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Words from Our New Dean

(Photo: Martin Dee)

Simon M. Peacock was appointed Dean of UBC Science September 1, 2006.

This is the first issue of *Synergy* published since my arrival at UBC, so let me start by briefly introducing myself.

I have been fascinated by geology ever since poking around abandoned lead–zinc mines in southwest Scotland as a child and taking a wonderful earth science class in ninth grade when I was growing up in New York. I earned BS and MS degrees in Geology from the Massachusetts Institute of Technology and my PhD in Geology from the University of California, Los Angeles. Thanks to geology, I have had opportunities to travel the world, conducting research in Antarctica, Scandinavia, the Alps, Japan, and throughout North America.

For 21 years, prior to coming to UBC, I was a geology professor and academic administrator at Arizona State University in Tempe, Arizona. I have taught courses that collectively span most of the earth sciences. They include introductory courses in physical and environmental geology; undergraduate major courses in tectonics, petrology, hydrogeology, and field geology; and advanced graduate courses in geoscience computing, metamorphic and igneous petrology, subduction zones, and orogenic systems.

My geoscience research focuses on understanding subduction zones—places on Earth, like beneath Vancouver, where tectonic plates dive into the mantle, triggering great earthquakes, explosive volcanism and mountain building. Our society can be profoundly affected by subduction-zone events, such as the devastating Sumatra earthquake of December 26, 2004, and the resulting tsunami in the Indian Ocean. How well prepared are we for a similar magnitude 9 earthquake off the coast of British Columbia?

I believe one of the biggest challenges facing our society is sustainability—meeting the needs of the present without compromising the ability of future generations to meet their needs. Over the past several decades, we have learned that the complex biogeochemical cycles that connect the Earth's major "spheres" (atmosphere, biosphere, hydrosphere, and lithosphere) are increasingly disturbed by, and in some cases dominated by, human activities. It is no longer possible to study many planetary-scale processes, such as atmospheric chemistry, without understanding and incorporating into our models the impact of humans on these processes. Indeed, the largest uncertainties with respect to global warming are not scientific uncertainties, but human uncertainties. Will our society continue to burn fossil fuels at an increasing rate? Or will our society react to the threat of global warming by significantly reducing carbon dioxide emissions?

Synergy—which is also the title of this publication—can be viewed as dynamic interactions that lead to the whole being greater than the sum of the parts. Scientific research and education depend on synergy. The complex problems facing science today require dynamic interactions among different scientific disciplines. The most important scientific questions we face as a society require that we transcend traditional scientific disciplines and reach beyond the sciences to connect with the social sciences, engineering and humanities.

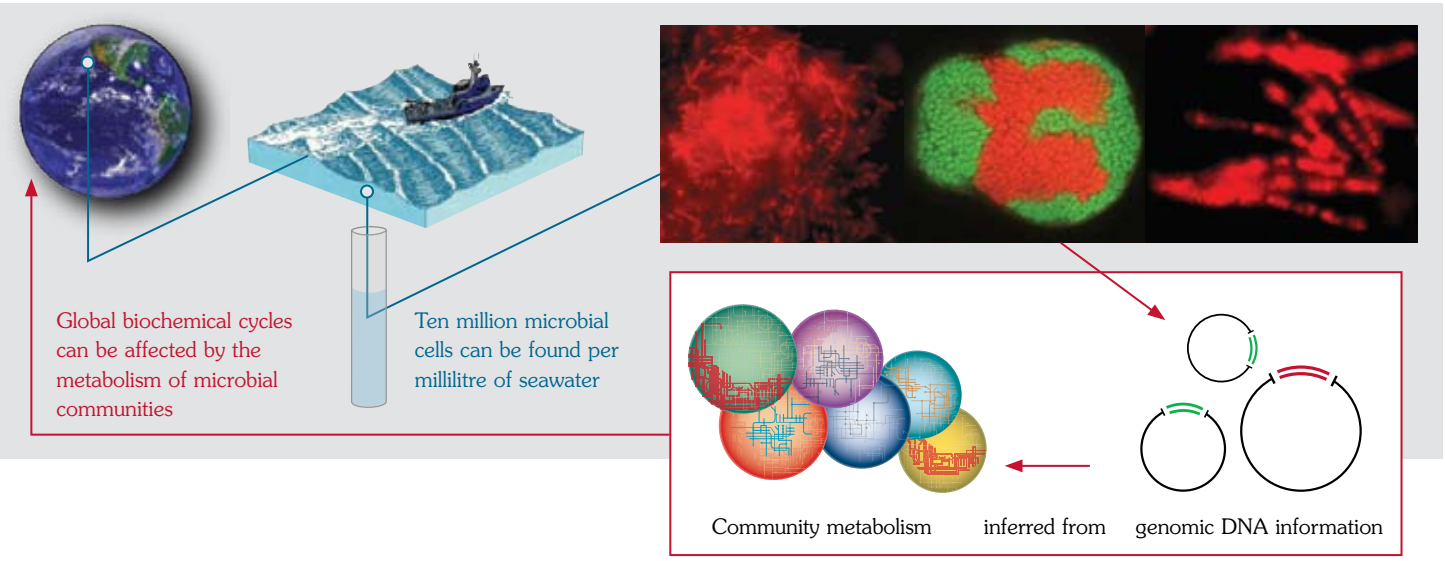
Universities are special places, where communities of scholars come together to discover and to learn. Universities have all the "parts" necessary to advance our understanding of, and to solve, complex problems like sustainability. How can universities best bring these parts together in creative, synergistic ways so that the university whole is greater than the sum of its parts? How can we best prepare our students—as the next generation of scientists and as global citizens—to meet these challenges?

As dean of Science at UBC, I draw energy from these complex challenges—and from our talented students, staff and faculty. I invite you to explore this issue of *Synergy* to get a taste of the exciting scientific research and educational advances that are taking place at UBC every day.

Simon M. Peacock
Dean, UBC Faculty of Science

Decoding a Genomic Wilderness

Community Metabolism of Uncultivated Microbes



Canada Research Chair in Environmental Genomics Steven Hallam is on a mission to understand how microorganisms and microbial communities contribute to ecosystem function in the natural world. He uses cutting edge molecular and computational tools to reconstruct the metabolism of microbial communities and how they affect global biogeochemical cycles.

There are more bacteria on Earth (10^{30}) than there are stars in the known universe—by approximately eight orders of magnitude—and there are more bacterial cells in the human body than there are human cells. "We might humbly admit that our body is not entirely ours, but rather one fragile component of an ecosystem that would quickly die without its microbial partners," states Steven Hallam, assistant professor in Microbiology & Immunology at UBC. While the notion of rampant bacteria running the helm of spaceship Earth might seem extreme, Hallam suggests that within the bacterial and archaebacterial domains of life there exist vast and hidden metabolic powers. These powers drive essential element and nutrient cycles that create and sustain the conditions for life. (Archaebacteria are ubiquitous and abundant microorganisms that have distinctive biochemical features setting them apart from bacterial and eukaryotic cells.)

"Microorganisms dominate our world and without them our existence would be radically transformed," says Hallam. However, in the climate of fear that permeates our culture today, most people consider microbes in the context of emergent disease or biological weapons. Putting aside the essential role of microbes in the production of wine, beer and cheese, not to mention antibiotics, one seldom considers this microscopic majority on intimate or beneficial terms. And yet even within our own bodies, bacterial communities are critical for extracting nutrition from food and protecting us from opportunistic infections. "Shared interactions contributing to enhanced fitness—this is a more appropriate way to consider microbes in the natural world," Hallam states. "It is a matter of dynamic balance, in population structure and metabolic activity that determines the overall contribution of microbes to health or disease states within our bodies and in the world around us."

Using Genomics to Analyze Microbial Communities

Hallam is part of a growing number of researchers at UBC and around the globe who study microbial communities by collecting them from their natural habitat and then applying techniques first developed to solve the puzzle of the human genome. Although complex and often tedious, this approach is necessary because the majority of microorganisms resist laboratory cultivation. "We sample an ecosystem—ocean, soil, even air—collect as much microbial biomass as possible and extract genetic material in the form of deoxyribonucleic acid (DNA)," he says. Following a series of laboratory manipulations, this complex mixture is separated into individual DNA fragments, and the precise order of nucleotides in each fragment is determined. The result is a massive amount of sequence information (imagine a million jigsaw puzzles after a hurricane)—which must be sorted, analyzed and interpreted.

