to silent phase, compared to the transition from silent to active," she notes. "We want to be able to quantify that difference."

Kuske and colleagues also investigated the notion of feedback in elliptic neuronal bursters. "If a neuron receives a lot of stimuli and goes into the active phase, it can affect the conductivity of the whole neural net, which in turn will cause that neuron to go back into the silent phase for awhile." Kuske explains. "One goal is to examine how the length of time a neuron spends in the active phase affects the physical growth of the entire neuronal network."

Neural Net Synchronization

One phenomenon observed by EEG analysis (electroencephalography) of neural networks is large-scale synchronization. This is extremely important in the thalamus of the brain, which regulates sleep/wake cycles and attention. Some theories propose that synaptic and thermic noise plays an important role in the information processing and synchronization of neurons in a neural network. An optimal level of noise could boost



The structural dynamics of hydraulic fractures are important for oil recovery. Injecting fluids at high pressure creates an extremely conductive path for oil or gas recovery. Kuske's analysis of mathematical models for these fractures aims at explaining what happens at the tip of a fracture and account for the simultaneous processes involved in a hydraulic fracture. (Images: Courtesy of Schlumberger) subthreshold activity, pulling one neuron into an active phase, and thereby exciting nearby neurons into activity as well, in a domino-like process. Kuske is working on methods to analyze the probability that a certain number of neurons will jump into the active phase, and what this number needs to be to produce a high enough electrical current to activate the entire neural network.

This research has important implications in neurobiology and the understanding of synchronization. Although it is critical for functions such as attention and sleep/wake regulation, for people suffering from epilepsy, neural net synchronization can contribute to seizures. Here, a bit more chaos is better. Kuske and colleagues analyzed and streamlined the Hindmarch-Rose model of thalamic neurons to better capture the basic behaviour of various neuron models. Their Resonant Integrate and Fire (RIF) model depicts similar silent-phase dynamics but simplifies active-phase dynamics. What she and her colleagues have shown is that understanding what is happening during the silent phase is crucial, because that is where the noise is having the biggest effect. "The analysis also tells you in some sense why and how a simple model can explain a more complex model."

Structural Dynamics of Hydraulic Fractures

Another key area of Kuske's research pertains to structural dynamics of physical systems, such as hydraulic fractures, which are a result of pressure exerted by a viscous fluid on a fracture in rock. These fractures occur naturally in volcanic dykes and seismic activity, or as a result of geological exploration and oil drilling, where fluid is used to bore into rock. The mathematics of these models is extremely complex and must account for the non-linear effects of the flow of fluid in the fracture, deformation of the rock, fracturing and creation of new surfaces, and fluid leak-off. In addition, the model must account for the history dependence governing the exchange of fluid between the fracture and the rock. "Again, the concept behind history dependence is somewhat similar to the delay in the machine tool model," says Kuske. "What is going on at the tip of the fracture actually affects what is happening behind it." She and her colleagues used asymptotic methods to determine what happens at the tip of a fracture. This information can be built into a larger numerical model that analyzes all of the simultaneous processes involved in a hydraulic fracture. Their work is significant because not all current computational models incorporate information about the fracture's tip behaviour. "This work could be of interest to a number of people, not only those involved in mineral exploration and oil recovery, but researchers trying to model other fractures in the earth," she states.

Kuske is driven—and invigorated—by the interdisciplinary nature of her applied mathematics. "I find similar problems are surfacing in a host of different applications, so discovering structural similarities between models is extremely exciting." ■

The Crystal Chemistry of Colour

Hunting for Canada's "Hidden" Gems

From the atomic level of crystal chemistry to geological field work, UBC professor Lee Groat is working to uncover Canada's emerald deposits, the mystery behind the colour of blue beryl, and the correlations between composition, crystal structure and formation of related minerals.

From ancient times, emerald has been considered one of the rarest, most beautiful and valuable gemstones. No wonder that its discovery in Ontario, the Yukon and Northwest Territories caused a stir among mineralogists and mining companies around the world. Mineralogy and crystallography professor Lee Groat in the Department of Earth & Ocean Sciences has studied beryl deposits in northern Canada to discover the nature and location of mineral formation and the mysteries of gemstone properties and colour—specifically, the unique deep-turquoise stones so far found only in the northern Yukon.

Emerald was first discovered in Canada in the 1940s, near Dryden, Ontario, but it wasn't until 1998 that the first major, and accidental, discovery was made by former UBC student Bill Wengzynowski. "Bill was working with Expatriate Resources, looking for copper, lead and zinc deposits, when the gem-quality beryl was found," says Groat, who X-rayed the sample and classified it as emerald. "It was a pretty exciting project that took over my life for a few years."

Over the next several years, Groat and colleagues Jim Mortensen of UBC and Dan Marshall of SFU were involved in several geological and mineralogical studies of beryl deposits in the Canadian Shield and Cordilleran regions. The three main emerald occurrences are located at Tsa Da Glisza (formerly Regal Ridge) in southeastern Yukon, Lened near the Yukon-Northwest Territories border, and the Taylor site in northwestern Ontario.

From Atomic Microcosm to Macrocosm of the Field

Emerald is defined as green gem beryl, with a chemical composition of beryllium, aluminium, silica, and oxygen ($Be_3Al_2Si_6O_{18}$). The colour of emerald is usually related to minor amounts of chromium, and depends not only upon the mix of elements but on the interplay of atoms in the crystal lattice. Emerald deposits have different characteristics in different geographical areas. At the macroscopic level, Groat's research in the mineralogy of gemstones is akin to geological detective work: first, in considering the characteristics of the sites and the rock in which beryl is discovered; second, in identifying factors such as the ratio of elements like magnesium and iron found in tourmaline minerals and their proximity to emerald mineralization; and third, in analyzing how the elements combine to form various types of beryl and gem-quality emerald.

At the microcosmic level, Groat uses advanced crystallography techniques such as single-crystal X-ray diffraction, neutron diffraction, and electron probe microanalysis to assess the unique molecular characteristics of minerals and gemstones.

Scientifically Unearthing Canada's Emeralds

Emeralds are rare because a main element of their composition, beryllium, is not usually found in the same area as chromium and vanadium, the trace elements that produce the emerald green colour. For instance, chromium is associated with oceanic rocks and beryllium is predominantly found in granitic rocks, explains Groat. "For emerald, you have to get beryllium together with chromium and these elements tend not to travel in the same geological circles."

