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Words from the Dean

Photo: Martin Dee

In Vancouver, the sea and sky come together with the mountains, the forests and the coast, making this one of the most beautiful places on Earth. Yet, if we transported ourselves back in time 15,000 years, we would find two to three kilometres of ice on top of our heads. The rich biosphere we see today—the lush temperate rain forest of coastal BC—formed on a barren land surface that was exposed by retreating ice sheets a few thousand years ago. In much more recent times, our planet's biosphere has been changing rapidly—in response to the impact of modern human activities on our land, oceans and atmosphere. Next year we will be opening the Beaty Biodiversity Museum, which is designed to connect researchers, K-12 students and the general public with the rich biodiversity that is critical to our survival (see p. 4).

Over this past year we have enjoyed a number of exciting advances in undergraduate education. The Carl Wieman Science Education Initiative is now positively impacting all of our science departments. One of its projects—a new approach for students to grasp statistical concepts—is highlighted on page 16. Together with the Faculty of Education, we have launched two dual degree programs leading to BSc and BEd degrees, one with Mathematics and one with Physics (p. 4). And on page 12, Shona Ellis, director of our General Science program, shares her vision for this increasingly popular undergraduate option.

I hope you enjoy this latest issue of *Synergy* and invite you to connect more frequently with UBC Science—visit our new website and sign up for *Science Connect*, our bimonthly e-magazine (see text box p.3).

Simon M. Peacock
Dean, UBC Faculty of Science

UBC Science (in the) News:

Google Diversity Scholarship for CS Graduate Students – May 2008
Pooja Viswanathan and Viann Chan, both PhD students with the Department of Computer Science are among 17 inaugural Canadian Anita Borg scholars and finalists. The memorial scholarships, awarded by the Internet search giant Google, honour computer scientist Anita Borg, who worked to increase the participation of women and underrepresented minorities in IT fields.

Uncovering Secrets of Supervolcanoes – The Canadian Press, May 2008

Photo: NASA

Researchers at UBC and McGill have simulated the conditions that result in so-called "supervolcanoes," eruptions so massive they can change weather patterns. "These eruptions are big enough to wipe out entire continents," said Ben Kennedy, a volcanologist at UBC's Department of Earth & Ocean Sciences. This new research explains what happens inside a magma chamber as the roof caves in, insights that could be useful when making hazard maps of such an eruption.

Did Earth Once Have Multiple Moons? – New Scientist, May 2008
The ancient catastrophe that gave birth to the Moon may have produced additional satellites that lingered in Earth's skies for tens of millions of years. A new model by UBC astrophysicist Matija Cuk suggests moonlets may have once occupied the regions in space where the gravitational tug of the Earth and the Moon cancel each other out.

Strokable Robot Rabbit Talks with Touch – New Scientist, May 2008
Computer scientist Steve Yohanan says that robotics researchers too often neglect haptics, or touch, as a form of communication. His pet robot, a furry, 35-centimetre long creature, is being used to probe the way the oft-neglected sense bolsters our emotional relationships.

Beluga Baby's First Chatter – The Vancouver Sun, Jun 2008
Chattering with babbly pulses, the three-day-old beluga whale is being recorded, monitored and interpreted by UBC PhD student Valeria Vergara, who has spent thousands of hours listening in on belugas at the Vancouver Aquarium.

"Impossible" Insight into Superconductors – The Vancouver Sun, Jun 2008
A team of UBC researchers has achieved what scientists thought impossible: developing a way to control and study electrons on the surface of superconductors. "This is the only way to really understand what is happening inside the superconductor," said physicist Andrea Damascelli, who led the experiments. Superconductors—materials that conduct electricity with no resistance—are used in MRIs, levitating trains and power lines, and are thought to be key to developing quantum computing and power lines with no energy loss.