The genetic make-up of an organism or a community of organisms can be inferred from primary sequence information with the aid of computers that search for patterns and motifs representing genes. In the central dogma of molecular biology, genes encode structural and functional proteins, and interacting protein networks define the metabolic properties of all living things. Reconstructing the complex metabolic networks of microbial communities from mixtures of sequence information is a major component of environmental genomic research.

Methane-Consuming Marine Microbes

One of the major processes that Hallam investigates involves methane consumption in marine ecosystems. Methane is a powerful greenhouse gas. Its atmospheric concentration has fluctuated naturally over geological time, but more recently has increased rapidly due to human activities. While the importance of methane on the earth's climate system is known, the global processes regulating its oceanic production are not well understood. Despite high rates of methane production along the continental margins, overall methane proliferation from oceanic sources to the atmosphere appear to be small in comparison to terrestrial sources. This is due to high rates of microbial-mediated anaerobic methane oxidation (loss of electrons occurring without oxygen) in oceanic sediments and water columns. Anaerobic methane oxidation consumes the majority of oceanic methane before it can enter the atmosphere. This helps to offset the production of terrestrial methane and reduces the overall impact of methane on global climate change.

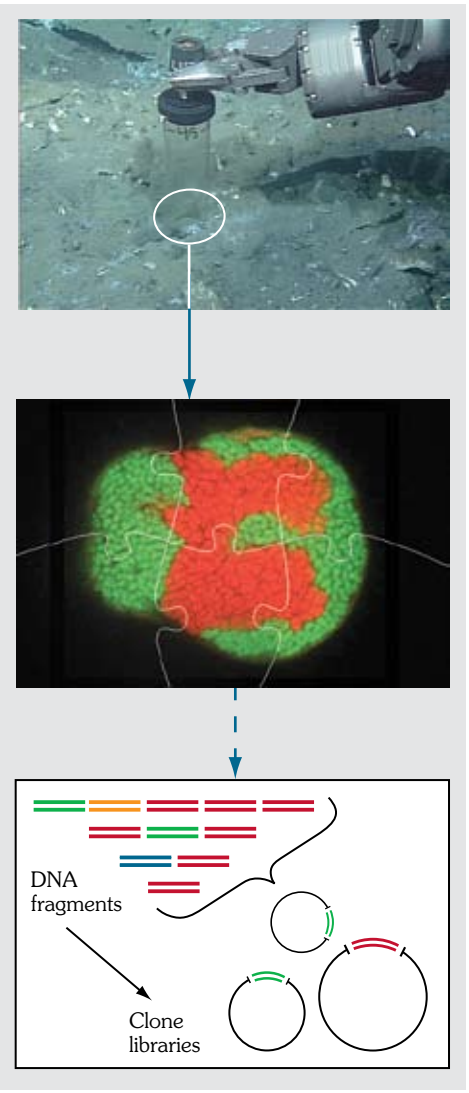
Hallam uses environmental genomic methods to explore the molecular mechanisms underlying this process of methane consumption. "We were amazed to find that microbial communities responsible for anaerobic methane oxidation were dominated by genes typically associated with methane production," he says. Although previous reports had hypothesized this scenario, Hallam's work provided the first genetic evidence that methane oxidation occurs by a reversal of one or more classical methanogenic pathways.

Methanogens are archaebacteria that convert compounds like acetate, hydrogen and carbon dioxide to methane as part of their metabolism. The methanogenic phenotype is thought to be ancient, dating back almost 3.5 billion years. "The realization that anaerobic methane oxidizing microbes have likely evolved by co-opting key components of the methanogenic pathway indicates that these two opposing processes may have played an integral role in shaping the earth's atmospheric composition over geological time," Hallam explains. While revelling in the symmetry of this arrangement, Hallam points out that this hypothesis remains unsubstantiated. "In effect, we have defined a parts list outlining the components of a biological methane filter. Our initial wonder has now been replaced by the sobering realization that gene prediction alone is not enough," he admits. "We need to determine the catalytic, structural or signalling role of the enzymes involved in order to develop a truly mechanistic understanding of the cellular process."

To undertake this task, Hallam and colleagues employ heterologous expression techniques, where genes from the environment are expressed in a suitable bacterial or archaebacterial host with a mutation in a particular gene of interest. They are also using functional screens that search for specific enzyme activity associated with methane oxidation pathways encoded in environmental genomic DNA libraries.

Hallam's efforts to move beyond genetic inventories toward a more functional perspective is motivated by both a desire for basic knowledge and a keen awareness that practical solutions to energy and bioremediation problems could emerge from his work. "The genomic DNA captured in our studies of uncultivated microbial communities represents a valuable genetic resource. Beyond computer-based models, we can screen this resource for novel enzymatic activities or for the production of secondary metabolites with industrial or biomedical applications," he states. For instance, in the case of methane oxidizing communities, researchers can look for genes capable of degrading aromatic compounds typically associated with hydrocarbon-rich marine sediments, or they can investigate molecular hydrogen production using components of the reverse methanogenic pathway.

By developing screening methods to investigate the metabolic potential of uncultivated microbial communities, Hallam hopes to access the enzymatic powers of uncultivated microbes and provide direct insight into the metabolic networks underlying fundamental biogeochemical processes.



Constructing genomic DNA libraries
Samples of marine sediments (top) contain a vast mix of microbials (middle). Probing this community's genetic information involves DNA extraction and library construction (bottom).

Microbial Diversity of Saanich Inlet

In collaboration with UBC colleagues Philippe Tortell (Earth & Ocean Sciences) and William Mohn (Microbiology & Immunology), Hallam has begun to explore the microbial diversity of Saanich Inlet, a marine fjord situated on the coast of Vancouver Island, BC.

Each year the inlet undergoes a cyclical process of stratification and mixing, which results in a predictable pattern of seasonal anoxia (complete depletion of oxygen). This has been recorded over many decades of chemical observation. The redox chemistry (electron flow between atoms/molecules) of the Saanich Inlet oxic/anoxic transition zone is primarily based on chemical energy stored in ammonia, methane, hydrogen sulfide, and molecular hydrogen, and resembles the stratified chemical gradients typically associated with anoxic marine sediments.

Hallam and co-workers have begun to compare genetic sequence information at various depths in the water column in relation to high-resolution trace gas and nutrient measurements. Their aim is to reconstruct microbial methane and ammonia metabolism during the seasonal stratification cycle. These efforts will help to better understand biogeochemical processes in oxygen minimum zones (OMZs) throughout the world's oceans. OMZs play a significant role as major sinks for nitrogen and methane, and as sources for the gases carbon dioxide and nitrous oxide. Microbial mediated biological activity associated with these systems impacts the productivity of the world's oceans and the balance of greenhouse gases in the atmosphere.

"It is a profound joy in my life that I have been afforded the opportunity to couple my sense of wonder and passion for the natural world with the rigorous pursuit of scientific understanding," Hallam declares. "It is also very satisfying to see a growing awareness in Canada of the importance of microbial diversity." He notes that this awareness is reflected in the creation of the Canada Research Chair in Environmental Genomics and in the potential formation of a Canadian Institute for Advanced Research program in integrated microbial diversity. Hallam also notes the strength of UBC research conducted in the area of microbial diversity and evolution by colleagues Naomi Fast, Patrick Keeling (*Synergy* 7.2), Brian Leander, William Mohn (*Synergy* 6.1), and Curtis Suttle (*Synergy* 4.2). While the funding climate for environmental genomics in Canada is still very much in its nascent stages of development, Hallam remains openly optimistic. "There is an emerging consensus, here and abroad, that environmental genomic research is opening up a previously undiscovered and almost limitless reservoir of genetic diversity and biological innovation in the microbial world. We are poised on the edge of a new frontier." ■

Molecular Manipulation

Constructing Compounds to Combat Disease

A major goal of biomedical research is the development of new therapeutic compounds to fight disease. Chemist Marco Ciufolini is developing novel techniques to synthesize complex molecules that have useful biomedical activity, such as anti-tumour agents, immunosuppressants, ion channel blockers, genetic modulators, and inhibitors of protein synthesis.

Imagine an engrossing three-dimensional game of chess, where each piece represents an atom and each position corresponds to the bonds required to form a molecule. One move could lead to the discovery of a biomedically useful molecule, a benign molecule, or a fatally harmful compound. The possibility also exists that you could play an entire game and end up in a stalemate, no farther ahead than you were before. This is the molecular chess game that Marco Ciufolini plays every day. The Canada Research Chair in Synthetic Organic Chemistry is not only working to find useful agents, but a more environmentally responsible way of producing them. "What we really do is build molecules, and we invent new reactions to allow us to build molecules that are of interest to biomedicine in general," he says.