Exploration companies want answers to questions such as: what are the characteristics of a site that promote gemstone formation, and how can deposits be more easily located? Groat has been working with industry partners True North Gems Inc. and Archer Cathro & Associates (1981) Ltd. to evaluate Canada's three main emerald occurrences. In each case the geology is strikingly different. In the Tsa Da Glisza site, the source of beryllium is granite and the source of chromium is the host rock, a mica schist. The emerald found in Ontario occurs right next to a granitic rock, not at a distance from it—at least several hundred metres—as at the other two sites. "It looks like the granitic material was mixed up with a schist to form an unusual black rock that has emeralds in it, so we are trying to explain how that happened," says Groat. In the Lened area, the source of beryllium is a mystery. "It is probably coming from nearby granite, but that granite doesn't have much beryllium in it," notes Groat.

The emeralds found in the Lened site have another unique characteristic—their colour comes from traces of vanadium, not chromium. "When people first realized that vanadium could cause great colour as well, there was a huge debate as to whether this type of beryl was really emerald," says Groat. Today, gemologists have relaxed their views. Since emeralds are notorious for having cracks and inclusions, it is the quality of the gem, not necessarily the type of colour-creating mineral, or chromophore, that determines its value.

Groat's work involves characterizing mineralized zones and the minerals in host rocks, and doing geochemical analyses to determine the sources of the chromophores in the beryl and emerald. In one method, Groat obtains stable isotope compositions with help from colleagues at UBC's Pacific Centre for Isotopic and Geochemical Research (PCIGR). These enable him to assess the nature and origin of fluids that lead to the formation of beryl/emerald, thereby providing molecular clues as to chromophore sources.

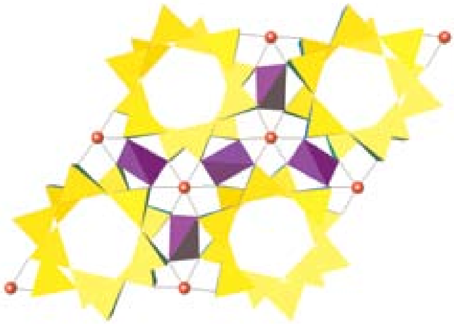
Tracking Canada's Rare Blue Beryl

In the summer of 2003, armed with a geologist's arsenal of equipment and aided by graduate students Heather Neufeld and Dawn Kellett, Groat and Wengzynowski took to the field in search of emeralds. Their work was exhausting and intense, but yielded another amazing, and accidental, find 100 kilometres northwest of the Tsa Da Glisza site—a brilliant dark blue beryl the colour of cobalt. A light blue specimen was found in 1976, but it wasn't until October 2003 that Groat identified it—along with the samples they had collected that summer—as true beryl. Their find attracted media attention across the globe. Canadians had unearthed their own unique, gem material. "The question of its value still depends on how much of it there is, and how much can be cut into gemstones," says Groat.

Blue gem beryl is commonly known as aquamarine, and its colour is due to iron, which is also not usually found in appreciable

Beryl
$Be_3Al_2Si_6O_{18}$

Pure beryl is "colourless." Its crystal structure (see below) is made up of silica oxide tetrahedra, SiO_4 (yellow), forming rings, which in turn are linked via beryllium oxide tetrahedra BeO_4 (purple). The red spheres represent aluminium oxide octahedra (AlO_6). Minor amounts of chromium, vanadium or iron replacing aluminium can change the colour of the gem significantly (see next page; photos: Lee Groat).



Emerald
$Al^{3+} \leftrightarrow Cr^{3+},V^{3+}$

Aquamarine
$Al^{3+} \leftrightarrow Fe^{3+}$

Dark Blue Beryl
$Al^{3+} \leftrightarrow Fe^{2+}$

quantities with beryllium. The deep blue of the Canadian beryl renders it gemmologically distinct, and the stone has created a stir in the research community because as yet scientists don't know exactly what causes the blue colour in aquamarine. "We know it involves iron, but we don't know the mechanism," admits Groat. "And since the dark blue beryl has more iron than normal aquamarine, we thought it would be a good material to use to try to solve the problem."

Canadian blue beryl samples have been studied in labs around the world. Groat's colleague George Rossman at the California Institute of Technology, is a world expert on colour in minerals. He believes that deep blue beryl might be the result of a yet undiscovered physical mechanism in crystal colouring. Groat has been working to understand the nature of the brilliant colour at the atomic level. "We think it might be a very small amount of iron that is sitting in a position in the crystal structure that is usually empty," he explains. "The difficulty is that it is probably such a minute amount that we don't see it with techniques like X-ray and neutron diffraction. "The colour of this dark blue beryl is turning out to be a fascinating and very complicated problem."

Characterizing Borosilicate Minerals

Among the many minerals that Groat studies, the borosilicates are some of the most chemically and structurally complex. They are found in pegmatites—course-grained igneous rock that contains exotic elements and gemstones. Boron, a primary element, plays a significant role in the evolution of geological systems through its influence on elemental transport processes. The occurrence of borosilicate minerals is important because they provide information on the behaviour of boron during these processes.

Groat's recent work involves the crystal characterization of the borosilicate mineral holtite, represented by the formula $[(Ta,\square,Al)Al_6(BO_3)(Si,Sb,As)_3O_{12}(O,OH\square)_3]$. The blank squares in the formula represent missing atoms. Even to the non-chemist, the structure is obviously extremely complex. Tantalum, a main element in holtite, is of increasing economic importance. Tantalum is used in aircraft manufacturing to make steel and in the electronics industry for capacitors. Because it is inert, impervious to body fluids, and well tolerated by the body, it is widely used in surgical implant procedures. Tantalum oxide is also used to make high-index glass for camera lenses.

"I began studying these minerals in 2000, because I realized that many questions concerning their stability and crystal chemistry remained unanswered," says Groat. "In particular, the role of heavy metals, hydrogen, and vacancies in the structure are still not clear."

Single-Crystal Neutron Diffraction

In the study of amblygonite, another mineral common in granite pegmatites, Groat travelled to the High-Flux Isotope Reactor in Oak Ridge, Tennessee, to use its single-crystal neutron diffractometer. The challenge in studying structural substitutions in amblygonite and many other compounds is that it is difficult to detect hydrogens with X-rays, because the X-rays interact with the electrons around the cations (positively-charged ions) and hydrogen has only one electron. Whereas, in neutron diffraction, the hydrogen is easily detected since neutrons interact with atomic nuclei. "In order to understand the substitutions that are occurring in the structure, we need to figure out what is happening with the hydrogens," says Groat. UBC chemist Colin Fyfe worked with Groat on nuclear magnetic resonance (NMR) analysis of amblygonite.

Currently the method of single crystal neutron diffraction bears a major limitation—it can only be applied to much larger crystals (about 3 mm across) than X-ray diffraction (0.25 mm). Groat is a member of the instrument advisory and design teams to build a new, more powerful single-crystal neutron diffractometer at the Oak Ridge facility. When completed, it will produce the most intense pulsed neutron beams in the world, allowing researchers to use the same smaller crystals now employed in X-ray diffraction. "This is really going to expand the area in a major way," says Groat. "It is exciting to be working on the cusp of this research."■

Reasoning about Uncertainty

Navigating a Sea Change in Statistics

Over the course of four decades, Jim Zidek has been working at the forefront of a discipline that has undergone a radical paradigm shift from primarily a mathematical science to an information science. His career achievements in statistics stem from his ability to combine and apply these concepts to real-world problems.