Founding Mother of BC Biotech: Julia Levy – Business in Vancouver, Jun 2008

Levy, a co-inventor of Visudyne, the most successful drug ever commercialized by a BC company, was appointed this January to the board of Toronto startup Cannasat Therapeutics, which is developing pain treatments from cannabinoids, the active drug in marijuana. UBC alumna and professor emerita in immunology, Levy shares her QLT experiences and her many current advisory roles.

Source: UBC media releases 2007/08 or as indicated

Discoveries and Innovations

Engineered Elastomeric Proteins with Dual Elasticity – Jul 2008
UBC chemists Yi Cao and Hongbin Li have designed a 'chameleon' elastomeric protein that can be transformed from a coiled elastic spring to a stable shock absorber, and back again. The new type of smart nanomaterial effectively combines the two extreme forms of elastic mechanical behaviour found in nature into a single protein, and has potential applications in nanomechanics and biomedical materials.

UBC Chemistry Grad Moving from Yale to Oxford – Macleans, Jul 2008
At age 55, chemist Andrew Hamilton, who completed his master's degree at UBC in 1976, becomes Oxford's vice-chancellor in October, leaving his position as the provost at Yale University.

Magic Tricks Provide Clues For Modern Science – Daily Telegraph (UK), Jul 2008
A magician's tricks can fool people into disbelieving what they see with their own eyes, says a new study from UBC and the University of Durham. Revealing the science behind age-old tricks will help us better understand how humans see, think and act. UBC researchers include Computer Science and Psychology professor Ronald Rensink and recent BSc graduate of UBC's Cognitive Systems program Alym Amlani.

Workers Set to Clear Sea-to-Sky – The Globe and Mail, Aug 2008
Commenting on slide-damaged Sea-to-Sky highway between 2010 Olympics hosts Vancouver and Whistler, geological engineer and UBC Earth & Ocean Sciences professor Erik Eberhardt said researchers are developing new ways to detect when rock is about to shatter and fall. Global positioning receivers can be installed that monitor for tiny physical movements, and new microseismic sensors could "hear" the infinitesimal sounds of two rock planes moving against each other.

Source: UBC Media Releases 2007/08 or as indicated

Self-destructive Cooperation Benefits the 'Public Good' – Aug 2008
An international team of researchers led by UBC theoretical biologist Michael Doebeli has applied a mathematical model to *Salmonella* bacteria to show how altruistic, self-destructive traits can evolve in biological populations. In the case of *Salmonella*, these traits could potentially result in stronger and more damaging infections by these bacteria.

Graduate Returns to UBC as Science Journalist – The Vancouver Sun, Aug 2008
Award-winning *Nature* editor Nicola Jones, who graduated from UBC's school of journalism and the Chemistry master's degree program, has returned to her alma mater as the university's first science journalist in residence.

Prickly Fish Support Darwin's Theory – The Canadian Press, Aug 2008

Photo: Ron Offermans

Shedding some genetically induced excess baggage may have helped a tiny fish thrive in freshwater and outsize its marine ancestors over the past 20,000 years, says a research study by UBC Zoology PhD candidate Rowan Barrett, post-doctoral fellow Sean Rogers and professor Dolph Schluter. While Darwin's theory of natural selection and of species evolving from common ancestors over time is nothing new, this study of stickleback adds a genetic understanding to that work.

Astronomers Discover Missing Link for Origin of Comets – Sep 2008
An international team of scientists that includes UBC Physics & Astronomy professor Brett Gladman has found an unusual object that has a backward and tilted orbit around the Sun, which may clarify the origins of certain comets.

Learning Centre Honours Dot.Ca 'Godfather' – Sep 2008
Former UBC Computer Science staff member John Demco was honoured for creating the dot-ca domain that put Canada on the Internet map. The Demco Learning Centre has been named after Demco for his volunteerism and foresight in conceiving the dot-ca domain in 1987 and administrating domain registrations for ten years. Earlier this year, the millionth dot-ca website was registered.

