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Words from the Editor

Dear Reader,

I am pleased to present this year's fall issue of *Synergy*, offering you a view behind the scenes of our scientists' exciting research and an opportunity to learn about recent developments in the Faculty of Science at UBC.

In this edition you will read about Allan Bertram's research on the chemo-physical properties of atmospheric aerosols and clouds for a more fundamental understanding of climate change. Mathematician Gordon Slade applies probabilistic models to make predictions about critical phenomena like population dynamics. Microbiologist Lindsay Eltis' basic research in enzyme engineering is providing insights into improved bioremediation as well as into antibiotics and diseases such as SARS. Computer scientist Cristina Conati's interdisciplinary research aims at developing interactive systems that react and adapt to user needs and help students learn.

Our regular features in this issue highlight our Computer Science department, the Aboriginal Initiatives in the Sciences, and the recent recruitment success in our nine departments, as well as national and international recognitions and awards won by our faculty members, and other exciting news.

We hope you enjoy this issue and, as always, we welcome your feedback. We

also like to hear from you if your address has changed or if you are not a subscriber but wish to receive *Synergy* regularly. Many thanks to all of you who sent comments and updates. You can e-mail us at any time at: synergy.science@ubc.ca

Carola Hibsch-Jetter

Investigating Climate Change
The Anatomy of Atmospheric Aerosols

Considerable scientific evidence indicates that climate change is occurring—yet the world has been slow to act. Physical and analytical chemist Allan Bertram and colleagues are studying the fundamental properties of atmospheric aerosols and clouds in order to accurately predict climate change.

Violent and unpredictable flooding, devastating droughts and episodes of killer smog all suggest that something is wrong with the earth's climate and environment. Still, the main polemic that is preventing action to reverse global warming is: Are these changes a result of natural fluctuations or human activity? Even if we all bought smart cars or converted to green power sources, it would not answer the questions: What is happening in the atmosphere to cause these changes? Or, how long do we really have before life as we know it is no longer sustainable?

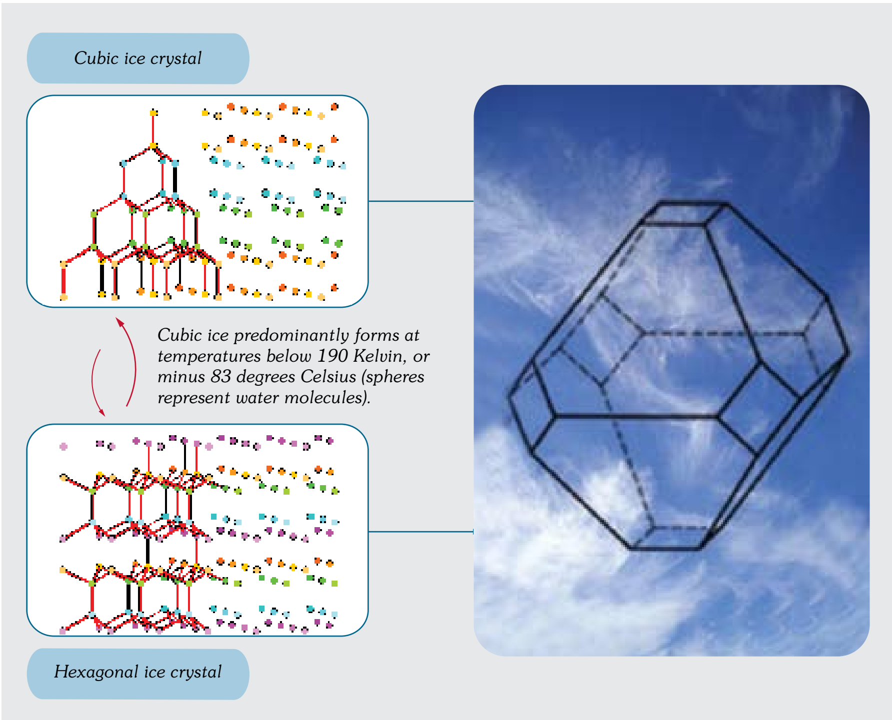
In order to convince sceptics—and to radically alter behaviour—scientists need irrefutable, quantifiable evidence that human activity is the primary cause of climate change. Current state-of-the-art models predict that the earth's surface temperature will increase from between approximately one and six degrees Celsius over the next 100 years. One degree might not be so bad, but six degrees could be catastrophic. "In order to make effective policies that determine what we are going to do, the uncertainty in this number needs to be reduced," states UBC Chemistry professor Allan Bertram.

Understanding Aerosols

To better understand the relation between atmosphere, pollution and climate change, and accurately model atmospheric chemistry, Bertram and his lab are studying the properties of atmospheric particles, such as their growth, crystallization and phase changes. Atmospheric particles—or aerosols—can be organic, inorganic, solid, or liquid, and these are only a few of the complex properties that affect their behaviour and role in the earth's atmosphere.

One way in which aerosols indirectly modify climate is by reflecting or absorbing solar and terrestrial radiation. For example, the increase in particulates we see as smog can scatter more solar radiation back into space, which would lead to cooling of the earth's surface. Alternatively, the particulates can absorb radiation and lead to a heating of the earth's surface. However, the effects on climate change are still poorly understood and more research on aerosols is needed to produce better climate models.

Cloud formation is another indirect effect that aerosols have on climate, since clouds are formed when water droplets or ice particles adhere to these aerosols. The concentration and size of cloud droplets and ice particles is governed by the number of aerosols in the atmosphere. A change in the number of aerosol particles may change the number and size of cloud droplets and ice particles—as well as their lifetime—and this would change the amount of radiation the clouds scatter and absorb. "This may either increase cooling or warming depending



Clouds on the Rocks

Clouds with a hair-like appearance or a silky sheen, which we see high up in the sky, are composed of ice crystals. The transient presence of cubic ice may modify the evolution of these clouds when cubic crystals are transferred en masse to hexagonal crystals, resulting in larger ice crystals and eventually causing dehydration in the upper atmosphere. (Figures: Daniel Conroy, Benjamin Murray)

on the situation, and it is one of the things we are still trying to understand," Bertram says.

Cubic Ice and Dehydration

The study of cubic ice, which is related to ice clouds, is one of Bertram's most intriguing research projects. It conjures up images of too many Scotches on the rocks rather than atmospheric chemistry. "It is almost always assumed that ice clouds in the atmosphere consist of hexagonal ice because that is the state at which ice is thermodynamically stable," he says. His lab investigated the phase of ice that forms when pure water and aqueous solution droplets freeze homogenously at temperatures ranging from 235 Kelvin to below 190 Kelvin—which covers the range important in the earth's upper atmosphere. The ice phase was monitored with X-ray diffraction. Results indicated that a large amount of cubic ice was observed at temperatures below 200 Kelvin, and cubic ice was the dominant product at temperatures below 190 Kelvin. "I think we have shown the first convincing evidence that cubic ice can form in the atmosphere," says Bertram.

These results have significant implications for the atmosphere and climate. Hexagonal ice has a lower vapour pressure (the pressure exerted by a vapour in contact with its liquid or solid form) than cubic ice. The transient presence of cubic ice in the upper atmosphere may modify the evolution of clouds through a process of mass transfer from cubic ice to hexagonal ice. This process could result in clouds with larger ice crystals, Bertram explains. These larger ice crystals will remove water vapour from the air mass more quickly in the form of precipitation, causing dehydration in the upper atmosphere. Water vapour is also important to climate since its ability to absorb infrared radiation makes it a strong greenhouse gas. "In order to predict climate change you have to be able to predict water vapour in the upper atmosphere, so understanding dehydration is extremely important," says Bertram.