Ciufolini's work is a conjunction of chemistry and medicine, basic and applied science—and the serendipity of discovery is bidirectional. "The more you learn about a substance that might have pharmaceutical applications, the more you need to know about its mechanism of action and structure," he says. "The exciting thing, especially with molecules that contain nitrogen, is that there is a huge opportunity to develop new reactions, because the methodology is underdeveloped. So we identify interesting molecules that could be beneficial for a variety of reasons, particularly in biomedical science."

In earlier research, Ciufolini developed a new type of reaction to make carbon–carbon bonds, one of the major problems in organic chemistry. Carbon is of particular importance because it is the only element that forms long chains of its own atoms. In addition, carbon–carbon bonds are extremely strong, and comprise a huge number of molecular forms, many of which are key structural elements of life. The formation of carbon–carbon bonds requires the creation of an electrically positive character on one carbon and an electrically negative character on the other, and then the use of electrostatic forces to get them to react and connect. "To create a negative character in one carbon, you normally need to attach it to a metal," states Ciufolini. He and col-

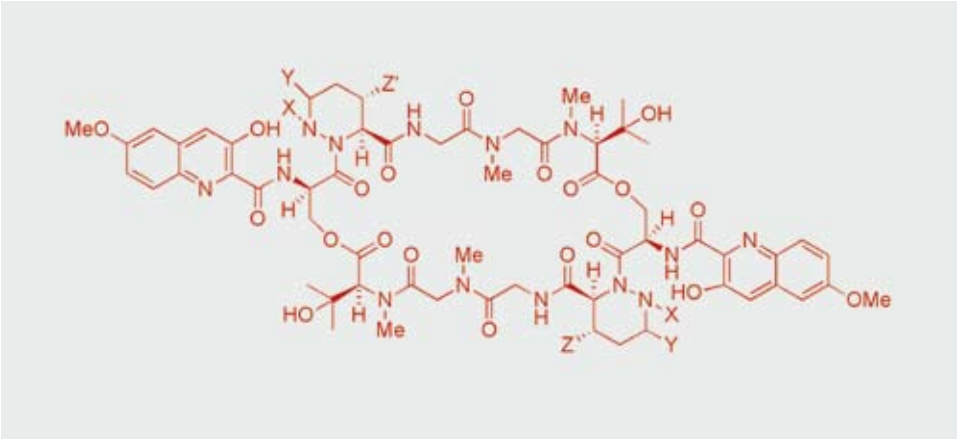
leagues found compounds that contained no metals, but had particular structural features that under certain conditions caused a carbon atom to behave like a negative carbon in the bond-forming process. This observation permitted the development of a metal-free variant of a reaction, called the adol reaction, which is now one of the backbones of organic chemistry.

Synthesizing Reverse Transcriptase Inhibitors

Ciufolini came to UBC from the Université Claude Bernard Lyon, France, where he was involved in a "hand-to-hand" battle to totally synthesize luzopeptins. These rare and chemically sensitive compounds were found to inhibit reverse transcriptase (RT), an enzyme that is required for infection and replication of retroviruses such as HIV. Before a compound like luzopeptin can be developed into a potential therapeutic drug, however, a number of fundamental questions have to be answered: What is the mechanism of action? What are the minimal requirements for luzopeptin-like structures to be anti-HIV active? Could these minimal structures be synthesized? Ciufolini describes the resultant work on luzopeptins as "an epic that spanned nearly ten years and two continents."

Cell division is the process whereby the "parent" cell divides into two "daughter" cells—the basis of propagation in all species. Ciufolini's research is currently focusing on inhibitors of another human enzyme, telomerase, a specialized RT that is required during cell division. Since cell division and DNA replication are rampant in cancerous tumours, the blocking of telomerase might inhibit cancer growth and possibly treat some age-related diseases. "It is possible that we may be able to create a luzopeptin-like molecule, which we now know how to make, to develop a telomerase inhibitor," he says. "To really address this issue you need expertise in a variety of fields, including biochemistry, cellular biology, enzymology, and biotechnology. So this would be a perfect collaboration for UBC's Centre for Drug Research."

Ciufolini notes that his move to Canada was motivated by the calibre of research at UBC and a supportive environment created by the Canada Foundation for Innovation and the Canada Research Chair program. He also acknowledges the support of industry partners like Merk-Frosst Canada.



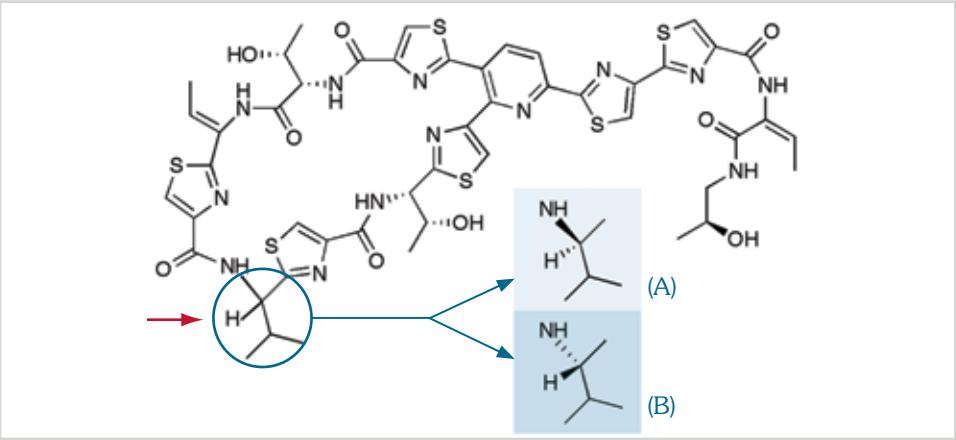
Chemical structure of luzopeptins
There are four luzopeptin derivatives differing in some of their bonding (X, Y) and substitutes (Z, Z'): Luzopeptin A (X, Y= π bond; Z = Z' = OAc), Luzopeptin B (X, Y= π bond; Z = H, Z' = OAc), Luzopeptin C (X, Y= π bond; Z = Z' = H), and Luzopeptin E2 (X = Y = Z = Z' = H).

Antibiotic Design—Mapping Micrococcin

Infectious diseases kill thousands of people every day, and have become the leading cause of premature death. In turn, antibiotic resistance has escalated, increasing the severity of the problem. The development of new antibiotics is a major area of scientific and medical research. One class of antibiotics that is promising in the treatment of "super bugs" is the thiopeptides.

There are many ways to kill bacteria, notes Ciufolini. Penicillin-type drugs work by suppressing the mechanisms that create the bacterial cell wall, which weakens and causes surrounding fluids to leak into the cells. Subjected to the osmotic pressure building up, the bacteria literally explode. Thiopeptide antibiotics do not act on the cell wall, but instead infiltrate the cell and inhibit the synthesis of all proteins. They do this by blocking the action of ribosomes, which are the organs of the cells where protein synthesis occurs. As a result, the cell dies.

Micrococcin is one of the simpler types of thiopeptides that Ciufolini and colleagues have been working to synthesize. In the process they made a surprising discovery. The structure that had been originally proposed for the molecule was wrong (see illustration on next page). And it is the structure of a molecule or compound that determines its interaction and function. "This business of erroneously assigning structure to new com-



Proposing the chemical structure of micrococcin

Micrococcin is a thiopeptide, a class of antibiotics that is hoped to work as powerful alternatives to penicillin-type drugs. Structures (A) and (B) look almost the same, but differ in their stereochemistry regarding the position of one C–H bond (see red arrow).

(A) Originally proposed structure of micrococcin P1 (incorrect)

(B) Newly proposed structure of micrococcin P1

pounds is commonplace," Ciufolini states. One of the tasks of synthetic organic chemistry is to ensure proposed structures are correct. "You cannot make a drug out of something unless you know its exact structure. And you cannot be absolutely sure of the structure until you can synthesize it."

Although micrococcin is considered a relatively simple thiopeptide, nonetheless, its synthesis requires around 30 chemical reactions, and twenty of these are linear—they must be performed sequentially. However, the correct chemical structure eluded researchers because of the complex stereochemistry of the molecule. Stereochemistry is an area of chemical science that deals with the spatial orientation of atoms around a molecule, and the consequences of atomic orientation on the properties of the molecule, which in turn affects its biological activity. Ciufolini and colleagues believe the key to what is wrong with the proposed structure of micrococcin lies with one hydrogen–carbon bond (see red arrow in diagram). Instead of pointing down (dashed line), it should be pointing up (solid wedge). "That is enough to make a molecule behave very differently," he says.