What do leading researchers do when they retire? Do they ever really retire? For UBC Statistics professor emeritus Jim Zidek, the question would be more aptly framed in the context of probability. And the probability that he will retire from research activities altogether seems to be zero. Today he is busier than ever, juggling several projects in statistical theory, decision analysis and environmetrics, authoring papers and books, and still supervising graduate students.

Zidek's numerous honours include a Gold Medal from the Statistical Society of Canada, a Distinguished Achievement Medal from the Environmental Statistics section of the American Statistical Association, an Izaak Walton Research Prize, and presenter of the J. Stuart Hunter Lecture for the International Environmetrics Society (2003). He is an elected Fellow of the International Statistical Institute, the American Statistical Association and the Royal Society of Canada. Despite all the honours, he is modest about his achievements and stresses that they always represent "a product of collaborative effort."

Zidek began his career at UBC as an assistant professor in Mathematics in 1967. He was instrumental in forming the Institute of Applied Mathematics and Statistics in 1971, the framework for statistical graduate studies and the forerunner of the Department of Statistics founded in 1983. That department, which he headed from 1984-89 and 1997-2002, has become an active national centre for applied and theoretical statistics.

Adopting and Adapting "Degrees of Belief"

In the initial stages of his work, Zidek admits, he was an avowed "frequentist." It wasn't until his first study leave at University College London in 1970 that he was introduced to Bayesian theory—leading him in an entirely new direction of research. Frequency theorists assign probability in terms of well-defined random experiments. The relative frequency of occurrence of an experiment's outcome (the landing of heads in a repeated coin toss, for example) is a measure of the probability of that random event. However, one of the limits of frequency theory is that many events to which scientists would like to assign probability cannot be repeated in experiments, and thus the predicted outcome cannot be tested.

"Interest in Bayesianity stems in part from frequency theory's failure to cover objectives such as the design of a nuclear power reactor," notes Zidek. Interpreting the statement, "there is a one-in-a-million chance of that reactor failing next year," in terms of an infinite sequence of power reactors being built and tested as in coin tossing, would be truly heroic and not very helpful. In Bayesian statistics, probabilities are assigned to statements even when no random process is involved, as a way to represent the "degree of belief" in its plausibility. Although prior knowledge is incorporated, the theory is less concerned with mathematical rigour—and is profoundly philosophical.

"The surprising thing is that this method provides a completely logical, coherent approach to probability theory and the analysis of probability, which frequency theory does not," Zidek admits.

"Bridging" the Probability Gap

Today, Zidek describes himself as a "relaxed Bayesian" who still draws heavily on other methods. For example, in complex problems that deal with a vast number of parameters, such as climate models, Bayesian methods break down; it is simply impossible to express beliefs based on prior knowledge and accumulated experience when dealing with hundreds of thousands of parameters. In a significant new research direction, Zidek and former PhD student Feifang Hu incorporate ideas from previous methods into a new theory of inference, which Zidek describes as a quick and simple alternative to Bayesian theory. An adaptation of the "likelihood" method developed in the 1920s by Sir Ronald Fisher, their "weighted likelihood" method allows limited input of prior knowledge in order to combine large data sets from disparate sources. It also provides data smoothing approaches in statistical quality control, among other things. Recent work, notably with his colleague and long-time collaborator, Constance van Eeden, shows this approach has considerable promise.

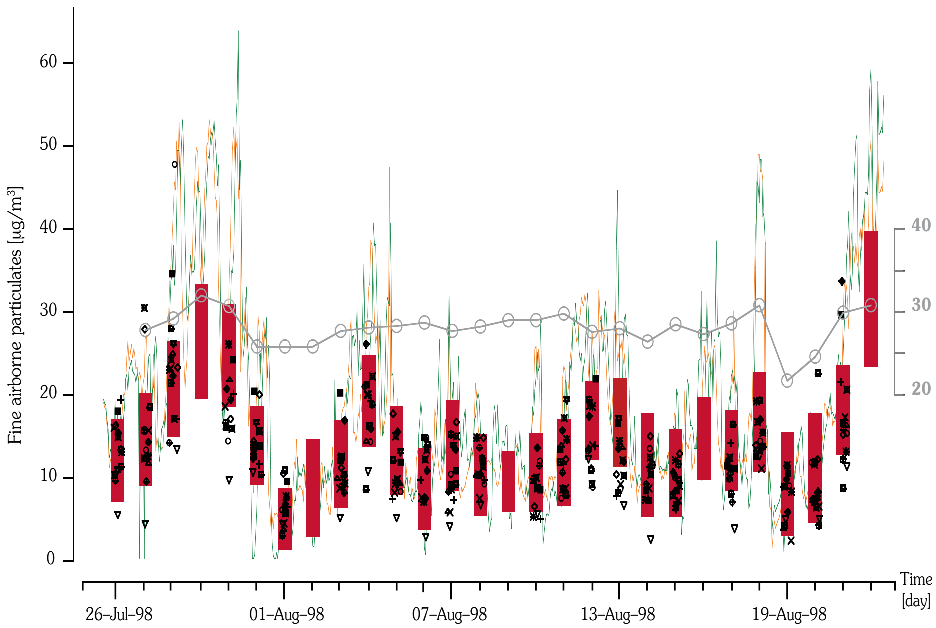
"Bayesian theory proved to be a useful way of thinking about practical problems," Zidek says. "On the other hand, under pressure of time and deadlines, I use frequency tools as well."

Zidek had his first opportunity to test his statistical methods in real-world applications in 1974, as a consultant on the Lion's Gate Bridge and later the Second Narrows bridge in Vancouver. He worked alongside a team of engineers to develop the first general design codes in the world for long-span bridges.

Innovations in Environmetrics

Zidek's research in environmental health sciences began with a consulting contract for the National Oceanographic and Atmospheric Agency on the start-up of drilling in the Beaufort Sea and the effects of exploration on marine life. This led to a US federal government contract and collaborations with Stanford and Harvard researchers to analyze trends in acid rain deposition—work that eventually formed the basis for much of his subsequent research.