Fundamentals of Phase

In addition to water content, the phase of a particle (whether it is solid or liquid) also governs the total mass of airborne particles, the amount of light they scatter and absorb, and their reactivity. Another aspect of Bertram's work is studying the phase transitions in a mixture of organic and inorganic particles. To date, little is known about the phase and hygroscopic (water absorbing) properties of aerosols, and the different properties of organic, mixed organic and non-organic aerosols. Knowledge of conditions under which particles crystallize or fully deliquesce (become liquid) is important since, as a rule, atmospheric particles reflect more radiation in the liquid state than as a solid. This is mainly because liquid particles are larger.

Condensed-phase organic material is abundant throughout the atmosphere, ranging from 10 to 50 percent of the fine particulate mass. However, prior to Bertram's work, most research only focused on pure inorganic particles. His research group studied the deliquescence and crystallization of particles consisting of ammonium sulphate, $(NH_4)_2 SO_4$, mixed with four different organics in order to better predict aerosol phase and reflectivity. They found that aerosols with numerous organic components are more likely to remain in a liquid state. "Previous to our study, very little research looked at how organic compounds affect phase transitions," states Bertram. "We have shown—and quantified—that they do affect phase, depending upon the amount of organic material involved."

This work is fundamental in building models to predict aerosol scattering and its effect on climate. It also has applications in heterogeneous chemistry, the study of gas-phase molecules and their interaction with aerosols in the atmosphere. "A significant source of acid rain is caused by N_2O_5 gas hitting a liquid particle and forming nitric acid," Bertram says. "The reaction rate is much slower on a crystal particle than on a liquid, so we are trying to predict phase changes in order to work this into models."

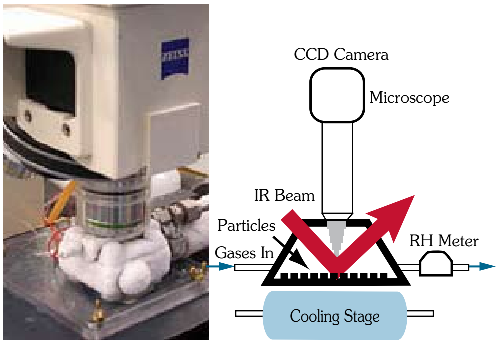
Hamburger–Ozone Chemistry

Barbequers and fast food aficionados take note! Up to 20 percent of the mass of aerosol particles in some cities can result from the cooking of meat. All "super size me" jokes aside, the effect on the atmosphere is substantial. By understanding how these aerosols interact with ozone (O_3), an important oxidant in the lower atmosphere, Bertram's lab is helping to quantify the role of meat-cooking aerosols and how long it takes to remove oleic acid (one of the main by-products of meat cooking) from the atmosphere. This has been a matter of considerable debate. Field measurements have indicated that the lifetime of oleic acid is several days. Lab measurements, on the other hand, suggest a few minutes.

Previous lab studies used liquid oleic acid particles as a proxy for meat-cooking particles. Bertram's group studied a more realistic composition of these aerosols and have shown that they can form wax-like solid–liquid mixtures, which significantly decrease the reactivity of the particles. The results from their laboratory studies are more consistent with the field measurements, providing further evidence that meat-cooking aerosols can be persistent in the atmosphere.

Bertram is also working with chemistry colleagues John Hepburn and Mike Blades on developing novel instrumentation to measure aerosol particles (see *Synergy* 2|2004). "It is an innovative laser-based instrument that brings John's laser research and Mike's mass spectrometry work together in a powerful new tool that we will use to study reactions on those particles and may eventually be used to characterize aerosol particles sampled from the atmosphere," Bertram says.

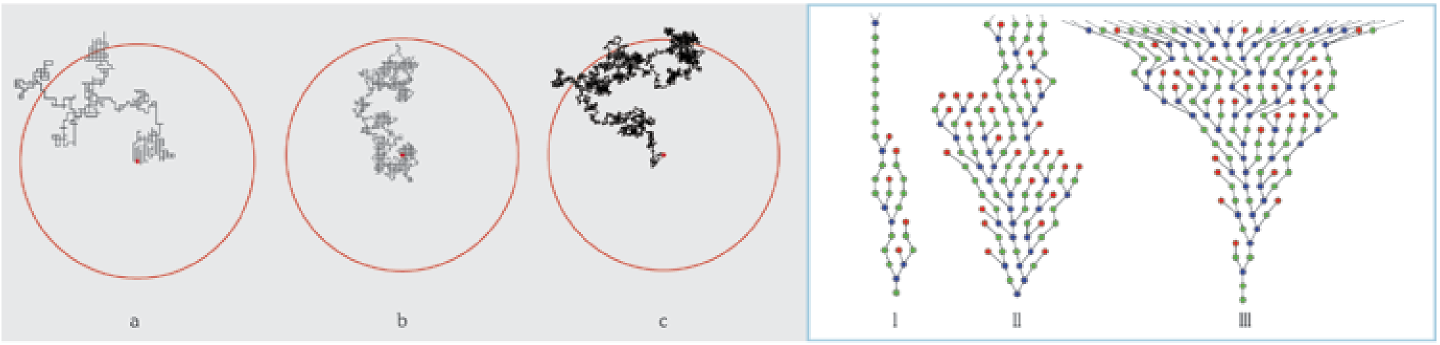
He acknowledges NSERC, CFI, the Canadian Foundation for Climate and Atmospheric Science, and the Canada Research Chairs program for funding this basic research—and his research group for their excellent work. "We need to understand some of these very fundamental things about climate before we can accurately predict global warming and the impact of human activity." ■



Fundamentals of Phase
A Fourier transform infrared spectrometer (Ftir) and an optical microscope are coupled to a particle cell to study the phase transitions in a mixture of organic and inorganic particles. Finding out about these aerosol properties will help determine how much atmospheric radiation they reflect and absorb, which in turn has a significant effect on the cooling or warming of the earth's surface.

The Puzzle of Probability

Random Walks Along a Critical Path



Random Walks and Random Trees

The random movement of microscopic particles immersed in a fluid can be modelled mathematically as a simple two-dimensional random walk. The nearest-neighbour random walks (shown on the left) take (a) 1000, (b) 10,000 and (c) 100,000 steps. The circle radius equals the square root of the number of steps, in units of the random walk's size.

The right panel shows random trees modelling a binomial offspring distribution, starting from generation one (at the bottom) with a family surviving for at least twenty generations (generation twenty at the top). The process continues forever or until the family dies out. Whether it dies out or not depends on the tree regime: It is subcritical (I) if the number of offspring is below one per ancestor, critical (II) if exactly one, and supercritical (III) if more than one. (Figures: Bill Casselman)

What critical point separates population explosion from extinction? What is the critical temperature beyond which iron does not stay magnetized? Mathematician Gordon Slade applies probabilistic models to make predictions about critical phenomena, and to prove theorems in multi dimensions.

Anyone who has played a game of poker has played with the concept of probability. What is the likelihood that your opponent has a pair of aces if you have one? Or a flush if you have three consecutive cards in a suit? In mathematics, the probability of any event occurring is a real number p between 0 and 1. In a role of the dice, for example, the probability of one dice landing on any of the numbers from one to six is p = 1/6—unless, of course, the dice is loaded.

For UBC Mathematics professor Gordon Slade, probability is much more than picking the ace of spades from the middle of the deck. A member of UBC's Probability Group—one of the three top groups in North America alongside Cornell University and University of California—Slade is particularly interested in probability theory as applied to critical phenomena.

Many of the more interesting questions arise from physics, chemistry and statistical mechanics, such as the random movement of a particle in Brownian motion, the complex folding of polymers, or the critical point that separates population explosion from extinction.

Population Dynamics and Critical Branching

To study critical phenomena, scientists use an array of probabilistic models. If a population's birth rate exceeds its death rate, for example, it will increase exponentially, causing a population explosion. If it doesn't exceed its death rate, the population becomes extinct. For mathematicians the question is: What is the nature of the critical point at which this transition takes place? The tool used to study this process is a branching model, which shows births as independent events, leading to other births, and so on. If everyone on average has fewer than one offspring, then the population will die out. Not surprisingly, if everyone has more than one offspring, a population explosion ensues. At the critical point where the mean number of offspring is one, the population is hovering between extinction and survival.