Potential Cancer Drugs and Gene Switches

Over the course of synthesizing thiopeptides for the development of antibiotics, Ciufolini observed that these notoriously difficult molecules have potential for other important therapeutic applications. Thiopeptides contain segments, or substructures, called thiazoles, which could plausibly be incorporated in a family of drugs known as kinase inhibitors. Kinases are enzymes that control the traffic of phosphate within the cell, and form the basis of cellular communication. "If you can selectively block one kinase without disrupting others, you could effectively interrupt specific forms of cellular communication that might be harmful," he says. Ciufolini and colleagues in Paris, Marseille and Strasbourg, France, have developed a thiazole-containing kinase inhibitor that is in advanced stage II clinical trials. They are testing its efficacy against certain types of aggressive, incurable cancers, such as multiple myeloma, gastrointestinal stromal tumour and other proliferative diseases that appear to depend on the uncontrolled activity of a specific kinase.

In addition to their function as protein synthesis inhibitors, thiopeptides can also trigger the expression of genes of unknown function in certain microorganisms. In another example of bidirectional serendipity, Ciufolini thinks that these molecules could be developed into a gene switch. The concept behind gene therapy to combat disease is to introduce a normal, healthy gene into the cells of a patient in such a manner that it will correct the defects of the abnormal, errant gene. However, the good gene must be introduced inside the cell in a suppressed or dormant form. Then a drug, or gene switch, is administered to turn the gene on, and when the drug is excreted from the body, the gene is re-suppressed. "We can do the thiopeptide chemistry," he states. "It would be fabulous to create a gene switch using thiopeptides or simplified forms of thiopeptides, in collaboration with other colleagues at UBC."

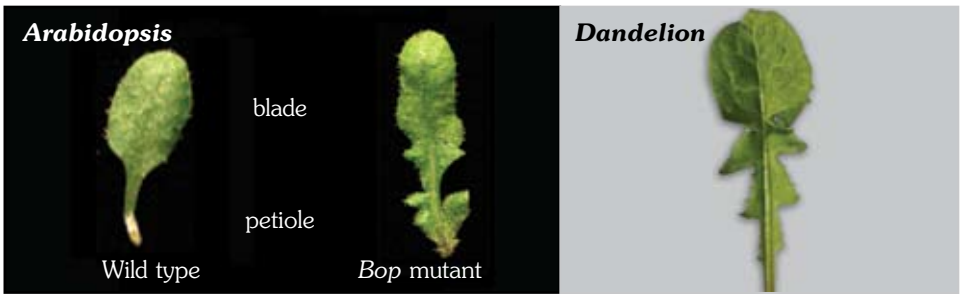
Harnessing Marine Compounds

There is a plethora of substances in nature that are bioactive, but for various reasons cannot be developed, notes Ciufolini. One agent that he is working to harness is tetrodotoxin, a potent marine neurotoxin found in several species of ocean fish, starfish, flatworms, and crabs. Tetrodotoxin, a sodium channel blocker, is used as a biochemical probe, but it is too poisonous to be of value in medicine. However, tetrodotoxin-like molecules displaying reduced toxicity, but retaining sodium channel blocking activity, could be important for the treatment of certain neurological conditions. Ciufolini hopes that chemical synthesis will ultimately reveal the path to one such molecule.

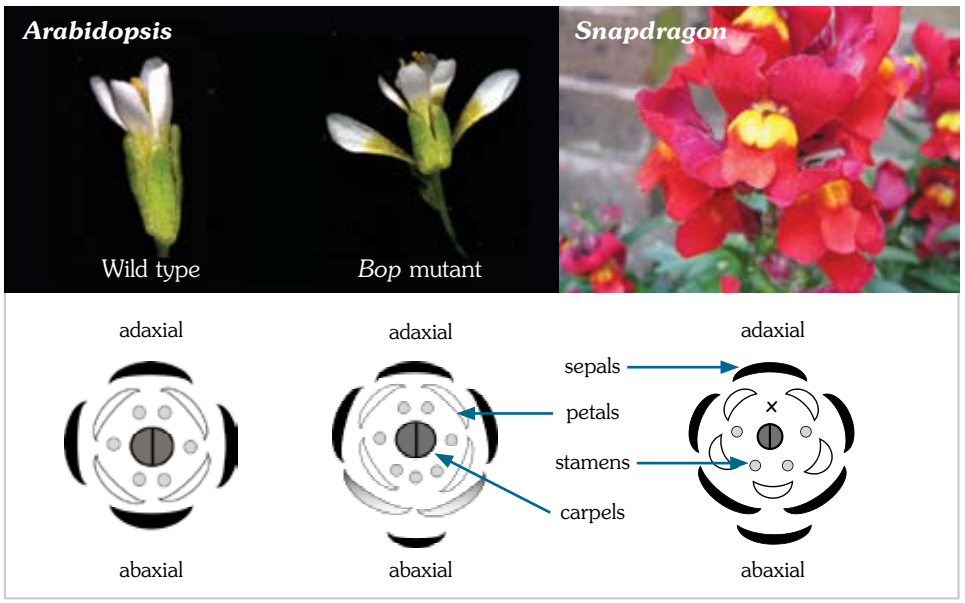
Another marine substance of potential biomedical interest is spiroleucettadine, which exhibits appreciable antibiotic activity. Again, to Ciufolini, the proposed structure of the compound looked suspicious. He and students Johan Chang and Bryan Chan developed a novel approach to synthesize spiroleucettadine that "ignores issues of absolute stereocontrol, focusing exclusively on structural questions." Their work confirmed that the proposed structure is incorrect. "Matter seems inherently adverse to human manipulation," he concludes. "Every single molecule that we have made has required the development of new technology in order to make it." ■

The Mysteries of Morphogenesis

Deciphering the Genetics of Form and Function



The* BLADE-ON-PETIOLE *genes
BOP1 and BOP2 are involved in the morphogenesis of leaves. The bop1 bop2 *double mutants of* Arabidopsis *have abnormally long leaves with blade development along the petiole, revealing close resemblance to the leaves of common dandelion.*



An even more dramatic morphological change in bop1 bop2 *mutants can be seen in* Arabidopsis *flowers. Wild type flowers are highly symmetrical.* Bop1 bop2 *flowers develop asymmetrically, with a pentamorous arrangement of organs, which can be found in flowers of other species such as* Antirrhinum *(snapdragon). (Photos [Arabidopsis]: Shelley Hepworth)*

Developmental biologist George Haughn researches cell growth, differentiation and morphogenesis—the processes whereby cells are transformed into organs and organisms. He and his UBC lab are investigating the genetics of plant growth and development in order to unravel the mysteries of morphogenesis.

The favourite movie line of plant developmental biologists was probably uttered by Marilyn Monroe in the 1961 Arthur Miller screenplay–John Huston production of *The Misfits*. "How tiny those seeds were. And yet they know they're supposed to be lettuces." UBC Botany professor George Haughn and his lab have a similar fascination (without Monroe's breathy incredulity, of course) with how plants take shape and what shape means for growth and development.

"Most of the diversity we see in plants is a result of morphological changes due to mutation," notes Haughn. In fact, virtually every plant we eat is a mutant of one type or another. Plants cultivated from the wild cabbage *Brassica oleracia* provide a dramatic example. Turnips, cabbage, Brussels sprouts, broccoli, and cauliflower are all the same species. A turnip is a deformed root. Broccoli is a branching mutant that forms profuse edible flowers on plants that are harvested before the flowers open. Cabbages make an abundance of leaves before they flower. Brussels sprouts produce leaves in the place of flowers. "Cauliflower is a branching mutant like broccoli that cannot produce floral organs," Haughn says.

One of the major objectives of developmental biologists is to identify the genes that encode regulatory proteins involved in morphogenesis in order to determine how they function together to direct shape and form. Transcription factor regulatory proteins control the fate of cells by interacting with DNA to switch genes on and off. "The number of transcription factors needed to control the complex processes of plant growth and differentiation is surprisingly small, because they often function combinatorially to specify separate developmental events at different times and places," Haughn explains. An important aspect of his work is the study of redundancy, where two genes with similar functions are expressed in the same tissue, thereby overlapping and providing backup if one fails to do its job.

Deciphering Redundancy in Plant Defence and Development

In a unique collaboration with Botany colleague Xin Li at UBC's Michael Smith Laboratories, Haughn and his lab studied the role of *NPR1*-related genes in the model plant *Arabidopsis thaliana*. *NPR1* has been widely studied for its role in plant defence mechanisms. When a leaf is attacked by a fungal spore, a typical plant resistance mechanism involves cell death at the site of infection, thereby isolating the invader spore. At the same time salicylic acid (SA) is released systemically, which signals other leaves to mount defences. *NPR1* is the gene that regulates the protein needed to translate this chemical signal into a biological defence response in leaf cells.