In a seminal 1992 paper, Zidek and UBC colleagues describe the numerous difficulties in designing cost-effective environmental monitoring networks that gather data for an array of consumers—from government environmental agencies to private industry. In a country the size of Canada, where monitoring areas are continental in scale, the cost of design and operation of these networks



Zidek investigated the exposure of 21 elderly Baltimore residents to fine airborne particulates in an 18-storey retirement facility. The "points" mark the 21 daily levels of exposure over those weeks—each symbol (black) represents one resident's exposure—while the vertical red bars show the range predicted by a large exposure model. The model depicts the daily maximum temperatures (grey) as well as ambient outdoor levels at the facility (orange line) along with that at a distant ambient monitor (green line). The ultimate purpose is to assess the relationship between particulate concentrations and cardiovascular mortality.

is enormous. The task of specifying how many monitoring stations should be installed and where they should be located in order to design a cost-effective network—particularly when no prior data exist—is equally daunting, and not intuitively obvious. Zidek's work has resulted in major contributions to environmental monitoring network design, including methods for determining monitor sites, interpolating between sites, and smoothing of network data.

A critical aspect of this environmetrics research involves modelling and monitoring pollution fields, which Zidek likens to very wrinkled sheets over a geographical area that change constantly with the atmosphere. His work "uncovered" a problem not previously addressed. When air pollution such as the particulate concentrations in spatial fields are measured in short time scales (e.g., hourly intervals), time and space become "inseparable." Zidek's methods address this problem, and have been widely published, most recently in a book co-authored by Zidek and long-time collaborator Nhu Le. "What does this random sheet look like as time goes on?" asks Zidek. "What are the overall characteristics? Once you have a grasp of that, then you can determine where to put the monitors," he states.

In recent and related work, Zidek is again combining two very different statistical modelling cultures to study large-scale environmental processes, such as weather, which evolve over expansive spatial domains. The physical laws that determine weather—air movement, temperature, etc.—are expressed by mathematical models using differential equations. However, mathematical models do not provide random outputs. If run a second time, the model will provide exactly the same answer. The other extreme is statistical modelling, which by comparison is very simple, but useful in that it can summarize data fairly well and express uncertainty in the outputs. Says Zidek, "The question is, how do you marry these two approaches to modelling? This is a really exciting area in which all kinds of scientists are involved."

Assessing the Impact of Pollution on Health

In another major direction of his research, Zidek examines the effect of exposure to air pollution on human health, particularly in sensitive groups such as seniors and children. Exposure to elevated levels of ambient ozone has been linked to morbidity as well as mortality, including cardiovascular disease and possibly cancer. Both have long latency periods. Yet most monitoring stations did not begin to track ozone until the mid '80s. Zidek and co-investigators developed statistical methods for "hindcasting" pollution measurements to better assess their health risks.

As part of their ozone studies, Zidek and UBC colleagues developed a computational platform, referred to as pCNEM (see sidebar), that allows users to design models for predicting the exposure of randomly selected individuals to a specified pollutant. In particular, they wanted to design a framework that would take into account the outdoor environment and how pollution levels change throughout the day, the behaviour patterns of individuals (whether they stay inside or venture out during hot, muggy days), and the effects of smoking and methods of cooking and heating on indoor environments.

The next aspect of the research involved testing the computer model to see if the forecasts were similar to actual ambient outdoor measurements. Along with co-investigators in the US, Zidek studied the exposure of 21 elderly Baltimore residents to fine airborne particulates, with the ultimate goal of assessing the relationship between particulate concentrations and cardiovascular mortality. The pCNEM model admirably captured the range of exposures for this group of seniors. "It was not a very large study, but the only one I am aware of for this kind of model, so it was exciting," Zidek says. This work led to ongoing research with colleagues at the University of Bath, UK. They have used pCNEM to forecast particulate exposure of seniors in London. Moreover, they are finding much stronger associations between cardiovascular mortality and particulate concentrations than they obtain using air quality measurements from monitors that are often located a long way from the homes of seniors.

Bayesian Consensus Building

Zidek recently served on a multidisciplinary panel of the US Environmental Protection Agency to formulate recommendations for photo-oxidants, including ozone. As a statistician, he realizes all too well the challenges in building consensus. Wherever there is a multiplicity of decision makers or experts with different value sets, many legitimate perspectives and a lot of uncertainty, an increase in information can actually increase uncertainty, thereby reinforcing individual positions and leaving less room for compromise. Given the increase in interdisciplinary research and academic/industry partnerships, this could prove to be the next exciting—and critical—application of statistical research. "In these big interdisciplinary teams, uncertainty is spread out over all the disciplinary components," Zidek states. "The Bayesian framework is ideal for working out this type of problem."■

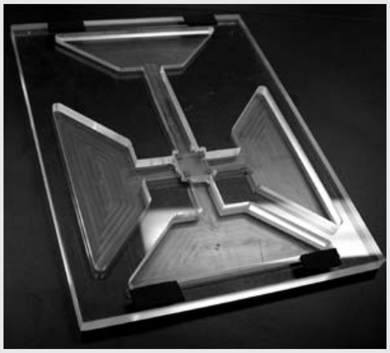
pCNEM is an acronym within an acronym. It comes from PNEM, the Probabilistic Version of the NAX (North American Ambient Air Quality Standards) Exposure Model. Zidek's group took similar concepts and built a much larger Canadian computer model, pCNEM, a WWW-based platform that can be accessed and run online after obtaining access permission from pcnem@stat.ubc.ca.

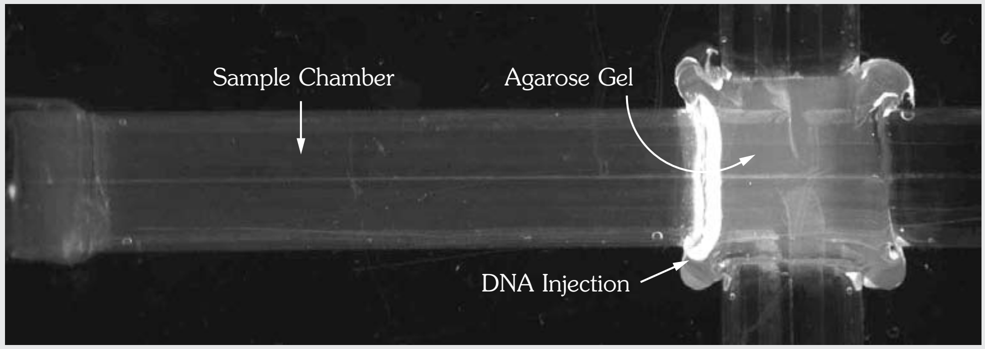
Molecular Segregation

Using Electrical Fields to Isolate and Trap DNA

Biophysicist Andre Marziali has developed novel methods for selecting and concentrating DNA using rotating electric fields. These techniques promise to provide a faster, cheaper alternative for several critical applications in health sciences, such as early cancer detection, pathogen detection and pharmacogenomics.