"This is a simple example of how varying a parameter can change a system," says Slade. Simple branching processes have a recursive nature; they don't depend on what has transpired before, and this facilitates computation. "When you know that an individual is born, you don't have to look back to what happened before. The branching is independent and that makes it easy to analyze." Independence, it turns out, is a positive characteristic in probability, and not the case in more complex models.

Global Cooperation—Copying the "Jones"

Imagine a large system of interacting particles that prefer to be like their neighbours. At high temperatures, when the particles are in an excited state, they are fluctuating too quickly to interact with each other. "When the system cools, and the thermal fluctuations slow down, the particles have time to check out their neighbours," says Slade. "In these situations, they prefer to line up with their nearest neighbour and whenever possible do what their neighbour is doing."

This kind of cooperation involves an agreement that initially takes place locally in a system and then abruptly spreads over the whole system, depending upon varying a critical parameter. In population dynamics, the parameter is fertility. In determining the point at which a magnetized rod of iron loses its magnetization, the critical parameter is temperature; above 770 degrees Celsius magnetization vanishes.

The concept of universality is extremely important in modelling critical phenomena, explains Slade. "You don't need local details of how the system is behaving as far as the global behaviour is concerned, since many essential features of a transition at a critical point depend upon relatively few attributes."

Random Walks and Critical Trees

Brownian motion, the random movement of microscopic particles immersed in a fluid, was discovered by botanist Robert Brown in 1827. Einstein later showed that the movement was caused by random difference in pressure of molecular bombardment on opposite sides of the particle, which in turn caused the particle to wobble back and forth and eventually stray from its original position. Higher temperatures, smaller particle sizes and a less-viscous fluid would increase the amount of motion.

In mathematics, Brownian motion can be modelled as a simple two-dimensional random walk. This sporadic and random path is often described as a "drunkard's walk home." The mathematical model can be used to describe random movements in a variety of areas, from subatomic physics to stock market fluctuations. To keep the errant particle, or operator, from straying too far outside the limits of the graphical framework, mathematicians "rescale space." When the path becomes too long, they simply shorten the size of the steps, so the random walk fits within a set radius. Interestingly, the average end-to-end distance of a simple random walk equals the square root of the number of steps ($\sqrt{n}$)—in any dimension.

Super-Brownian motion (SBM) combines random spatial motion with random branching, where a particle is not only circulating through space, but is also undergoing critical branching. Each of its offspring is also undergoing independent Brownian motion and critical branching at the same time. Slade uses critical trees to model SBM. "We want to do the same thing with critical trees that we do with random walks," he says. "We look at the ones that are extremely large, and take some kind of limit so that we get a continuous object where the branching is taking place instantaneously."

Self-Avoidance and Higher Dimensions

Spatial dimension is another key feature in the study of critical phenomena. "Dimension is one of the things that affect the nature of transition of a critical phenomenon," Slade explains. "If we change the dimension, we want to know how the features of the system change." For the non-mathematician, simply grasping the concept of changing dimensions is mind-boggling, never mind dealing in (space) dimensions of five and up. Paradoxically, many of the problems that Slade studies are easier to solve in higher dimensions.

Although it is not easy to visualize, the algebra is fairly simple. If you have to indicate where a point is on a line, you give it a number; in a plane, you give it two numbers; in three dimensions which also include depth, you give it three numbers; in four dimensions you assign four numbers, and so on up.

When studying the way random geometrical objects fit and move in space, mathematically they are more constrained in low dimensions than in higher dimensions, particularly when they have to avoid each other. In higher dimensions, there are simply more places to go when you don't want to run into your neighbour.

Dimensionality is particularly important for mathematical models called self-avoiding walks, which have been used to model the complex folding pattern of long-chain molecules such as proteins. Although logic would suggest that these physical phenomena would be simpler to model in three dimensions, they are, in fact, more difficult. A self-avoiding walk is a random walk that cannot retrace steps or cross the same path. Similarly, no two atoms can occupy the same space. It turns out that self-avoidance constraints are not that important in higher dimensions. Slade and colleague Takashi Hara in Japan proved that self-avoiding walks behave like simple random walks in five dimensions and higher. In these higher dimensions, their average end-to-end distance is also $\sqrt{n}$.

After 50 years of studying self-avoiding walks, mathematicians are still stymied as to how to prove anything about end-to-end distance in three dimensions. The problem is considered intractable. However, Slade and UBC colleague David Brydges are getting closer; they are currently working on self-avoiding walks in four dimensions.

Lace Expansion and Lattice Trees

Using a model called lace expansion, developed by Brydges, Slade can systematically relate a self-avoiding walk to a simple random walk in these higher dimensions. In essence, lace expansion is a formula that rewrites self-avoiding walks as random walks with larger steps, and uses graphs to represent self-avoiding walks the way algebra uses letters to represent unknown numbers. Lace expansion also permits the analysis of a "weakly self-avoiding walk," where self-intersection is allowed, but "mathematically punished."

"In the case of a weakly self-avoiding walk, we look at all possible paths, including ones that have self-intersection, and assign a weight to each path," explains Slade. Any time there is self-intersection, the weight of the path is diminished. This is also another example of universality. "Even if you punish the path only slightly if it has self-intersection, it is still going to behave as if you forbid self-intersection completely."

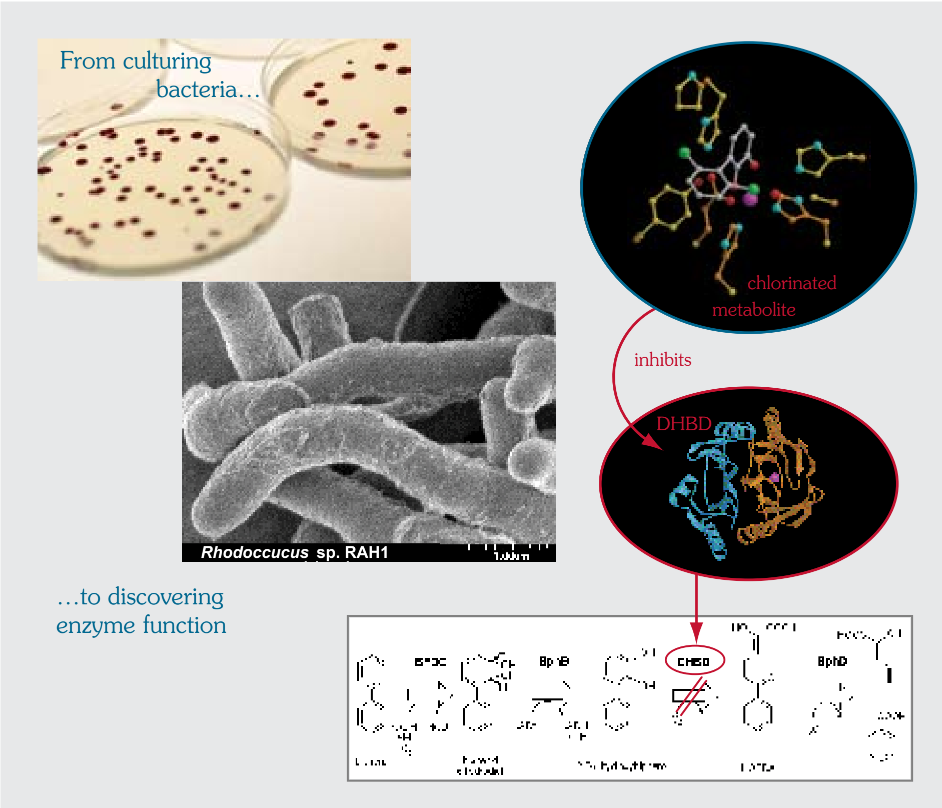
Slade applies a similar technique to lattice trees, which are like self-avoiding walks that also have branches that are also not allowed to intersect, and therefore have a stronger kind of self-avoidance. Slade and colleagues have used lace expansion to study lattice trees above eight dimensions.