Xin Li's research determined that another five genes are closely related to *NPR1*, but their individual effects on the *Arabidopsis* defence mechanism were yet to be identified. Li and colleagues used reverse genetics (see side bar) to engineer a loss of function in each related gene in order to determine whether any effects on the pathogenic response mechanism of a plant would result. Some loss-of-function mutations did affect plant defence. The most surprising result, however, was found with two closely related genes *BLADE-ON-PETIOLE BOP1* and *BOP2*. These genes were not involved in the defence response, but were required for morphogenesis instead. "What we found was that if we knocked them both out in the same plant, there was no effect on resistance to pathogen attack," Haughn remarks. "Instead, we saw dramatic morphological changes."

The earliest notable defect in the *bop1 bop2* double mutant was in the shape of the leaves. Wild type *Arabidopsis* has rosette leaves divided into distinct proximal (petiole or stem) and distal (blade) zones. The mutants have abnormally long leaves with blade development along the petiole, resulting in a loss of distinct proximal and distal zones in the leaf, similar to the common dandelion (see illustration on page eight). However, Haughn and his lab observed that the most dramatic morphological change in *bop1 bop2* mutants was in *Arabidopsis* flowers. Wild type flowers are highly symmetrical, with four sepals, four petals, six stamens, and two carpels arranged in concentric whorls around the floral meristem. In contrast, *bop1 bop2* flowers develop asymmetrically, with a pentamorous arrangement of organs similar to other species such as snapdragon.

Research on *BOP* genes is causing a stir among botanists around the world, and the field is very competitive. Unbeknownst to Haughn and his lab, several other groups were simultaneously working on similar research. Although there was overlap in the work on *BOP* function from the different groups, Haughn notes that the studies were also complementary in many respects.

The most exciting aspect for Haughn is that *NPR1*-like genes are not only involved in plant pathogen defence, but also in plant development. "It is quite possible that loss of function in these kinds of genes has led to some of the morphological diversity we observe between different species of plants, but so far, nobody has investigated this hypothesis," he admits.

Genotype versus Phenotype

The unique set of genes of any specific organism, plant, animal, or individual is called the genotype. The organism that is produced from the action of the genes is the normal or wild-type phenotype. DNA alone does not determine phenotype, but works in tandem with environmental influences and variations. However, mutations affecting gene function often result in a new (mutant) phenotype.

TILLING for Reverse Genetics

Reverse genetics, a key tool of molecular biology, involves the identification of organisms carrying mutations in cloned genes in order to determine or manipulate gene function. Several techniques have been developed. However, some are labour intensive, others give ambiguous results, and yet others are unsuitable for isolating mutants that have lethal or sterile phenotypes.

Haughn and research associate Erin Gilchrist have established the CAN-TILL facility at UBC for a new reverse genetic technique developed by Steve Henikoff, Luca Comai and colleagues in Seattle. The new technique, called Targeted Induced Local Lesions in Genomes (TILLING), has several advantages over other reverse genetic techniques. It can be used for virtually any organism, regardless of genome size, reproductive system or generation time. It is also capable of high-throughput analysis. TILLING is currently being used for the detection of both induced and natural variations in several plant and animal species. Haughn and Gilchrist are working with several UBC colleagues, including Quentin Cronk, Joerg Bohlmann, Carl Douglas, and Brian Ellis, as well as others outside of UBC, to develop TILLING in a variety of different species (see www.botany.ubc.ca/can-till).

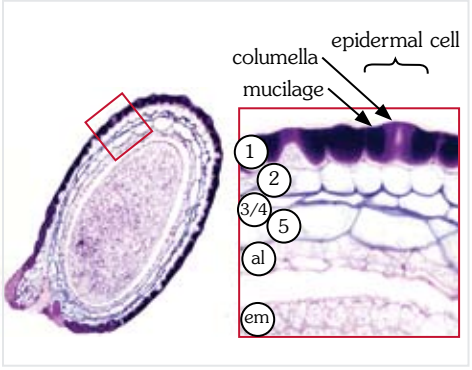
Uncovering Seed Coat Development

From the whirligigs of maple trees to the fluffy parachutes of dandelions, each plant has a unique seed coat that plays a critical role in its propagation. The seed is formed from the ovule as a result of fertilization, a transformation that leads to the development of an embryo, endosperm and seed coat. The seed coat consists of several layers of specialized cells that provide protection for the plant embryo during dormancy and germination, as well as hydration and enhanced seed dispersal—as we can easily observe in the maple tree and dandelion.

While seed embryos represent the beginning of plant life, seed coats, derived from maternal tissue, represent the very last stage in plant development, and undergo a complex pathway of cellular differentiation. Despite these fascinating traits, the molecular and cellular events of seed coat development have received little research attention compared with other aspects of plant development, Haughn notes. He and colleagues are pioneers in research on seed coat development in *Arabidopsis*, where seed growth and formation involves a dramatic transformation in five layers of cells. His laboratory has focused on the development of the epidermal (outer) layer of plant seed coats. Their goal is to better understand certain aspects of the specialized function of these cell types.

When immersed in water, the seed coat epidermal cells of some species release a large amount of mucilage, a jelly-like substance primarily composed of pectin, which encapsulates the seeds. Pectin is a complex carbohydrate that is an important component of many cell walls and well known for its use in making jams and jellies. Seed coat mucilage has been shown in the lab to aid seed hydration and protect against chemicals, but its role in the natural environment isn't clear.

"We think we can learn how cell wall pectin is made, secreted and controlled, by studying mutants that are defective in seed coat mucilage," says Haughn. In a study of mutations in five mucilage-modified *(MUM)* genes, they discovered that *MUM4* is not only required for normal levels of mucilage, but also for proper formation of the thick secondary cell wall, the columella (see illustration). "This suggests that normal mucilage production has a role in cell morphogenesis. It is an intriguing connection that we hope to investigate further," says Haughn. ■



Seed Coat Development
Cells of the innermost layer (5) of the Arabidopsis *seed coat synthesize tannins, which later oxidize to give the seed coat its brown colour. Cells of the other two inner layers (3/4) do not differentiate further and are crushed together as the seed develops. The subepidermal layer (2) produces a thickened cell wall on the inner tangential side. In the epidermal layer (1) the vacuole, or embryo sac, contracts as cells of the epidermal layer secrete a large quantity of mucilage that fills a horseshoe-shaped space surrounding a cytoplasmic column in the centre of the cell. A secondary cell wall replaces the cytoplasmic column to form the columella. In these late stages of seed development, the cells of all seed coat layers die, and the structure of the epidermal layer is preserved by the mucilage and the columella.*

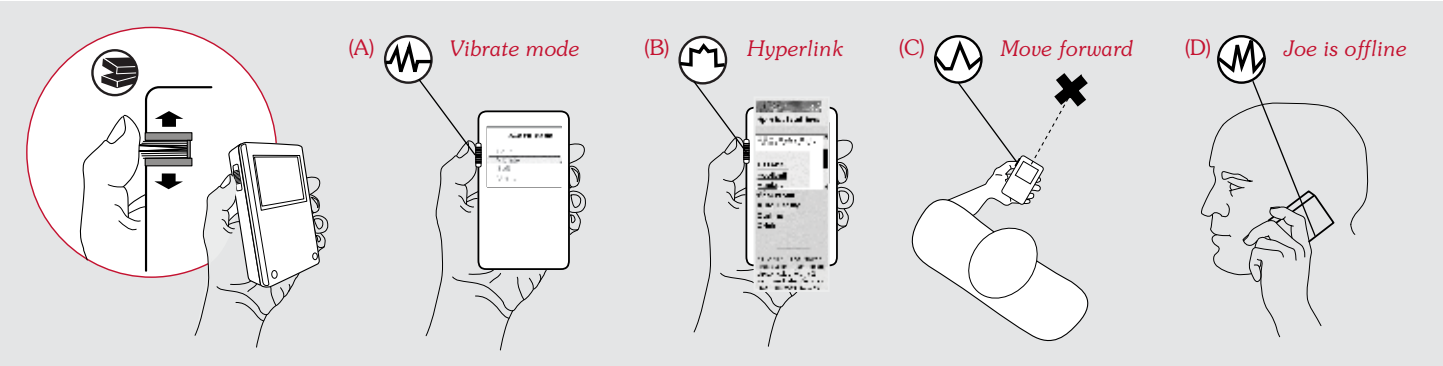
Enhancing Haptics

Tactile Wizardry Advances Technology

The yellow brick road of haptic design is leading to enriched interaction with technology and to devices that assist us in daily tasks by unloading visual stimulus onto our sense of touch. Just as haptic devices involve force feedback, Karon MacLean elicits user feedback to help develop a palpable iconic language and to aid in device prototyping.