As with many scientific discoveries, Andre Marziali's latest research was motivated by serendipity. His advanced methods for highly selective detection and concentration of DNA (deoxyribonucleic acid) molecules involve a technique that allows researchers to segregate DNA out of a mixed pool of molecules. Marziali, associate professor in Physics & Astronomy, says the idea for this came out of a coffee room conversation on video display technologies with departmental colleague Lorne Whitehead. In order to change the reflectivity of certain display screens, electric fields are applied that move molecules toward and away from the display surface. Marziali and Whitehead brainstormed the possibility of altering this motion by applying an optical field that would change the drag on the molecules. In the process, they realized that with DNA this could be done electrically, without an additional external field. "This is because of the unique characteristics of DNA molecules; they are long, heavily charged and change shape under applied electric fields," says Marziali. Their innovative method of trapping and concentrating DNA from a fluid solely with electric fields achieved a type of molecule concentration that had never been possible.





SCODA (Synchronous Coefficient Of Drag Alteration) works as a "DNA trap." It's an innovative method of non-linear electrophoresis, manipulating DNA molecules to move toward the centre of the fluid by applying multiple electric fields to a solution (see illustration on next page). The method is entirely electrical, and it can handle DNA molecules in fluids containing a large background of other molecules and contaminants. (Photos: Richard Attfield, left; Carolyn Cowdell, right)

Electrical Concentration of DNA

In the realm of DNA concentration, Marziali and his team knew they were on to a major breakthrough. DNA molecules are long double-stranded, helical molecular chains of genetic "letters," lined up in a sequence that is characteristic for each species and individual. Every cell contains this characteristic mixture of DNA molecules, some of them copies with identical sequence and many others differing in sequence and length. DNA carries the genetic information of all living organisms, and can serve as a fingerprint for molecular detective work. For modern diagnostics, including biomarker analysis in pathogen and early cancer detection, concentrated DNA has to be prepared from biological samples that contain other cellular materials like proteins, structural cell debris and metabolites. Since DNA molecules are found in low abundance compared to other molecules, it is necessary to concentrate DNA to enable detection or other analysis, and this process can be extremely difficult and costly.

Since current techniques for DNA purification and concentration can limit the efficiency of diagnostic tools, this is an area of significant research and development both in academia and industry. One existing technique, gel electrophoresis, separates DNA molecules based on the length of the molecular chain. When a constant electric field is applied to a sample containing different DNA molecules, the smaller molecules all migrate faster through the gel, leaving the long-chain nucleic acids behind. This method works well for separation of various DNA molecules, but not for concentration of DNA from a mixed solution. In other separation methods such as chromatography, it is difficult to separate DNA from other molecules and cellular material because cell debris or precipitates can plug filters.

With funding from the US National Institutes of Health, CIHR and Genome BC, Marziali and Whitehead developed an innovative method of non-linear electrophoresis, called SCODA (Synchronous Coefficient Of Drag Alteration). The method involves applying multiple electric fields to a solution, thereby manipulating DNA molecules to move toward the centre of the fluid. The beauty of SCODA is that it is entirely electrical, and it can handle DNA in fluids containing a large background of other molecules and contaminants.

DNA Kinetics—A Non-Linear Two-Step

Marziali, also a Michael Smith Laboratories associate in Genomics, and his team based their technology on the unique kinetic behaviour of long, charged polymers. "Most molecules only double their speed in a gel when the applied voltage is doubled," he explains. However, because electric fields also change the shape of DNA chains, these molecules are more dynamic. The speed of DNA molecules through a gel more than doubles if the electric field driving the DNA is doubled. When plotted on a graph, the velocity versus field strength tends to curve upward for DNA, whereas for most molecules, it will be linear. When a second electric field is applied in another direction, DNA molecules not only move in that direction, they also move farther in the first field direction as well. With the strategic application of electric fields, Marziali manipulates the DNA into the equivalent of a kinetic "two-step"—something like two steps forward, one step back, two to the left, one to the right—until all of the DNA molecules are concentrated in the centre of the "dance floor" or sample solution.

"The actual electric fields are quite complicated, and involve configurations rotating at different speeds," says Marziali. "The outcome is that every DNA molecule is forced by these fields to one point in the solution. So you can take a relatively large volume of fluid that has DNA molecules floating around in it and make the DNA all drift to the centre of that volume."

SCODA Results and Applications

Marziali designed and installed a bench-top device capable of concentrating selected DNA from a sample, and extracting and delivering the purified sample. In studies to date, SCODA has produced a 10,000-fold concentration of DNA from cell samples, with the recovery of DNA ranging between 80 and 100 percent. Existing filtration methods are limited by lower efficiencies and cannot work from large volumes of highly contaminated solutions. In recent tests, Marziali and his team, led by David Broemeling, have demonstrated the ability to concentrate and detect as few as 10 molecules of DNA from a few millilitres of water—a concentration of approximately one zeptomole (zepto = 10^{-21}).

A major advantage of their recent work is the development of a system that eliminates the need for loading the fluid into a gel. Instead, unprocessed samples are loaded into a cross-shaped chamber, with a gel cast in the centre of the cross. By applying two sets of electric fields, one inside the gel and another across the reservoirs on opposite sides of the gel, the DNA gets trapped inside while contaminants either do not move, or float through to the buffer on the other side. "One major advantage is that you can keep harvesting DNA from fresh sample fluid; you are not limited to working with a few microlitres," Marziali says.

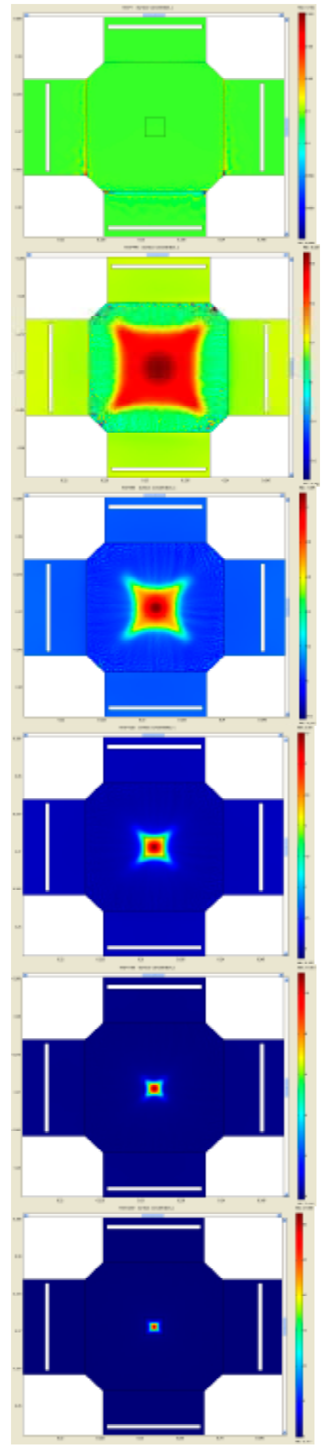
SCODA has important applications for research in detection or identification of DNA and cancer biomarkers, which require high-yield, high-purity DNA samples. Diagnostic techniques can be performed directly from a SCODA-concentrated sample—including the most sensitive methods for detection of tumour-related genomic alterations based on the polymerase chain reaction (PCR). The next step in the instrumentation development is to be able to perform PCR for immediate detection of genomic mutations. Other potential applications include DNA extraction to detect pathogens in clinical, forensic, food, and water samples, and applications in biodefence. "If someone wants to look for pathogens such as *E. coli* or even anthrax, with this technology they could harvest litres of fluid over weeks and continue to collect DNA molecules in a volume that allows for efficient analysis," Marziali says. "SCODA helps to make these tests extremely sensitive."