"Lattice trees are used to model branched polymers, and self-avoiding walks are used to model linear polymers," Slade notes. Although physicists and chemists have used these modelling tools for some time, the challenge for Slade is in proving the mathematical theorems behind the concepts.

Most of Slade's work has been in higher dimensions. Whether working with lattice trees or self-avoiding walks, there is an upper critical dimension above which the model should behave like an independent model. "So a self-avoiding walk should behave like a random walk, and the lattice tree model should behave like a branching process," says Slade. "Proving this kind of thing is one of my main activities." ■

Bacterial PCB Busters

Engineering Enzymes to Improve Bioremediation



A wide variety of bacterial strains are able to aerobically transform some PCB congeners. This transformation is effected by the bph pathway (below), which specifies the assimilation of biphenyl. The pathway comprises biphenyl dioxygenase (BPDO), a dehydrogenase (BphB), 2,3-dihydroxybiphenyl dioxygenase (DHBD), and a serine hydrolase (BphD). The ability of the upper bph pathway to degrade PCBs varies from strain to strain. Eltis' studies indicate that the degradation of PCBs by the bph pathways is inhibited by the action of a relatively small number of chlorinated metabolites on specific enzymes. (Photos: Rob Kruyt, Thomas Heuser; Figure: Jeff Bolin [DHBD])

A group of UBC scientists have discovered several metabolites that inhibit the bacterial biodegradation of PCBs. Lindsay Eltis and his collaborators' basic research in enzyme engineering is being used in bioremediation and is also providing insights into antibiotic development and diseases such as SARS.

Imagine the most remote and pristine places on the planet—a glacier-fed lake in the Yukon, a sand dune in the middle of the Sahara, or a rain forest in Costa Rica. Unfortunately, we can only imagine them as being unspoiled. Every place on earth is contaminated with polychlorinated biphenyls (PCBs), a family of chemical compounds in which chlorine replaces hydrogen atoms. There are no known natural sources of these chemicals.

Over one billion pounds of PCBs were produced worldwide over a 50-year period for a wide array of industrial uses including electrical insulators, plastics (bread wrappers and cereal boxes), adhesives, paints, and varnishes. They are not only pernicious, they are persistent in the environment and their bioaccumulation remains a threat to the health of humans and the ecosystems on which we depend. Even though their use and synthesis has been banned in the western world since 1977, they are still a major environmental concern, particularly for the most fragile ecosystems.

"Until recently, incineration was the method of choice for destroying PCBs," says Microbiology & Immunology professor Lindsay Eltis. "If incineration isn't done at high enough temperatures, you can get by-products such as dioxins that are even nastier." His group has been studying nature's own process of bioremediation—how common soil bacteria break down PCBs. Their work is providing the basic science needed to understand, harness and speed up these biological degradation processes.

Bacterial Taste Tests

There are over 200 different types of congeners, or toxic substances, produced in the synthesis of PCBs. The production of any one commercial mixture typically included around 100 of these substances. One of the reasons microbiological remediation is so difficult is because the bacteria must be able to degrade everything in the mixture; any one component has the potential to block the degradation process. PCB transformation also depends upon the bacterial strain, which adds to the complexity of bioremediation.

"There are different classes of bacteria that can break down PCBs, and they work in fundamentally different ways," explains Eltis. Bacteria that degrade PCBs anaerobically (without oxygen) remove chlorine atoms on highly chlorinated PCBs (i.e., those carrying six to nine chlorines). However, they are fussy eaters, and typically leave three or four chlorines. Eltis works with bacteria that break down PCBs aerobically. "They do more than get rid of the chlorine; they actually break down the carbon skeletons as well," Eltis says. "Some of these aerobic strains can attack congeners that have up to six chlorines, but that is pretty rare and degradation is not complete."

To help colleagues engineer a faster and more complete breakdown process, Eltis and his group have been studying the structure and function of enzymes in the four-step bacterial pathway, which specifies the assimilation of biphenyl and transforms it to benzoate and other degradable molecules. Eltis' lab must understand how the enzymes work and also why they don't. They discovered that problems in PCB breakdown are caused by a small number of PCB metabolites, or intermediate degradation products, that inhibit these enzymes—specifically, metabolites on the third and fourth enzyme of the pathway that were previously unknown.

The Eltis lab uses a combination of powerful techniques to study these enzymes. Biochemical and kinetic (reaction rate) characterization helps determine what enzymes can and cannot degrade, how fast they degrade biphenyls, what inhibits them, as well as the strength of the inhibitors. Their spectroscopic studies help determine how certain compounds electronically or structurally interact with the enzyme's active site.

Eltis collaborates with crystallographer Jeff Bolin at Purdue University in the US to procure crystal structures (very detailed atomic structures) of these enzymes—both alone and bound to inhibitors—in order to gain insights into enzyme function. At UBC, Eltis also collaborates with microbiologists William Mohn and Julian Davies, chemist Mike Blades, and Robin Turner in the Michael Smith Laboratories. "I really think that because of these collaborations, UBC is the best possible place for me to do my research," Eltis says.

Directed Evolution

Protein engineering is a common tool used to help discover the mechanisms underlying the enzyme's function and to change that function. There are two basic approaches scientists can use to change an enzyme's activity. The first is site-directed mutagenesis, or random mutation, developed by the late UBC biochemist and Nobel Laureate, Michael Smith. In this rational engineering approach, the amino acid residues in a protein are changed in a targeted manner to see how this alters the function of the enzyme. "You need to know a lot about the enzyme in order to alter the amino acids in a predictable manner and observe the outcome," says Eltis. "The problem is that proteins are very complex molecules and it is not easy to predict how different residues contribute to function."

Eltis and his lab use a newer approach to modify enzyme activity called directed evolution, which adopts nature's method of selecting gene mutations that promote certain activities. Natural evolution of a bird in a forest might mean mutations that result in a long beak for probing insects out of bark. Directed evolution for industrial purposes might include finding an enzyme that produces better laundry soap, explains Eltis. The technique involves isolating the gene that encodes the enzyme of interest and mutating it in a random fashion, and then screening the library of mutated genes for

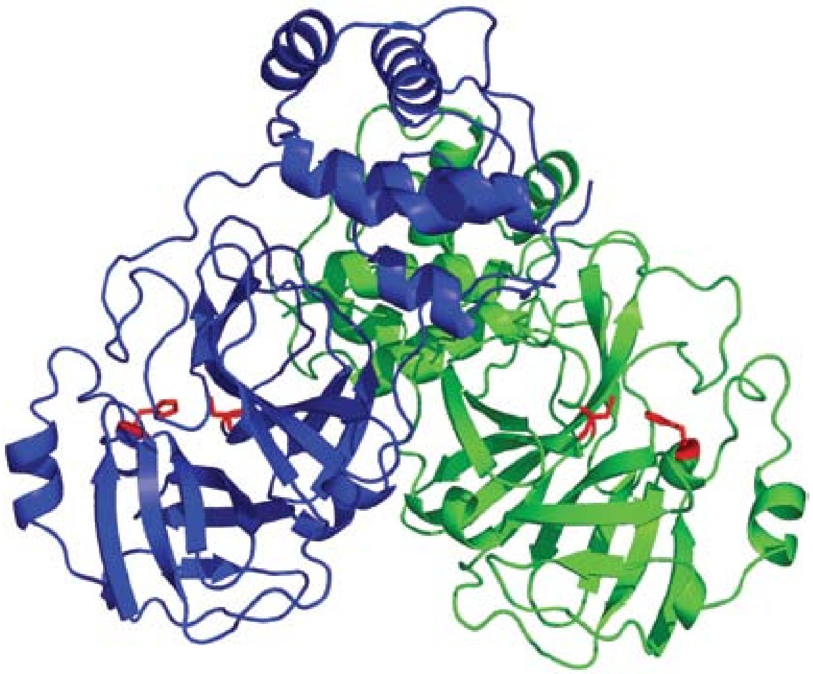
Screening for SARS Inhibitors

The use of directed evolution to study enzymes such as a proteinase—an enzyme that breaks down other proteins—has resulted in a fascinating and potentially life-saving offshoot of Eltis' research. His lab chose a viral proteinase, which is easy to produce in large amounts and would be a good target for trying to change enzyme activity. Meanwhile, Eltis' collaborators in the Genome Sciences Centre at UBC were sequencing the SARS coronavirus. They discovered that the proteinase essential to the life cycle of the SARS coronavirus, $3CL^{pro}$, is very similar to the proteinase that Eltis was working on. And at the University of Alberta, colleague John Vederas had already developed inhibitors for the highly similar $3C^{pro}$. "It was too interesting an opportunity to pass up," admits Eltis.