In the world of human–computer interaction (HCI), the sense of touch is underutilized. Haptics is the science of incorporating touch into technology to make devices more adaptive and responsive to human needs. "Interfaces must go beyond meeting simple performance and functionality requirements, to forming a pleasurable emotional bond with the user, which in turn increases usability and performance," says UBC computer scientist Karon MacLean, whose multidisciplinary research also incorporates psychology and engineering.

Just as technology is changing the way we interact, it is also changing the way we learn. One would assume that the emphasis on academics and technology in current high school curricula would benefit haptic design. Paradoxically, it doesn't. As a computer scientist who builds things, MacLean notes that students today lack tactile skills and sensitivity that courses such as industrial arts and home economics—and playing with physical toys instead of video games—used to help develop. She sees this lack of tactile experience with the physical world as a drawback to students' holistic learning experience. "When you use your hands you are stimulating creativity, and touching and using tools is an alternate pathway to understanding problems that have a physical aspect," says MacLean. "This tactile learning is essential, because reading and manipulating information on a computer screen simply does not



provide the same skills. I think we're losing much of our ability to feel—and within a single generation."

With funding from the Canada Foundation for Innovation, the Advanced Materials and Process Engineering Laboratory, and the Institute for Computing, Information and Cognitive Systems, MacLean spearheaded the building of a machine shop for graduate students that is accessible to those in departments like Computer Science, who don't traditionally build "things." "Technology is isolating us from the real world to an extent that physicality has come to feel unnatural," she states. "Part of my interest is in understanding how we are wired and how our sense of touch helps us to learn. The other part is to add value to technology, because it's here to stay."

Tactile communication involves unique opportunities as well as challenges. Our sense of touch is distributed over our entire body and is bidirectional (we receive and transmit sensation), providing feedback required to perform dynamic and precise tasks. Unlike sight and hearing, touch is very personal and intimate. Others might be able to hear or see the same phenomena we do, but they cannot feel what we feel.

Designing a Haptic Language

Developing haptic devices that are simple, intuitive and that match users' needs in daily life requires creating a haptic language—or a tactile iconography that is intuitive and instantly recognizable by the user. This "language" could incorporate heat/cold, force feedback, specific vibrations, or textures to transmit information to the user.

In exploring a scientific, perceptually grounded approach to haptic iconography, MacLean and her Sensory Perception and Interaction (SPIN) research group found themselves trailblazing unknown territory counter to the general trend in the field of haptic design. Instead of increasing complexity, the prototypes they developed are mechanically simple (like the Hapticat; see page 12). However, the techniques used to design the applications must be all the more sophisticated. "I don't think we can make good devices until we understand how people perceive them," MacLean says. She applies user feedback in an iterative, user-centred design process that allows key parts of a prototype to be separated and the problems solved individually.

Haptics and Hand-held Mobile Devices

MacLean and former UBC graduate student Joseph Luk, and Jérôme Pasquero, a graduate student co-supervised with MacLean's McGill collaborator Vincent Hayward, are exploring advanced haptic technology to aid navigating on hand-held mobile devices, such as cell phones, personal digital assistants (PDAs) and portable media players. As these devices become smaller and more complex—and their use increases—control and display design becomes more difficult. Since these devices are worn or carried wherever a person goes, they must be practical in a wide variety of contexts. Visual displays and controls are often loaded with information that demands time and attention to scroll through. And, the way the devices notify us of incoming information can be intrusive, such as a phone ringing during a meeting or dinner. Simple haptic notification, such as vibra-

The haptic hand-held mobile device *uses piezoelectric actuators causing lateral skin stretch. The storyboard sketches of the hardware prototype depict initial application concepts—list selection (A), scrolling (B), direction signalling (C), background status notification (D). The figures shown as call-outs represent haptic icons. (Source: Steve Yohanan)*

tion in phones and pagers, is now common. However, this vibrotactile stimulus is produced across the entire device, with only two levels (on or off), and no bidirectional interaction.

MacLean's group is developing haptics to enhance HCI in mobile devices. Their prototype uses piezoelectric actuators—made of crystals that generate a voltage in response to applied mechanical stress—to produce different skin-stretching sensations that are coded in a menu of tactile icons. The technology can transmit sensations such as bumps, gratings and other types of motion relative to the user's fingers. A study on perceivable stimulus speed showed that these devices are capable of signalling the direction of stimulus movement over a large range of speeds. This suggests that a directional "tactile flow" signal could assist in navigational tasks such as scrolling through the menu of a hand-held device.

The group developed a second study to assess perceivable differences in sensations allotted to specific haptic icons. They have designed a multi-dimensional scaling technique to map the organization of the stimuli in a perceptual space. Icons that feel similar are closer together on the map. Their results showed that users tend to structure the stimulus space first in terms of one dominating perceived parameter (for example, the frequency of the stimulus waveform), then to differentiate the other parameters in relation to this first categorization, forming "families" of subtly unique stimuli that share a dominant characteristic. This family structure can be exploited in icon design. At a "haptic glance" the user can easily distinguish the icon's family (which might, for instance, indicate that an urgent telephone call has come in), then assess exact identity (who is calling). Their initial work was supported by the BC Innovation Council, the Institute for Robotics and Intelligent Systems, and they have received new funding from industry giants Nokia and Immersion.

Sharing Control with Intelligent Systems

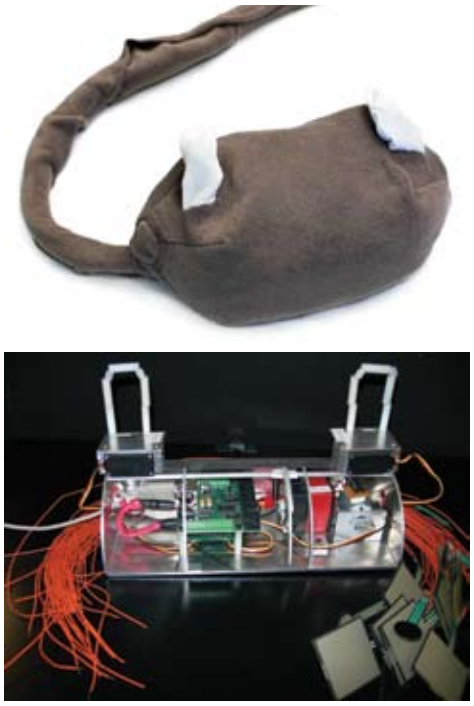
Another key aspect of MacLean's work is developing intelligent systems that share control with humans and can sense and reduce cognitive workload. This requires interplay between the intelligent system and the user akin to the physical interaction between musicians and their instruments—but where the system has goals programmed into it. MacLean is studying how we can best work in tandem with smart systems and still feel in control. For example, when driving, a smart system might detect an obstacle the driver misses. What is the best way for the system to signal this without alarming or distracting the driver?

In a navigational task experiment, MacLean used a simple driving simulation with both visual and haptic signals that indicated which way to turn. Conventional wisdom says that reinforcing visual signals with haptic ones should improve performance. Instead, they discovered that when subjects were given both visual and haptic signals, they actually did worse at navigating. "Multimodal interfaces can be distracting," says MacLean. "The challenge is to design interfaces that are more selective about what they send us, that are more transparent and actually understand what our sensory thresholds are."

If It Only Had a Heart

How do we use touch to communicate emotions? How can this be used to improve HCI and build better intelligent systems? What mechanisms are required for an agent-driven interface to read and communicate emotion through touch alone? MacLean and her students are working to understand the tactile expression of emotion in human communication in order to restore some of the connectedness that is lost via technological communication—and to improve our experience of it, and with it. To do this, they built simple devices that were stripped down to the bare essentials. In one experiment designed by former graduate student Jocelyn Smith, two people physically isolated from each other were able to communicate various emotions, such as anger or delight, through pairs of linked haptic knobs.