Marziali and Microbiology & Immunology professor emeritus Julian Davis are refining the SCODA protocol for applications in metagenomics—the reconstruction of the genome from unculturable microorganisms. In fact, less than one percent of all microorganisms observed in nature can be cultured in the laboratory. Metagenomics is a powerful new tool capable of accessing the other 99 percent of the genetic information of nature's microorganisms in order to discover and study new therapeutic compounds. However, its value as a tool is dependent upon large, unfragmented molecules of microbial DNA. Existing DNA purification methods from soil and other samples tend to fragment DNA into pieces of around 50,000 nucleotides. "Soon we should be able to extract DNA in very long segments, up to one million nucleotides," says Marziali. "The potential in metagenomics is very exciting."

Selective Molecule Detection with Nanopores

Most biological assays examine a large population of DNA molecules and provide an average reading of the properties of those molecules. However, this approach does not always detect variations or mutations in molecules that have a specific sequence within the population. Other current technologies require PCR and fluorescent detection and tend to be relatively expensive. In another area of his research, Marziali has developed a technique to separate and detect DNA molecules of one target sequence at a time, in order to determine if there are different families of molecules within a population and to gather information on those differences.

Electric fields, if applied in the right way, can stretch the DNA molecules into long and skinny strands that can be filtered through



DNA Concentration in Action
At the beginning (top), DNA is uniformly diluted in the solution. SCODA's electric fields originating at the four electrodes in each arm of the cross-shaped configuration force the DNA molecules towards the centre, showing the highest level of concentration (red) at the bottom. (Image: Stephen Inglis)

tiny nanopores. Marziali's separation technique involves running single-stranded DNA molecules through a minute hole in a cell membrane. Whenever there are two DNA strands with a complementary (matching) sequence, they align and bind to each other. The result is a double helix of two nucleic acid molecules that is too thick to go through the nanopore and is caught.

"We look for the binding and forming of this double helix, and when it gets stuck we know we have captured something of the correct sequence," Marziali explains. "Then we can pull the two strands of DNA apart and actually get a direct measure of their binding energy, and that is how we can tell if it is a perfect match to the sequence or if it is a mutation." The nanopore detection method he developed is completely electrical and potentially much less expensive than other current technologies.

Marziali is studying applications for nanopore-based detection in personalized medicine. These include prevention of adverse drug reactions, and screening populations undergoing clinical trials in order to match their genotype to the efficacy of the drug being tested. "The ultimate goal of this nanopore work is to develop a silicon chip with nanopores and DNA probes that allow you to electrically test DNA samples for specific genotypes or mutations," says Marziali. The result would enable clinics and hospitals to personalize treatments and drug prescriptions based on individual genotypes. ■

Portrait: The Department of Physics & Astronomy

Physics & Astronomy is located at the core of the UBC campus. Just south of the clock tower, you can see many of our department's teaching activities and research facilities. In addition, several faculty members conduct their research at UBC's Advanced Materials and Process Engineering Laboratory (AMPEL) and at TRIUMF, a world-class laboratory hosted by our university, which specializes in generating extremely intense beams of particles. Other research is carried out at major international facilities, and for some we use space-based instruments.

Over the past 40 years the department has established a prominent international profile based on our award-winning researchers. They have contributed to a wide range of fields such as general relativity (e.g., Unruh radiation), high-temperature superconductivity, the cosmic microwave background, the physics of biological membranes, and subatomic physics (with key participants at TRIUMF).

Exciting new frontiers are now being forged by several young faculty members. Close to one half of our more than 50 faculty members have been hired in just the past eight years, and they comprise a mix of outstanding theoreticians and experimentalists working in fields that include:

- Astronomy and cosmology
- Atomic, molecular and optical physics
- Biophysics and medical physics
- Condensed matter physics
- String theory
- Subatomic physics

Four of our young stars received prestigious Sloan Fellowships in 2005 and 2006. Seven faculty members hold esteemed Canada Research Chairs. Several research groups in our department generate valuable intellectual property that is either licensed or has formed the basis of successful spin-off companies.

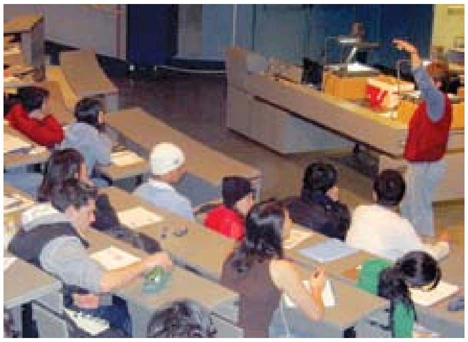
We are equally proud of the many teaching awards received by faculty members and of the innovative teaching and outreach activities they have spearheaded. A theme behind many of the course-based initiatives has been stimulating learning by inquiry and hands-on exposure to contemporary science and technology, starting right off with first-year students. Much energy is going into implementing yet more of this teaching design—to convey to our students the relevance and excitement of physics and astronomy.

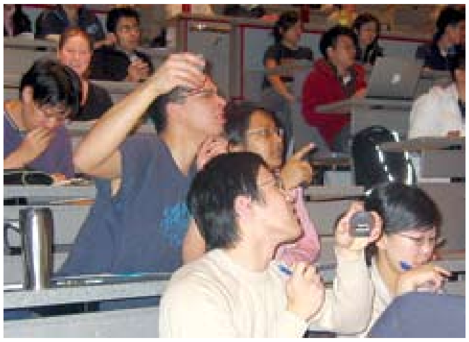
Our outreach initiatives are targeted at K-12 students and the public in general. These include our extremely popular Physics Olympics, which attracts over 65 teams each year from high schools throughout the province; summer camps; the Faraday Lecture Series; and a public Open House (over 1,500 people walked through our laboratories on June 4, 2005).

In addition to providing service courses, which are aimed at non-physics students from across campus, the department offers specialized undergraduate programs in physics, astronomy, biophysics, and engineering physics, as well as various joint programs with other departments in the Faculty of Science. Enrolment in these programs has increased steadily over the past five years: approximately 100 students graduated from the department in 2005. We also have over 140 graduate students who take an array of specialized courses, work as teaching assistants in our undergraduate courses, and carry out forefront research in diverse areas of physics and astronomy.