His lab acquired the clone for the SARS proteinase from the Genome Sciences Centre, expressed it, and developed an assay for it using a technique known as quenched fluorescence resonance energy transfer (FRET). This type of assay can be measured directly, without additional steps to purify or characterize the products. It also permits enzymatic reactions to be monitored in real time to obtain accurate reaction rates.

Colleague Eric Brown at McMaster University performed high-throughput screening of the proteinase against 50,000 small drug-like molecules in the screen. From 572 primary hits they narrowed it down to five, and in the final analysis, they found two molecules with apparent selectivity for $3CL^{pro}$.

"Right now we are trying to take this to the next level. Michael James, a collaborator at the University of Alberta, has just obtained detailed structure information about how some of these inhibitors bind to the proteinase," says Eltis. "This gives us clues as to how to modify their chemical structure." Developing more potent inhibitors to the SARS proteinase is the first step in designing drugs to fight the disease.



Crystallographic Structure of the SARS 3CL^{pro} Proteinase

The ribbons (blue and green) represent the fold of each subunit. Two catalytically essential residues are shown in red. (Figure: Carly Huitema)

desired activity. His lab is using the process to isolate the bacterial enzymes and the metabolites that inhibit them, and then to develop screens that look for better PCB degrading activities in these enzymes.

"Most of the mutations that you introduce into the gene are going to be deleterious to function," says Eltis. "But a very small percentage will actually push the enzyme in a new direction, and with a powerful screening system we can pick those out of the pack."

Decoding *Rhodococcus*—A Complex and Beneficial Bacterium

In order to further understanding of soil bacteria and their role in environmental remediation, Eltis, along with UBC colleagues William Mohn and Julian Davis, spearheaded and completed the sequencing and annotation of *Rhodococcus* sp. RHA1—the largest bacterial genome that has been sequenced to date. "Humans have 30,000 genes, and this bacterium has 10,000, which is more than some eukaryotes," Eltis exclaims. "The question is: What are all of those genes doing?"

Their work, funded by Genome Canada and Genome BC, has led to other promising discoveries. *Rhodococcus* may be one of the most efficient soil degrading bacteria, but it also happens to be closely related to *Mycobacterium tuberculosis*, the bacterium that causes tuberculosis in humans. "Our *Rhodococcus* isn't pathogenic, it just cleans up toxic pollutants for us," says Eltis. However, some of the basic processes of RHA1 are similar to pathogenic bacteria, and since studying deadly bacteria can be hazardous, using the more friendly and helpful *Rhodococcus* provides a safer alternative.

Rhodococci are also closely related to streptomycetes, a family of bacteria that produce over 70 percent of the antibiotics in use today. Eltis, Mohn and Davis hope that by making the RHA1 genome sequence available to the international scientific community, other researchers could use the knowledge to develop cheaper, more efficient antibiotics.

And as if this isn't benefit enough from one microbe, *Rhodococcus* also is one of the most commercially successful organisms in green chemistry, where companies use microbial rather than chemical processes to make industrial compounds, without producing toxic by-products.

"This is the wonderful thing about doing basic science," Eltis affirms. "You can start off in one direction, and suddenly you discover something totally unexpected that opens up exciting new avenues of research." ■

Enhancing Learning

Intelligent Environments That Prompt and Praise

Computer scientist Cristina Conati's interdisciplinary research intersects the areas of artificial intelligence, human–computer interaction and cognitive science in order to develop interactive systems that react and adapt to user needs and help students learn.

When personal computers first came on the market, they performed a limited number of functions for a rather elite group of users. Today, preschoolers and adults alike use programs such as MS Word, and users from all age groups and cultures are exchanging and processing an ever increasing amount of information. UBC Computer Science professor Cristina Conati is working to develop interactive systems that support a multitude of tasks and a variety of users. It is a mammoth undertaking that requires expertise in artificial intelligence (AI), human–computer interaction and cognitive science—a branch of psychology that attempts to understand human cognition.

We are all familiar with MS Word's paper clip, one of the first intelligent interfaces on the market. It was developed using AI techniques to improve the computer's capability of understanding—and assisting—the user. However, when it comes to understanding the complex behaviour of humans, AI tools are not enough, explains Conati. "You first need to understand all of the cognitive elements of the user spectrum—such as what actions users want to do and how they do them—and then determine what AI techniques should be used."

One challenge is to represent this cognitive information so that an interactive system can use it to reason about the user and then to apply it to produce real-time human–computer interactions that are transparent and user-friendly. In any human–computer interaction, a user should get feedback from the computer that is clearly linked to the action performed and the outcome of that action, says Conati. In intelligent interfaces, where the computer can "take charge," users should still be able to understand what the computer is doing and why, and they should always be able to control the interaction.

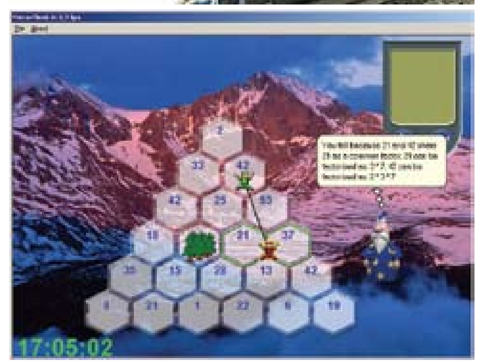
However, developing interactive systems that can dynamically adapt to user needs in a user-friendly way requires modelling more than just cognitive features such as goals, knowledge and preferences. Conati is working to expand the range of features that can be captured and processed in computational models to include personality traits, emotional reactions and meta-cognitive skills (a learner's awareness of their own knowledge and the ability to understand, control and manipulate cognitive processes).

Another challenge of this endeavour is the considerable uncertainty in building comprehensive user models. "One can either use approximations to deal with this uncertainty or use formal methods," Conati says. "Formal probabilistic methods are my general approach when working with interactive systems."

Creating Intelligent Learning Environments

Although there is still much work to be done in the general area of interactive systems and adaptive interfaces, creating intelligent environments that enhance student learning is even more demanding. There are more things the computer needs to understand about the user, such as what students know, what they feel and how they learn. For example, some students learn more and perform better in subsequent tasks when they work through examples to reason about the underlying domain knowledge. This meta-cognitive process is called self-explanation. Importantly, it is a skill that can be learned. However, there are also students who already understand the concepts and prefer to jump right into problem solving and ignore the examples. An intelligent system must recognize both approaches, and intervene or not intervene accordingly.