Another device, developed by graduate student Steve Yohanan in MacLean's lab, takes the metaphor of research path as yellow brick road to new extremes. The Hapticat, a soft pillow-shaped "pet," was developed to



If it only had a heart... *The soft outer appearance of the Hapticat (initial prototype) developed to study tactile communication reveals its hardware core. While designed to be mechanically simple, it bears an all-the-more sophisticated inner design for reacting to haptically expressed emotions. (Photos: Martin Dee, Steve Yohanan)*

study tactile communication and how affect can enhance HCI. Yohanan used what HCI prototype builders call Wizard of Oz design. Rather than building a fully functional and expensive robot—complete with computer vision, sensors and actuators—they initially used people to simulate computation in much the same way the wizard in the 1939 film classic conjures his sorcery. Instead of smoke and mirrors, SPIN researchers, who were hidden from users, manipulated the Hapticat with cables, pumps and manually triggered motors. Using inputs based on what subjects were doing with the device (stroking it, slapping it, pulling its ears), the pseudo-pet was made to respond with purring, ear movement, slow breathing, or agitation. "People are very uninhibited in how they communicate emotion with pets, which make pets a better experimental 'partner' than other people," observes MacLean.

Her group found that this simple haptic device, modelled on the relationship between humans and animals, was able to shed light on how touch aids communication and influences emotional state. They are now building a fully actuated version of the Hapticat, and starting on a model of haptically triggered and expressed emotion.

One important application is in medical care. Research has shown that people with pets are happier, healthier and recuperate from illness faster. Surrogate pets could fill in for Rex or Felix in recovery rooms and hospitals where pets aren't allowed, or provide comfort to children with allergies. If the Tin Man in *The Wizard of Oz* is an allegory for today's technological devices, then MacLean's work will ensure that the tin men of tomorrow will be more touchable, and be designed with (a) heart. ■

Portrait: The Department of Statistics

Regular enquiries from the public notwithstanding, the Department of Statistics does not collect sports or employment statistics! Rather, our teaching and research mandate is the development and implementation of statistical methodology for quantitative studies.

Though it is the smallest department in UBC's Faculty of Science, Statistics is relatively large compared to other statistics groups in Canada and internationally. Indeed, many universities have no separate statistics department. That one emerged here in 1983 reflects the university's recognition of the broadening of statistical science and its potential for interaction with virtually every discipline in the sciences, social sciences and engineering.

The Department of Statistics now has fifteen regular faculty members, plus professors emeriti, adjunct as well as honorary professors, and associate members. Seven faculty members have been appointed in the past three years, including Canada Research Chairs Arnaud Doucet and Kevin Murphy, both cross-appointed with Computer Science, and bioinformatician Jenny Bryan, jointly appointed with the Michael Smith Laboratories.

The faculty's research interests reflect the diversity of statistical science. Biostatistics and bioinformatics have been very important to us for many years. We have a long history of research in environmental statistics, from studies involving global climate models to analysis of pollution data (see *Synergy* 1|2006, "Navigating a Sea Change in Statistics"). Other research concentrations include statistical learning, often called "machine learning," and Bayesian inference, a paradigm increasingly popular with scientists for dealing with complex uncertainties, such as missing or mis-measured data in medical studies.

Faculty members collaborate with researchers at many organizations, including the BC Cancer Agency, Children's and Women's Health Centre of BC, UBC's Multiple Sclerosis/Magnetic Resonance Imaging Study Group, St. Paul's Hospital, wood products research institute Forintek, and the US Environmental Protection Agency, to name just a few.

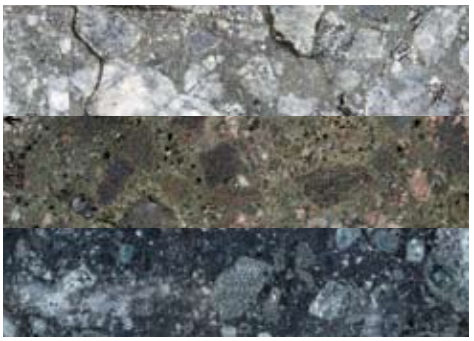
The department has a consulting service (www.stat.ubc.ca/SCARL) that provides research assistance, from the design of experiments and surveys all the way to the interpretation of findings. Clients are from inside and outside UBC—the Greater Vancouver Regional District and the Insurance Corporation of BC, and Schering AG in Germany, for example—and projects may be short-term or long-term.

Faculty members have been recognized by numerous positions on prestigious editorial boards, by fellowships and by offices with professional bodies. In particular, Founding Head Jim Zidek is a Fellow of the Royal Society of Canada, and Prof. John Petkau serves on the US National Multiple Sclerosis Society Advisory Committee on Clinical Trials.

The department offers major, honours and co-op undergraduate programs. Increasingly popular are the combined programs with other departments, such as Economics or Computer Science. Statistics has 35 graduate students, divided about equally between the MSc and PhD programs. For many years, there has been very strong local, national and international market demand for our graduates, in medical research, industry and academia.

The faculty, staff and students of the Department of Statistics invite you to visit our website at www.stat.ubc.ca to learn more about our achievements. Find information for, and about, our alumni at www.stat.ubc.ca/People/Alumni.

Projects and Initiatives: Advancing Mineral Research and Exploration



From the diamond fields of the Northwest Territories to the Andes of Peru and the gold fields of Tanzania, the Mineral Deposit Research Unit (MDRU) examines the where and why of mineral deposits and how one goes about finding them. MDRU has been built and sustained by a partnership between UBC Science and Canadian and international mining and exploration companies.

Initiated in 1989, this collaborative venture is a hub of integrated geologic and geophysical research for solving mineral exploration-related questions. The research unit meets the scientific information interests of the mining industry, while providing quality training for the next generation of geologists. In 2006, eight Earth & Ocean Science faculty members supervised MDRU research projects that supported over 30 graduate students and six research associates.

When first established, MDRU projects centred around geologic and metallogenic problems unique to the BC Cordilleran, such as the gold deposit at Eskay Creek and the copper and gold mines at Mount Polley, which now contribute to the economy of central BC. By 1999 research activity had expanded throughout North America and into Central and South America, Australia, Asia, and Africa, in line with the global interests of industry sponsors of MDRU. Current projects study gold deposits in Tanzania, Papua New Guinea, and Nevada in the US; copper and gold deposits in western Canada, Tibet, Mongolia, eastern Australia, and Turkey; zinc and silver deposit in Peru; silver deposits in Argentina; nickel deposits in Canada and Australia; and diamonds in Canada.

Richard Tosdal, the director of MDRU, believes that fundamental scientific questions guide every applied research problem. MDRU research is directed toward solving both, and is broadly aligned in six interrelated themes: hydrothermal deposits, magmatic systems, framework studies (defining the broad-scale characteristic of regions containing mineral deposits), exploration methodology, kimberlite (a common host rock of diamonds), and sustainability. The first three themes revolve around the metals industry, which has been the traditional backbone of research at MDRU. The largest currently active project examines copper and gold ore deposits in central BC, with a parallel component in Australasia. Another theme focuses on questions related to the diamond industry. The exploration methodology and sustainability themes address questions that cross between the diamond and metals industries.

Kimberlite is a recently emerged theme. Research established in conjunction with Canadian and international diamond companies examines diamond formation. It also looks at how diamonds are transported from great depths in the Earth to the surface, and then concentrated during the eruption of a kimberlite volcano. To further these efforts, MDRU has received a significant commitment of $1 million from a generous donor in support of kimberlite research. These funds are a critical step toward building an internationally recognized diamonds research program to rival the global stature of the metal-focused research program at MDRU.

Another new theme addresses the growing challenge of greenhouse gas emissions. Supported by two international mining companies, professor Greg Dipple and his students are demonstrating that tailings rich in serpentine extract atmospheric carbon dioxide (CO_2) and fix it in stable carbonate minerals that do not weather. Their work suggests that although CO_2 sequestration by mine tailings will not reverse any trends toward global warming, there is potential for emissions from active mines rich in serpentine to become CO_2 neutral overall—resulting in zero contribution to any further global warming.