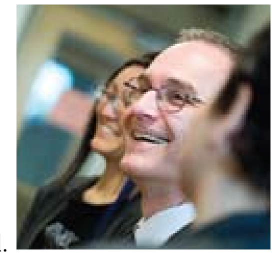

Photo: Martin Dee

Invasive Species a Serious Threat – The Vancouver Province, Sep 2008
UBC researchers say invasive species are a serious threat to BC's biodiversity. A study by Oceanography PhD student Cathryn Murray shows that once foreign aquatic species are brought into BC's Pacific Coast, likely by ballast water in ocean-going vessels, they are spread throughout the coast and into lakes and rivers by smaller boats. In BC it is estimated a quarter of endangered species are hurt by invasives.

Four Renewed Canada Research Chairs in Science – Oct 2008
David Brydges, CRC in Mathematical Physics, Erin Gaynor, CRC in Bacterial Pathogenesis, Edwin Perkins, CRC in Probability, and George Sawatzky, CRC in Physics and Chemistry of Nanostructured Materials are among thirteen Canada Research Chairs renewed at UBC this year.

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UBC Science (in the) News: Initiatives and Events

Inspiring—Career Mentoring for Graduate Students

This May, the inaugural Vivien M. Srivastava Career Mentoring Workshop invited science graduate students to develop tactics to set, manage and balance their career goals with personal life goals. About 100 participants explored topics ranging from professional networking to research success strategies to family planning. They also had a chance to interact with inspiring role models from academia, non-academic research labs and industry, and to exchange ideas with their peers from various fields. In memory of science pioneer and UBC alumna Vivien M. Srivastava, her family established an endowment fund at UBC Science. The fund not only supports this workshop, but also provides ongoing assistance to female graduate and post-doctoral students experiencing financial hardship. More at science.ubc.ca/ws.

Photo: Nancy Nguyen

Innovative—Imaging Research at 'High Range'

Photo: Don Ehrhardt

Dolby Laboratories invested $1.15 million in UBC's high dynamic range (HDR) display technology research, with $750,000 in funding to establish the Dolby Computer Science Research Chair. The Chair will support associate professor Wolfgang Heidrich's research into HDR imaging. His work has already resulted in processing algorithms that are a key part of this technology (see *Synergy* 2 | 2007). "HDR gets us much closer to the range of contrast that we see in the real world," he says. "The brights get brighter, the darks darker." Related fundamental and applied research by Heidrich includes human perception of extreme contrast and colour, and developing software for converting legacy video to HDR. The core technology of HDR displays was invented by a team of researchers led by UBC physicist Lorne Whitehead and spinoff Brightside Technologies, which Dolby acquired last year (see *Synergy* 1 | 2008).

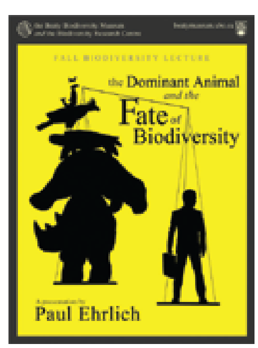
Progressive—Turning Science Students on to Teaching

A new dual degree out of UBC Science and Education is designed to encourage science students to consider teaching as a rewarding career. The recently launched dual BSc-BEd program allows science majors to begin taking education courses towards a teaching specialization as early as second year. Core studies as a science major in physics or mathematics will be maintained, while gradually increasing education courses and classroom teaching experiences. Graduates qualify for recommendation to a professional teaching certificate. "Better equipped science teachers in elementary and secondary schools will more likely inspire students at a young age to see science as an exciting way of understanding the world around them, and to choose science—or science education—as a career," says dean Simon Peacock.