All department activities are supported by an enthusiastic and energetic group of technical and administrative staff, many of whom have also received awards for their outstanding service. To learn more about the UBC Department of Physics & Astronomy, please visit: www.phas.ubc.ca

Projects and Initiatives: Skylight on Science Education





Skylight associate Milner-Bolotin inspires students to engage in interactive learning. (Photos: Daryl Smith)

How can peer-led calculus workshops help students become independent problem-solvers? How can we identify the cognitive and motivational processes that our students use to master organic chemistry? Can students use e-Portfolio technologies to improve learning through self-reflection and assessment? How can biology students with language difficulties benefit from online courses? How can "interactive engagement" in learning be implemented in huge physics classes?

Questions like these are driving a wide range of research projects initiated by Skylight, UBC's Science Centre for Learning and Teaching. Established in 2001, Skylight has become part of an ongoing strategy to promote excellence in teaching and learning across the nine Science departments.

In practice, this means that Skylight associates are researchers and instructors who are investigating how to improve the teaching and learning of science, often inspiring collaborations with, and among, faculty members.

"The team is diverse and growing," says educational anthropologist and Skylight director Joanne Nakonechny, whose research interests include developing deep structure learning—learning that incorporates facts, principles and concepts. "We use visual guides to help the students expand the depth and breadth of their learning. We also use computer-based simulations such as 'Virtual Lab' from Carnegie-Mellon University to help the students understand experimental design." And Skylight colleague Leah Macfadyen, a molecular microbiologist with research experience in intercultural communication and distance learning, integrates learning technologies such as wikis (a type of website that allows users to easily add and edit content) into teaching projects. In addition, she is exploring how professional development tools and online resources may help faculty members build a strong teaching and research community.

Skylight's associates, cross-appointed with various departments, play a range of research, teaching and curriculum development roles. For example, physicist Marina Milner-Bolotin is working with colleagues in Physics & Astronomy, to introduce interactive learning into large lecture classes. She investigates how modern technologies such as video analysis software and clickers (personal response systems) can help individual students engage in interactive learning—even in classes of 250 students.

Milner-Bolotin uses Vernier Logger Pro software and a digital video camera to record data during lecture demonstrations of physics concepts; e.g., the swinging of a pendulum. Following the lecture, students can access the data from the Web for further analysis, allowing them time to work with the data to develop a deeper understanding and uncover misconceptions. During the subsequent lecture, students submit the results of their analysis, using a classroom response system that offers feedback on their answers. This approach capitalizes on the appeal of the traditional "show-and-tell" demonstrations, turning them into interactive learning experiments that can positively impact student success.

Other Skylight projects include revising the life sciences core curriculum—an undertaking coordinated by research associate Gülnur Birol, and exploring how students solve problems in organic chemistry—a study led by instructor Jackie Stewart.

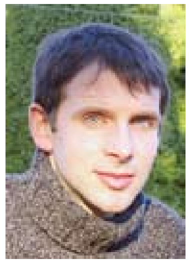
In addition to these teaching and research initiatives, Skylight has a growing lending library of science teaching literature and technology tools, including laptops, LCD projectors, tablet PCs, and camcorders. Twice a year the Skylight Development Grant competition encourages and supports learning and teaching projects in the Faculty of Science.

Skylight just launched its new, multi-functional website. You are invited to make use of the resources and tools the website offers: the new Teaching Large Classes resource bank, event listings and registration, equipment booking, library searching, and various communication forums for discussion and exchange with science-teaching colleagues. Find out more at: www.skylight.science.ubc.ca

New Masterminds: Brain Gains at Science

Brosnan

Dunham



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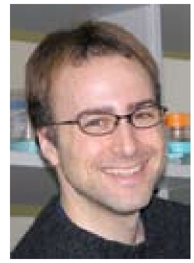

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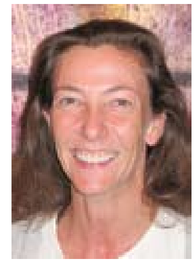

Johnson

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

Patrick Gerald Brosnan, Assist. Prof., Dept. of Mathematics; AB Mathematics, Princeton University, New Jersey, US; MA and PhD Mathematics, University of Chicago, Illinois, US. Prior appointment: Member of the Institute for Advanced Study and Assist. Prof. at the State University of New York at Buffalo, US. *Research:* I am interested in algebraic geometry and its applications to problems in algebra, number theory and theoretical physics. One long-term goal of mine is to understand the algebraic geometry arising in calculations of Feynman amplitudes.
www.math.ubc.ca/~brosnan

Bruce Dunham, Instructor, Dept. of Statistics; BSc Mathematics, University of York, UK; MSc Statistics, University of Sheffield, UK; PhD Probability Theory, University of London, UK. Prior appointment: Senior Lecturer in Statistics, University of Derby, UK. *Research:* My previous research contributions have been in applied probability and statistical modelling, though I also have an interest in actuarial and financial mathematics. As an instructor my primary focus is statistical education, including course development, curriculum design, the creation of study material and, of course, teaching.
www.stat.ubc.ca

Joshua A. Folk, Assist. Prof. and Canada Research Chair in the Physics of Nanostructures, Dept. of Physics; BSc and PhD Physics, Stanford University, California, US. Prior appointment: Post-doctoral Fellow, Delft University of Technology, Holland. *Research:* My group studies quantum properties that emerge at very low temperature, in structures so small that their dimensions are measured in nanometers. For example, we build semiconductor nanostructures, using advanced lithographic techniques, and also measure the electrical conductivity of single atoms and molecules. The discoveries that come out of this research may have implications for the computing industry as well as for our fundamental understanding of solid state physics. www.physics.ubc.ca/~jfolk

Raphaël Gottardo, Assist. Prof., Dept. of Statistics; Diplôme d'ingénieur, Applied Mathematics, Université Claude Bernard, Lyon, France; MSc Statistics, Portland State University, Oregon, US; PhD Statistics, University of Washington, Seattle, US. Prior appointment: PhD student, University of Washington. *Research:* My primary research interest is the development of statistical methods and software for the analysis of data issued from high throughput genomics projects (analysis of gene expression data). In particular, I develop Bayesian models that can be used to obtain relevant information from these complex biological data sets.
http://hajek.stat.ubc.ca/~raph