As a global leader in each of these new themes, as well as in its well-established research areas, MDRU ensures a continuous flow of high-quality research and highly trained geologists. The intellectual capital of the research—and the human capital—are of critical importance to the future industrial capacity of Canada. For more information visit www.mdru.ubc.ca

(Photos: Kathy Dilworth, MDRU, Al O'Connor of Ashton Mining, Emma Gofton)

New Masterminds: Brain Gains at Science

Gordon

Karczmarek

Meyer

Rieseberg

Sack

Sammis

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

Julia Gordon, Assist. Prof., Dept. of Mathematics; MSc Mathematics (Diploma), St.-Petersburg State University, Russia; PhD Mathematics, University of Michigan, Ann Arbor, MI, US. Prior appointment: Postdoctoral Fellow, University of Toronto. *Research:* It is one of my long-term goals to explore the algebraic geometry behind the classical objects that appear in representation theory of p-adic groups. The main tool used is motivic integration, which lies at the crossroads of algebraic geometry and logic. www.math.ubc.ca/~gor

Joanna L. Karczmarek, Assist. Prof., Dept. of Physics & Astronomy; BSc Mathematical Physics, Queen's University, Kingston, ON, Canada; PhD Physics, Princeton University, NJ, US. Prior appointment: Post-doctoral Fellow, Rutgers University. *Research:* I work in theoretical physics, focusing on the fundamental physics at short distances as described by string theory. I am particularly interested in the origin of space and time and the cosmological implications of quantum gravity. www.phas.ubc.ca/~joanna

Irmtraud M. Meyer, Assist. Prof., Dept. of Computer Science and UBC Bioinformatics Centre; MSc Physics (Diploma), RWTH Aachen University, Germany; PhD Bioinformatics, University of Cambridge, UK. Prior appointment: European Bioinformatics Institute, Cambridge, UK. *Research:* My group focuses on new algorithms in bioinformatics. We use novel comparative methods to predict functional RNA structures and protein coding genes with a variety of potential applications in health research and, basically, all areas of the life sciences. www.cs.ubc.ca/people/faculty.jsp

Loren H. Rieseberg, Prof. and Canada Research Chair in Plant Evolutionary Genomics, Dept. of Botany; BA Biology, Southern College, Chattanooga, US; MS Botany, University of Tennessee, Knoxville, US; PhD Botany, Washington State University, Pullman, US. Prior appointment: Distinguished Professor of Biology, Indiana University, US. *Research:* I use a combination of genomic and ecological approaches to investigate the origins of crops, weeds and new species. This work focuses on the sunflower family, the largest family of flowering plants. www.botany.ubc.ca/people/rieseberg.htm

Fred D. Sack, Prof. and Head, Dept. of Botany; BA Sociology, Antioch University, Yellow Springs, OH, US; PhD Plant Biology, Cornell University, Ithaca, NY, US. Prior appointment: Professor and Chair, Dept. of Plant Cellular and Molecular Biology, Ohio State University, Columbus, US. *Research:* We study the molecular and cellular biology of the development of stomata, which are leaf pores central to plant productivity. Current emphases are division regulation, pattern generation and cell shaping. www.botany.ubc.ca/people/sack.htm

Glenn M. Sammis, Assist. Prof., Dept. of Chemistry; BSc Chemistry, Stanford University, CA, US; MSc and PhD Chemistry, Harvard University, Cambridge, MA, US. Prior appointment: Post-doctoral Fellow, Princeton University, NJ, US. *Research:* My research program focuses on the synthesis of natural products. We develop and apply new organic chemistry methods, including new bond construction techniques, and explore proposed biogenetic pathways through biomimetic synthesis. www.chem.ubc.ca/personnel/faculty/sammis

Recent appointments also include: Colin Gay, Assoc. Prof., Dept. of Physics & Astronomy. www.phas.ubc.ca – Neil Dryden, Sen Instructor, Dept. of Chemistry. www.chem.ubc.ca – Kenneth Wayne Harder, Assist. Prof., Dept. of Microbiology & Immunology. www.microbiology.ubc.ca – Celeste Leander, Instructor, Depts. of Botany and Zoology. www.botany.ubc.ca – Mark MacLean, Instructor, Dept. of Mathematics. www.math.ubc.ca/~maclean/maclean.html – Domingo Louis-Martinez, Instructor, Dept. of Physics & Astronomy. www.phas.ubc.ca – Antoine Mellet, Assist. Prof., Dept. of Mathematics. www.math.ubc.ca/~mellet – Dinesh K. Pai, Prof., Dept. of Computer Science. www.cs.ubc.ca – Malabika Pramanik, Assist. Prof., Dept. of Mathematics. www.math.ubc.ca – Jeff Smith, Prof., Dept. of Mathematics. www.math.ubc.ca

Faculty of Science: Kudos and News

In 2006 Science faculty members won the following prestigious academic awards.

Ian Affleck, Prof., Physics & Astronomy
- CAP Medal for Career Achievement, Canadian Association of Physicists

Gordon Bates, Assoc. Prof., Chemistry
- CIC Award for Chemical Education, The Chemical Institute of Canada

David Dolphin, Prof., Chemistry
- Order of Canada, Government of Canada

Brett Finlay, Prof., Michael Smith Labs and Microbiology & Immunology
- 2006 Flavelle Medal, Royal Society of Canada
- National Killam Prize (Health Sciences), Canada Council for the Arts
- Officer of the Order of Canada, Government of Canada

Walter Hardy, Prof. Emeritus, Doug Bonn, Prof., and Ruixing Liang, Research Assoc., Physics & Astronomy
- Brockhouse Canada Prize, NSERC

Wolfgang Heidrich, Assoc. Prof., and students Xavier Granier and Christophe Schlick, Computer Science
- Guenter Enderle Award, Eurographics 2006

Karen Hodges, Assoc. Prof., UBC Okanagan, and Assoc. Member, Zoology
- Aldo Leopold Leadership Fellowship, Woods Institute for the Environment

Patrick Keeling, Assoc. Prof., Botany
- Senior Scholar Career Investigator Award, Michael Smith Foundation for Health Research

Yoshikata Koga, Sen. Instructor Emeritus, Chemistry
- Society Award, Japan Society of Calorimetry and Thermal Analysis

Gail Murphy, Prof., Computer Science
- Anita Borg Early Career Award, Computing Research Association

Sarah (Sally) Otto, Prof., Zoology
- Fellow, Royal Society of Canada

Daniel Pauly, Prof., Zoology, and Director, UBC Fisheries Centre
- 2006 Volvo Environment Prize, Volvo Environment Prize Foundation

Mati Raudsepp, Honorary Prof. and Research Scientist, Earth & Ocean Sciences
- Leonard G. Berry Medal, Mineralogical Association of Canada

Robert Sim et al., Post-doctoral Fellow (James Little's lab), Computer Science
- Best Robotics Paper Award, Canadian Conference on Computer and Robot Vision

Vinayak Vatsal, Assoc. Prof., Mathematics
- Ribenboim Prize, Canadian Number Theory Association

Erich W. Vogt, Prof. Emeritus, Physics & Astronomy, and co-founder of TRIUMF
- Order of British Columbia, Lieutenant Governor of BC

Carl Walters, Prof., Zoology
- 2006 Volvo Environment Prize, Volvo Environment Prize Foundation
- Award of Excellence, American Fisheries Society

Brightest Young Minds

Max Metlitski won the Governor General's Gold Medal, honouring him as the university's best student among 1,487 peers graduating from UBC with a master's degree in the 2005/06 academic year. Supervised by Physics & Astronomy professor Ariel Zhitnitsky, Metlitski delved into the puzzling worlds of condensed-matter theory and particle astrophysics. PhD graduate in Computer Science Jihong Ren, who was nominated for the GG's Gold Medal competition for the best PhD thesis, received the UBC Science Graduate Prize 2005/06. Supervised by professor Mark Greenstreet, Ren's outstanding research contributions have led to a major advance in chip-to-chip communications.

UBC Science at a Glance 2006

Our Faculty's annual overview—now available at www.science.ubc.ca.

Events—Science and Beyond

The UBC Biodiversity Lecture Series will feature Dr. Biruté Galdikas, president of the Orangutan Foundation International, on November 17, 2006. A scientist, conservationist and educator, Galdikas has worked closely with the orangutans of Indonesian Borneo and is the world's foremost authority on the orangutan. Find out more about the Beaty Biodiversity Museum and Biodiversity Research Centre at www.biodiversity.ubc.ca.

The Global Citizenship Seminar Series is a joint initiative of UBC's Faculties of Arts and Science, with the primary mission to educate the UBC community—and, specifically, our undergraduate students—on the pressing global issues of our time. Speakers include Wade Davis presenting a talk entitled "Cultures on the Edge" (November 8, noon; UBC Vancouver, Chan Centre); novelist, historian and essayist Ronald Wright (December 6, evening; UBC Okanagan); and physicist, ecologist, activist, editor, and author Dr. Vandana Shiva (March 12, 2007, noon; UBC Vancouver, Chan Centre). Everyone welcome. For further details and ticket information visit www.terry.ubc.ca.

New Science Department Head

Fred Sack was appointed new head of Botany as of June 2006. He came to UBC from Ohio State University, where he was chair of the Department of Plant Cellular and Molecular Biology. His lab pioneered the identification of genes needed to form stomata and shaped current views about how plants sense gravity.

HELP SAVE A TREE

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