Photo: Martin Dee

Essential—Sustaining Biological Diversity

In September the Beaty Biodiversity Museum, the outreach arm of UBC's Biodiversity Research Centre, hosted acclaimed biologist and Stanford professor Paul R. Ehrlich, who presented his latest book, *The Dominant Animal and the Fate of Biodiversity*. Ehrlich argued that only a biologically rich and diverse environment can sustain agricultural production and food security—which is intrinsic to sustaining life on Earth. Thus, biodiversity is essential for a healthy economy. The main factors the 'dominant animal'—or human species—needs to address are consumption of the Earth's limited resources and over-population. While Ehrlich is optimistic about what humans can do to safeguard biodiversity, he is not certain that the necessary steps will be taken. Ehrlich congratulated UBC for its foresight in creating a centre fully dedicated to biodiversity research. More about the Biodiversity Lecture Series and other outreach activities at www.beatymuseum.ubc.ca.



Faculty of Science: Kudos

Congratulations to our faculty members on having been awarded these prestigious and well-deserved distinctions in 2008!

Ian Affleck, Prof., Physics & Astronomy
- APS Outstanding Referee, American Physical Society

Joerg Bohlmann, Prof., Botany
- C.D. Nelson Award, Canadian Society of Plant Physiologists

Kellogg Booth, Prof., Computer Science
- CHCCS Achievement Award, Canadian Human Computer Communications Society

Jesse Brewer, Prof., Physics & Astronomy
- CAP/DCMMP Brockhouse Medal, Canadian Association of Physicists

David D.Y. Chen, Prof., Chemistry
- W.A.E. McBryde Medal, Canadian Society for Chemistry

Ron Clowes, Prof. and former Dir., Lithoprobe, Earth & Ocean Sciences
- 2008/09 CSEG Distinguished Lecturer, Canadian Society of Exploration Geophysicists

Ivar Ekeland, Prof., Mathematics
- Elected Member, Royal Society of Canada

Roger François, Prof., Earth & Ocean Sciences
- G. Huntsman Award, Royal Society of Canada

Paul Gustafson, Prof., Statistics
- CRM-SSC Prize, Centre de Recherches Mathématiques

Oldrich Hungr, Prof., Earth & Ocean Sciences
- 2008 Schuster Medal, Association of Environmental and Engineering Geologists and the Canadian Geotechnical Society

Jim Little, Prof., Computer Science
- Precarn 20th Anniversary Commercialization Success Award, Precarn Inc.

Jennifer Love, Asst. Prof., Chemistry
- 2008 AZC Award in Chemistry, AstraZeneca Canada

Jane Roskams, Assoc. Prof., Zoology
- Career Achievement Award, International Foundation for Research in Paraplegia
- Synapse Award for Mentorship, CIHR

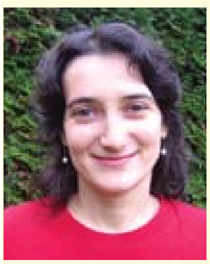
George Sawatzky, Prof., Physics & Astronomy and Chemistry
- Elected Fellow, Royal Society, London

Curtis Suttle, Prof., Earth & Ocean Sciences, Botany and Microbiology & Immunology
- Elected Fellow, Royal Society of Canada

Stephanie van Willigenburg, Assoc. Prof., Mathematics
- Humboldt Research Fellowship, Alexander von Humboldt Foundation

Carl Wieman, Dir., CWSEI, Prof., Physics & Astronomy
- Elected Member, US National Academy of Education

Bright Young Minds—Mirela Andronescu



Graduate student Mirela Andronescu won the 2007/08 IBM PhD Fellowship Award. This worldwide, highly competitive program honours exceptional PhD students in academic disciplines ranging from computer and mathematical sciences to engineering to business sciences. "Winning an IBM fellowship is unusual for someone in her field—bioinformatics," states Computer Science professor and supervisor Anne Condon.

Andronescu develops and applies algorithmic techniques to help solve problems in computational biology. She focuses on tools that can predict the secondary structure, or the two-dimensional folds and pins, of ribonucleic acids (RNA). While the core 'bauplan' of RNA strains—composed of nucleotides like beads on a string—has long been discovered, the geometry of the strains in space, such as in the living cell, remains a problem yet to be solved. Understanding RNA molecule structure is of paramount interest to biologists investigating RNA function or early evolution of life, and to medical scientists looking for novel therapeutics. Andronescu's computational tools have been used in research such as brain disease studies at the Vancouver Centre for Molecular Medicine and Therapeutics. Vienna RNA WebServers, the internationally most comprehensive server of RNA structure prediction tools, has incorporated her RNA energy parameters into their RNAfold server—a significant recognition of her contributions to the field.