The holy grail of these educational environments is to foster learning by complementing classroom instruction with one-to-one computer-aided support. "If you



Probing Learning Behaviour
Kids usually have a lot of fun with educational games. But do those highly motivating games actually help students to learn? Using a combination of biometric sensor techniques and probabilistic models, Cristina Conati and her research team measure the players' emotional states and assess their level of reasoning and knowledge to find out about the balance between student learning and engagement.

want to help a person to learn, you need to understand whether they are actually learning or not," Conati explains. Because emotional, motivational and personality factors play a critical role in the learning experience, Conati believes a holistic understanding of the user is essential in developing intelligent learning environments.

Determining Learning in Educational Games

Educational computer games are an increasingly important component of teaching and learning because they foster a high level of learner engagement. The dilemma is that although these games can be highly motivating, there is scant evidence that they promote learning. "In fact, most of the time they don't; students have a lot of fun, but with little gain," Conati admits. She and her students are working on devising intelligent pedagogical agents to help students learn better from educational games.

Student modelling is an important tool to help an intelligent pedagogical agent predict and improve learning behaviour. However, building an accurate student model for an educational game is even more challenging than in more traditional learning environments because game performance is an unreliable reflection of student knowledge. Conati and colleagues worked with Prime Climb, an edu-game for number factorization developed by the EGEMS group (Electronic Games for Education in Math and Science) at UBC. Using probabilistic methods and machine learning techniques, they built a student model encoding, among other things, the uncertainty of whether making a correct move is based on reasoning and knowledge—or on sheer luck. "Using this model, we can actually assess student learning with 80 percent accuracy," says Conati.

Showing—and Sensing—Our Emotions

Conati is also developing a computational model based on a well-known cognitive theory of emotions, the Ortony, Clore and Collins (OCC) model, to capture student affective states that may interfere with learning. Her approach to modelling student affect involves the same probabilistic techniques. She employs a combination of personality traits, student goals and game actions to come up with a model that generates probabilistic assessments of a student's emotional reaction to game interaction. Following the OCC model, if a game state matches the student's goal, it generates positive emotions; if the game and goal do not match, it creates negative emotions. Goals might include "learn math," "have fun" or "learn by myself." If a student's goal is to succeed by her/himself, but the agent intervenes by giving tips, the model's probability that the student will feel a negative emotion such as irritation toward the agent goes up.

Evaluating the accuracy of an affective model is difficult because of the ephemeral nature of emotions. To validate their model, Conati and her team created an interface that allows students to input what their emotions are as they play. "This kind of self-report on emotions is suspected to be unreliable," she admits, "but eventually, with a large pool of data, we were able to verify that it is reliable."

Using this methodology, they were able to show that their affective model can determine emotions of joy/regret toward the game and reproach toward the intelligent pedagogical agent with roughly 80 percent accuracy. However, only around 40 percent of the students admired the agent. "This is mostly due to the fact that getting an accurate assessment of goals is still a challenge," Conati says. For example, some students say they want to learn by themselves when they actually want help, but the model thinks the agent should not intervene.

To overcome the challenges of modelling emotions by relying solely on possible causes of affective reactions (e.g., the match between student goals and game states), Conati uses biometric sensors. These sensors measure indicators for emotional states, such as skin conductants, respiration and blood volume pressure (heartbeats). They can reliably measure an increase in emotion, and under certain circumstances they also tell whether the emotion is positive or negative. "Even when we can only get information on emotional arousal, it is still valuable information," says Conati. "If arousal is not very high, then it is not worth interrupting the user, and vice versa."

The affective model, together with the model of student learning, will inform the interventions of the intelligent agent for the Prime Climb game so as to achieve the best balance between student learning and engagement.

In a related area of research, Conati uses eye tracking devices to better capture the user's reasoning processes. For one project, she is studying the relationship between gaze shift and self-explanation during interaction with an intelligent learning environment that uses animated simulations to help students understand mathematical functions. Using screen layout information, Conati was able to make assumptions about gaze patterns that helped assess when students were engaged in learning. From empirical observations of actual student interactions and the corresponding attention traces, Conati and her group computed the probability that a person can self-explain and not have a gaze shift, or have a gaze shift but not be doing anything meaningful. They then built a probabilistic model based on this data. Again, they had very good results, about 75 percent accuracy in assessing both self-explanation behaviour and consequent student learning. These results are even more impressive for this high-level cognitive process.

Conati's goal is to combine all of her research using probabilistic models and sensor techniques into one comprehensive model of human learning. Considering the success of her work to date, the brave new world of computer-enhanced intelligence is perhaps closer than we thought. ■

Portrait: The Department of Computer Science

The UBC Department of Computer Science (CS) has undergone a dizzying period of expansion in recent years. Currently, the department has 53 faculty members, 200 graduate and 900 undergraduate students. In the past two years, fifteen new faculty have been recruited along with a new department head, William A. Aiello, from AT&T Research Labs in New Jersey. These new faculty strengthen the department's international reputation, as they integrate into the eight CS research laboratories:

- Graphics, Visualization and Human–Computer Interaction
- Computational Intelligence and Robotics
- Database Research
- Distributed Systems and Networking
- Software Practices
- Integrated Systems Design
- Bioinformatics & Empirical and Theoretical Algorithmics
- Scientific Computing & Visualization

Computing touches virtually every field of science and engineering—and all aspects of daily life. Consequently, the work in these labs is both broad and multidisciplinary as evidenced by a variety of joint appointments and collaborations with research units throughout UBC and the province, including several departments in the Faculties of Science, Applied Science and Medicine, at the BC Cancer Research Centre and at St. Paul's Hospital. Many of these collaborations have arisen through the Institute for Computing, Information and Cognitive Systems (ICICS).

To ensure that the CS undergraduate students are equipped to meet the ever increasing multidisciplinary challenges in computing, the department is now offering combined degrees with many other Science departments. In addition, a new program, the bachelor of Computer Science (Integrated Computer Science) is for students who already hold at least a bachelor's degree in another discipline (visit: www.arc.cs.ubc.ca).

Three Canada Research Chairs reside in the department: Michiel van de Panne (Graphics and Animation), Kevin P. Murphy (Machine Learning and Computational Statistics) and Alan Mackworth (Artificial Intelligence and Robotics) who is also the first Canadian president of the American Association for Artificial Intelligence. Anne Condon holds the NSERC/GM Chair for Women in Science and Engineering for the BC/Yukon region. Gail Murphy and Joel Friedman received a Killam Research Fellowship in 2005. The First Mathematical Programming Society recognized Michael Friedlander with a Best Young Researcher Award and for contributing to the advancement of women in computing research. Joanna McGrenere received the first Anita Borg Early Career Award. As well, three instructors (Paul Carter, Michael Feeley and Ian Cavers) have had their excellence in the classroom recognized with a UBC Killam Teaching Prize. For lifetime service and achievement, James J. Little was honoured this summer by the Canadian Image Processing and Pattern Recognition Society.

This summer a new $40 million facility officially opened, including an addition to ICICS/CS and the Hugh Dempster Pavilion, a lecture/classroom complex. For more information about the department, please visit: www.cs.ubc.ca. Alumni are encouraged to stay in touch by registering at: www.cs.ubc.ca/alumni

Projects and Initiatives: Aboriginal Science






UBC is a place of great diversity; much of the university's success is a result of the rich cultural and geographical backgrounds of our people. The university's exciting new vision, Trek 2010, stresses the goal to "expand UBC's engagement with Aboriginal communities and develop strategies for the recruitment and retention of Aboriginal students." The Faculty of Science's goals align with those expressed in Trek 2010. In fact, our Faculty has been engaged in Aboriginal initiatives in collaborations across campus for several years.

Thirty Aboriginal students are currently enrolled in the sciences at UBC. This is still too few, considering that 8.3 percent of the K–12 public school students in British Columbia are Aboriginal. In 2003, the Faculty initiated projects aimed at increasing Aboriginal students' preparedness to pursue a post-secondary education and attracting more Aboriginal students to UBC. "On average, fewer than 40 percent of Aboriginal students graduate from high school in British Columbia, and out of those who do, very few have the grades to get into science," says Tim Michel, Aboriginal Coordinator in the Faculties of Science and Land & Food Systems.