Steven J. Hallam, Assist. Prof. and Canada Research Chair in Environmental Genomics, Dept. of Microbiology & Immunology; BA Biology and Religion, Sarah Lawrence College, Bronxville, New York, US; PhD Molecular, Cellular and Developmental Biology, University of California Santa Cruz, US. Prior appointment: Postdoctoral Research Fellow, Department of Civil & Environmental Engineering, Massachusetts Institute of Technology, Cambridge, US. *Research:* My lab investigates the metabolism of wild microorganisms. We utilize the powerful tools of environmental genomics, proteomics and bioinformatics to understand how uncultivated microbes contribute to the biological transformation of energy and matter in nature (biogeochemical cycle of carbon). At present we focus on reconstructing the metabolic potential of microbial groups dwelling within marine sediments and stratified water columns, where the anaerobic oxidation of ammonia and methane (to carbon dioxide) occurs.
www.microbiology.ubc.ca

Catherine Louise Johnson, Assoc. Prof., Dept. of Earth & Ocean Sciences; BSc in Geophysics, Edinburgh University, Scotland, UK; PhD in Earth Science, Scripps Institution of Oceanography, University of California (San Diego), La Jolla, US. Prior appointment: Assoc. Prof. of Geophysics, Scripps Institution of Oceanography, La Jolla, US. *Research:* My group investigates the interior and surface structure and evolution of planets in our solar system, using data from planetary missions. In addition, we focus on exploring Earth's magnetic field, through field and laboratory work and application of techniques in time series analysis, statistics and inverse theory. www.eos.ubc.ca/public/people/faculty/C.Johnson.html

Faculty of Science: Kudos and News

Congratulations to our highly recognized, award-winning Science faculty

Mona Berciu, Assist. Prof., Physics & Astronomy
• A. P. Sloan Fellowship, Alfred P. Sloan Research Foundation
Jörg Bohlmann, Assoc. Prof., Michael Smith Labs, Dept. of Botany, and Faculty of Forestry
• E. W. R. Staecie Memorial Fellowship 2006, NSERC
Doug Bonn, Prof., Physics & Astronomy
• Elected Fellow, Royal Society of Canada
William Cameron, Honorary Prof., Earth & Ocean Sciences
• Order of Canada, Government of Canada
Kris De Volder, Assist. Prof., Computer Science
• Faculty Award of Innovation, IBM
David Dolphin, Prof., Chemistry
• Gerhard Herzberg Gold Medal for Science and Engineering 2005, NSERC
Brett Finlay, Prof., Michael Smith Labs and Microbiology & Immunology
• Partnership Award for SARS Accelerated Vaccine Initiative, Canadian Institutes of Health Research
• Solutions through Research Award, BC Innovation Council
Michael Fryzuk, Prof., Chemistry
• National Killam Research Fellowship, Canada Council of the Arts
Nassif Ghoussoub, Prof., Mathematics
• Jeffery-Williams Prize 2007, Canadian Mathematical Society
Robert Hancock, Prof., Microbiology & Immunology
• Fellow, Infectious Diseases Society of America
Gregor Kiczales, Prof., Computer Science
• Faculty Award of Innovation, IBM
Joanna McGrenere, Assist. Prof., Computer Science
• Faculty Award of Innovation, IBM
Marina Milner-Bolotin, Research Associate, Physics & Astronomy
• Vernier Technology Award, National Science Teachers Association
Robert Miura, Prof. Emeritus, Mathematics
• Leroy P. Steele Prize 2006, American Mathematical Society
Gail Murphy, Assoc. Prof., Computer Science
• E. W. R. Staecie Memorial Fellowship 2006, NSERC
• Faculty Award of Innovation, IBM
Jozsef Pálfy, PhD student, James Mortensen, Prof., and Paul Smith, Prof., Earth & Ocean Sciences
• Highly Cited Scientist, Science Citation Organization
Timothy Parsons, Prof. Emeritus, Earth & Ocean Sciences
• Order of Canada, Government of Canada
Harvey Richer, Prof., Physics & Astronomy
• Fulbright Scholar, Fulbright Foundation
Alla Sheffer, Assist. Prof., Computer Science
• Faculty Award, IBM
Jozsef Solymosi, Assist. Prof., Mathematics
• A. P. Sloan Fellowship, Alfred P. Sloan Research Foundation
Tai-Peng Tsai, Assoc. Prof., Mathematics
• Andre Aisenstadt Prize, Centres de recherche mathématiques

Carl E. Wieman Joins UBC


Photo: U. of Colorado, Boulder

Carl Wieman, Nobel Prize winner in Physics and renowned leader in science education, is coming to UBC, joining the Dept. of Physics & Astronomy early in 2007. UBC has committed $12 million over the next five years to provide an unprecedented quality of education for science students. Wieman enthusiastically offered his expertise to help develop a science education project that emphasizes student experience, stimulates inquiry and encourages measurement of educational outcomes. Five Science departments will participate in the project's initial stage.

Science Graduate Students the Best

Zoologists Graham Scott (Master's) and Charles Darveau (PhD) were awarded the Governor General's Gold Medals. On behalf of the Governor General of Canada, UBC honours two of the university's students graduating with a Master's and a PhD degree, respectively, for the most outstanding academic records. In the 2005 graduating class, Scott excelled among 1,000 master's graduates and Darveau among 300 doctoral graduates. In addition, Darveau received the Canadian Council of University Biology Chairs Prize.

Premier Undergraduate Scholars

Three BSc students, Lik Hang Lee, Supna Kaur Sandhu and Laura Melanie Winter, have been awarded a Premier Undergraduate Scholarship. Each year UBC honours 20 undergraduate or postbaccalaureat students as "Wesbrook Scholars" in recognition of their multiple accomplishments in scholarship, service and athletics. This year, seven Science students received this award, among whom the three Premier Undergraduate Scholars stand out, each receiving a larger scholarship.

SUS President Supports Student Centre

Patricia Lau, the third president of the UBC Science Undergraduate Society, has been instrumental in making the Ladha Science Centre a reality. Over the last two years she has ensured that Science students were a central part of the ongoing discussions about the building design and the funding arrangements for this centre—through a period of uncertainty. Construction of the centre, which is generously supported by entrepreneur Abdul Ladha, started early this year.

Alumni Reunion 2006

Mark your calendars: The UBC Alumni reunion weekend is scheduled for September 29 to October 1, 2006. For more information visit: www.alumni.ubc.ca/reunions

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Faculty of Science (SYNERGY)
1505–6270 University Boulevard
Vancouver BC V6T 1Z4 Canada

SYNERGY » JOURNAL OF UBC SCIENCE
Published by the Faculty of Science
University of British Columbia (UBC)
www.science.ubc.ca
Fax. 604.822.5558
E-mail. synergy.science@ubc.ca
Editor. Carola Hibsch-Jetter, UBC Science Communications
Writers. Research articles: Mari-Lou Rowley, Pro-Textual Communications
Regular features: Leah Macfadyen (Skylight), Jeff Young (Physics & Astronomy)
Circulation. 29,000 (two issues per year)
Layout/Artwork. www.mediagroup.ubc.ca
Photos. UBC Faculty of Science or as indicated.

Printed in Canada on recycled paper.