Eighty percent of Aboriginal children in Vancouver live in poverty and face tremendous social challenges—including a very low level of encouragement and support in pursuing degrees in higher education. There are strong links between education, socio-economic status and health. A focus on education outreach can help these young people to participate more fully in the social and economic success of this province.

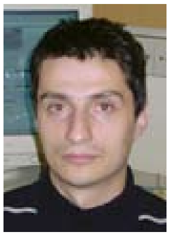
Currently, one of the most prominent projects supported by UBC Science is the CEDAR Summer Day Camp for Aboriginal Middle School Students. CEDAR formally stands for Cross-cultural Education through Demonstration, Activity and Recreation. Reaching out to Aboriginal youth early in their high school years, this two-week summer program focuses on fun activities, building academic skills, and making university more accessible to youth.

This August, twenty sixth to eighth graders from Aboriginal communities of the Greater Vancouver area participated in the free camp, which is a joint initiative of the Faculties of Science, Land & Food Systems, Forestry, and Arts, the UBC First Nations House of Learning, and the "Let's Talk Science" Association. The project builds upon the success of the Science 101 and Humanities 101 programs, involving volunteers from UBC students, faculty and staff. The high school students were engaged in science presentations and workshops such as "Physics is Fun" and "Urchins and other Undersea Creatures." Hands-on activities included a planting seed experiment and a day trip to UBC's Malcolm Knapp Research Forest near Maple Ridge.

The camp aims at helping these young people to acquire the language, math and other analytical skills needed for post-secondary education. On "Community Day," students, parents, guardians, and instructors gathered to wrap up the two-week camp with a barbeque, games and community interest presentations. CEDAR is unique in that it recognizes and addresses the barriers to success that Aboriginal middle school students often face. By helping to connect the UBC community with the urban Aboriginal youth, we hope to increase their access to post-secondary science education. For more information visit: www.science.ubc.ca/firstn.htm and aboriginal.science.ubc.ca

Photos: Courtesy of CEDAR

New Masterminds: Brain Gains at Science



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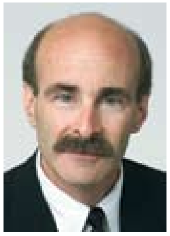

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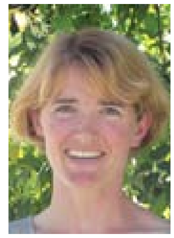


Harris

Horst

Krems

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

Arnaud Doucet, Assoc. Prof. and Canada Research Chair in Stochastic Computation, Depts. of Statistics and Computer Science; MSc Telecom INT, Paris, France; PhD Information Engineering, University Paris-Sud Orsay, France. Prior appointment: Cambridge University, UK. *Research:* Many systems and data like the World Wide Web or the volatility of the stock market can only be analyzed using complex probabilistic models. I develop simulation-based methods to study these problems.
www.cs.ubc.ca/~arnaud

Edward R. Grant, Prof. and Head, Dept. of Chemistry; BS, Occidental College, Los Angeles, CA, US; PhD, University of California, Davis, US. Prior appointment: Purdue University, US. *Research:* We study the dynamics of elementary rate processes using laser and spectroscopic techniques. In this work, lasers initiate reactions, characterize products and probe molecular electronic structure, very often in supersonic molecular beams.
www.chem.ubc.ca/personnel/faculty/grant

Carl L. G. Hansen, Assist. Prof., Dept. of Physics & Astronomy and Faculty of Applied Science; BSc Engineering Physics, UBC, Vancouver, Canada; MSc Applied Physics, California Institute for Technology, Pasadena, CA, US; PhD Biophysics and Biotechnology, California Institute for Technology, Pasadena, CA, US. Prior appointment: Institute for Systems Biology and California Institute of Technology, US. *Research:* Our research focuses on the development of microsystems technology for "proteomics," including applications to structural biology, cell biology and chemical genetics. We take part in the UBC Proteomics Initiative associated with the Michael Smith Laboratories.
www.phas.ubc.ca/~chansen

Christopher D. G. Harley, Assist. Prof., Dept. of Zoology; BSc Aquatic Biology, Brown University, Providence, RI, US; PhD Zoology, University of Washington, Seattle, US. Prior appointment: Bodega Marine Laboratory, US. *Research:* I study the population and community ecology of rocky shorelines, with a focus on climate change. My research includes work on temperature stress, interactions between species, and long-term changes through time.
www.zoology.ubc.ca

Sara E. Harris, Instructor, Dept. of Earth & Ocean Sciences; BA Earth Science, Wesleyan University, Middletown, CT, US; PhD Oceanography, Oregon State University, Corvallis, US. Prior appointment: The Sea Education Association, US. *Research:* My research interests are marine sedimentology and paleoceanography. I use a variety of marine sedimentary parameters to reconstruct past ocean circulation patterns and terrestrial climate variability.
www.eos.ubc.ca

Ulrich Horst, Assist. Prof., Dept. of Mathematics; BSc and MSc (Diploma) Mathematical Economics, University of Bielefeld, Germany; PhD Mathematics, Humboldt University Berlin, Germany. Prior appointment: Humboldt University Berlin, Germany. *Research:* My research is primarily concerned with interacting stochastic processes and their applications in finance and economics. The focus is on microstructure models for price fluctuations in financial markets.
www.math.ubc.ca/~horst

Roman V. Krems, Assist. Prof., Dept. of Chemistry; BSc Physical Chemistry, Moscow State University, Russia; PhD Physical Chemistry, Goteborg University, Sweden. Prior appointment: Harvard University, US. *Research:* The goal of our research is to understand the nature of chemical reactions and find mechanisms to control them with external radiation and electromagnetic fields. We study dynamics of atoms, molecules and chemical reactions at temperatures near absolute zero.
www.chem.ubc.ca/faculty/krems

Parisa Mehrkhodavandi, Assist. Prof., Dept. of Chemistry; BSc Chemistry, UBC, Vancouver, Canada; PhD Inorganic Chemistry, Massachusetts Institute of Technology, Cambridge, US. Prior appointment: California Institute of Technology, US. *Research:* My group develops novel catalyst systems for biodegradable materials. By using the tools provided by inorganic catalysis this research aims to create industrially viable and environmentally benign polymers for applications ranging from pharmaceuticals to materials science.
www.chem.ubc.ca/faculty/mehr

Mehrkhodavandi

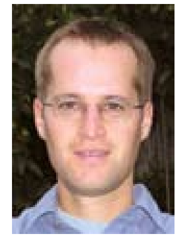
Momose

Reinsberg

Rottler

Shadwick

Signorell



Vellend

Takamasa Momose, Prof., Depts. of Chemistry and Physics & Astronomy; BSc, MSc and PhD Chemistry, Kyoto University, Japan. Prior appointment: Kyoto University, Japan. *Research:* My team develops new techniques to generate extremely cold molecules, which are expected to behave quite differently from those at high temperatures. We explore chemistry, coherent control and potential quantum computation of such cold molecules and probe the birth of molecules in the universe.
www.chem.ubc.ca/faculty/momose

Stefan A. Reinsberg, Assist. Prof., Dept. of Physics & Astronomy; Pre-Diploma, Physics, Universität Leipzig, Germany; MSc Physical Chemistry, Durham University, UK; PhD Physical Chemistry, Johannes Gutenberg-Universität, Mainz, Germany. Prior appointment: Royal Marsden Hospital & Institute of Cancer Research, UK. *Research:* Magnetic Resonance Imaging and Spectroscopy. My research goal is to develop imaging methods that improve the treatment of cancer patients. I am interested in techniques that can guide radiotherapy and predict its outcome.
www.physics.ubc.ca/people

Jörg Rottler, Assist. Prof., Dept. of Physics & Astronomy; MSc (Diploma) Physics, Universität Konstanz, Germany; PhD Physics, Johns Hopkins University, Baltimore, MD, US. Prior appointment: Princeton University, US. *Research:* I use computer simulations and statistical physics to study the molecular origins of macroscopic material behaviour. Topics include deformation and fracture of polymer and metallic glasses, non-equilibrium processes such as the microstructural evolution of surfaces during thin film growth, and electrostatic interactions in biomolecular systems.
www.physics.ubc.ca/~jrottler

Robert E. Shadwick, Prof. and Canada Research Chair in Integrative Animal Physiology, Dept. of Zoology; BSc Zoology, University of Western Ontario, London, ON, Canada; PhD Zoology, UBC, Vancouver, BC, Canada. Prior appointment: Scripps Institution of Oceanography, US. *Research:* We study two areas of organismal biomechanics—the mechanisms used by marine invertebrates to create protein polymers, and propulsive systems in fast and unsteady swimming fishes. Inspired by nature's blueprints, our research aims to design biomimetic materials for new biomedical or industrial devices.
www.zoology.ubc.ca

Ruth Signorell, Assoc. Prof., Dept. of Chemistry; BSc and Diploma Physics and Chemistry, PhD Physical Chemistry, Swiss Federal Institute of Technology, Zürich, Switzerland. Prior appointment: Georg-August-Universität, Germany. *Research:* The objective of our research is the controlled generation and detailed spectroscopic characterization of molecular nanoparticles, aerosols and clusters with sizes from subnanometers to microns. We aim to unravel the microscopic origin of the characteristic patterns found in the spectra of these weakly bound molecular aggregates.
www.chem.ubc.ca/faculty/signorell

Mark Vellend, Assist. Prof. and Canada Research Chair in Conservation Biology, Depts. of Botany and Zoology; BSc and MSc Biology, McGill University, Montreal, Canada; PhD Ecology & Evolutionary Biology, Cornell University, Ithaca, NY, US. Prior appointment: National Center for Ecological Analysis & Synthesis, US. *Research:* My general interests are in the ecology, evolution and conservation of plant populations and communities in changing landscapes. My group investigates the causes and consequences of biodiversity at the levels of genes and species.
www3.botany.ubc.ca/vellend/

Recent appointments also include:
Patrick Brosnan, Assist. Prof., Dept. of Mathematics.
www.math.ubc.ca/~brosnan

Joshua Folk, Assist. Prof. and Canada Research Chair in Physics of Nanostructures, Dept. of Physics & Astronomy.
www.phas.ubc.ca

Raphael Gottardo, Assist. Prof., Dept. of Statistics.
hajek.stat.ubc.ca/~raph

Catherine Johnson, Assoc. Prof., Dept. of Earth & Ocean Sciences.
www.eos.ubc.ca

Photos: Carola Hibsch-Jetter (2), private archives (12)

Faculty of Science: Kudos and News

In 2005 Science faculty members won the following prestigious academic awards.

Robert Anderson, Adjunct Prof., Earth & Ocean Sciences
• Service Award, Geological Association of Canada

Martin Barlow, Prof., Mathematics
• Elected Fellow, The Royal Society of London

Douglas A. Bonn, Prof., Physics & Astronomy
• Elected Fellow, The Royal Society of Canada

Leslie Burtnick, Prof., Chemistry
• Leadership Award of Distinction, BC and Yukon Heart and Stroke Foundation

Ronald Clowes, Prof., Earth & Ocean Sciences
• Logan Medal, Geological Association of Canada

Michael Doebeli, Assoc. Prof., Mathematics and Zoology
• E. W. R. Steacie Memorial Fellowship 2005, NSERC

David Dolphin, Prof., Chemistry
• Heroes of Chemistry Award, American Chemical Society
• Finalist, Gerhard Herzberg Gold Medal for Science and Engineering, NSERC

Joel Feldman, Prof., Mathematics
• Jeffery-Williams Prize, Canadian Mathematical Society

Brett Finlay, Prof., Michael Smith Laboratories and Microbiology & Immunology
• Michael Smith Prize in Health Research, Canadian Institutes for Health Research
• Gates Foundation Award, Bill and Melinda Gates Foundation and US Foundation for the National Institutes of Health
• Fellow, The Canadian Academy of Health Sciences

Robert Hancock, Prof., Microbiology & Immunology
• McLaughlin Medal, The Royal Society of Canada

Walter N. Hardy, Prof. Emeritus, Physics & Astronomy
• Chairman's Award for Career Achievement 2005, BC Innovation Council

John Hepburn, Prof., Chemistry
• Academy Fellow, The Royal Society of Canada

Philip A. Hieter, Prof. and Dir., Michael Smith Laboratories
• Elected Fellow, The Royal Society of Canada

Patrick Keeling, Assoc. Prof., Botany
• Seymour H. Hunter Prize, International Society for Protistology

James Kronstad, Prof., Michael Smith Laboratories and Microbiology & Immunology
• Fellow, American Academy of Microbiology

Vlada Limic, Assist. Prof., Mathematics
• A. P. Sloan Fellowship, A. P. Sloan Research Foundation

James J. Little, Prof., Computer Science
• Research Excellence and Service Recognition, Canadian Image Processing and Pattern Recognition Society

Andre Marziali, Assoc. Prof., Physics & Astronomy
• Medal for Excellence in Teaching, Canadian Association of Physicists

Joanna McGrenere, Assist. Prof., Computer Science
• Faculty Award of Innovation, IBM

Daniel Pauly, Prof., Zoology and Dir., Fisheries Centre
• International Cosmos Prize, Expo'90 Foundation in Japan

Steven Plotkin, Assist. Prof., Physics & Astronomy
• A. P. Sloan Fellowship, A. P. Sloan Research Foundation

Gordon Slade, Prof., Mathematics
• Prix de L'Institut Henri Poincare

Paul Smith, Prof., Earth & Ocean Sciences
• Highly Cited Scientist (earth sciences), Science Citation Organization

Terry Snutch, Prof., Michael Smith Laboratories and Zoology
• Distinguished Visiting Neuroscientist, Raymond and Beverly Sackler Foundation

Tadeusz Ulrych, Prof. Emeritus, Earth & Ocean Sciences
• Honorary Membership, Society of Exploration Geophysicists

Mark Van Raamsdonk, Assist. Prof., Physics & Astronomy
• A. P. Sloan Fellowship, A. P. Sloan Research Foundation

Mark Velland, Assist. Prof., Botany
• Young Investigators' Prize, American Society of Naturalists

Carl Walters, Prof., Zoology and Fisheries Centre
• Murray Newman Award for Excellence in Research, Vancouver Aquarium

Fei Zhou, Assist. Prof., Physics & Astronomy
• A. P. Sloan Fellowship, A. P. Sloan Research Foundation

James Zidek, Prof. Emeritus, Statistics
• Honorary Member, Statistical Society of Canada

Science Dean Now UBC's VP, Research

John Hepburn took over from acting vice-president, Research and Chemistry professor David Dolphin this October 1. Hepburn, who has been a UBC faculty member in Chemistry and Physics & Astronomy since 2001, started out as head of the Dept. of Chemistry and has been dean of the Faculty of Science since 2003.

New Science Dean *pro tem*

R. Grant Ingram, professor in Earth & Ocean Sciences, was appointed Science dean *pro tem* on October 1. He came to UBC in 1997 from McGill University. In 2003 he completed his six-year term of office as the founding principal of UBC's St. John's College, and has served as associate dean, Strategic Planning and Research in the Faculty of Science since 2004.

New Science Department Head

Ed Grant, professor in Chemistry, became head of the Dept. of Chemistry in May 2005. He came from Purdue University to UBC.

Faculty of Science at a Glance

The UBC Science 2005 booklet presents the first in a series of annual overviews of the Faculty. You can read and download your own copy at: www.science.ubc.ca

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