The IBM fellowship tops a seamless series of annual awards Andronescu has won ever since she finished her master's thesis. She received the Governor General Gold Medal as best student among all her UBC peers graduating with a master's degree in 2003.

Born in Targoviste, Romania, Andronescu came to Canada and to UBC in 2001. She had worked as systems administrator for the Romanian Academy and as an analyst programmer for a couple of software companies, after graduating with a BSc in Computational Economics in Bucharest. "While attracted by excellent research opportunities at UBC, my success wouldn't be possible if not for the welcoming and collaborative climate I've felt in my department."

Andronescu describes herself as an analytical thinker, who enjoys working on mathematical approaches. "At the same time," she states, "current biological and medical research is in great need of solutions that lie in quantitative sciences. I'm very excited to ask questions about fundamental biological functions, leading to answers on how and why diseases occur—and how to cure them." She is also an enthusiastic outdoors person. "Hiking, biking and running help me feel more connected to nature. And there's a link to my research, too. The virtual world of computers—and how I use them—can help us to better understand nature," says Andronescu, who will finish her PhD thesis by the end of the year.

With an NSERC post-doctoral fellowship already under her belt, her eyes are set on the University of Washington's Department of Genome Sciences. "This will give me the opportunity to apply my expertise in bioinformatics more directly to health research—and get closer to my personal goal of helping improve the quality of people's lives."

Wondrous Whelks

The Self-Healing Biomaterial of Sea Snails

Canada Research Chair Robert Shadwick has discovered puzzling properties in egg capsules of marine snails. The biomaterial can be pulled, heated or subjected to chemical treatment without breaking or permanently deforming. Shadwick is exploring the capsules' mysterious biological function and whether the molecular re-assembly mechanism can be mimicked. If so, the material could have important applications in materials science.

The old adage "mysteries of the deep" certainly applies to a group of humble marine snails called whelks (see photos). For UBC Zoology professor Robert Shadwick, the study of this unlikely creature was serendipitous. An expert in fish locomotion mechanics, he was introduced to whelk capsules by a colleague at the Marine Sciences Lab at the University of Delaware. Shadwick has been working on "this very strange material," along with other projects ever since.

Most marine snails deposit their embryos in egg capsules that are constructed of a complex multi-layered structural protein. Observed with a scanning electron microscope, whelk egg capsule biopolymer (WECB) resembles overlapping sheets of laminate or plywood positioned at slightly differing angles. Shadwick notes that WECB layers look as if they are laid down like a thick paint, with fibres more or less parallel, but each successive layer is oriented a bit differently.

In studies of two whelk species, *Busycon canaliculatum* and *Kelletia kelletii*, Shadwick and colleague Scott Rapoport, from Scripps Institution of Oceanography in La Jolla, California, found that when initially subjected to a small amount of strain, or pulling, the WECB acts as a stiff linear spring. With larger extensions, the material becomes rubbery and highly elastic. Instead of breaking or deforming (losing elasticity), it "yields reversibly," reforming itself to its original shape and stiffness and dissipating large amounts of energy in the process. For example, even after fifteen cycles of extension, the WECB recovered initial shape and stiffness.

Stiff Spring and Shock Absorber

As Canada Research Chair in Integrative Animal Physiology, Shadwick combines research in engineering science, physiology, molecular biology, digital imaging, motion analysis, and micromechanical testing. He is also developing a research program on biomechanical design—ranging from molecules to tissues, structures and whole organisms. Understanding how marine egg capsules are formed, how WECB behaves and what functions it might serve, either for snails—or ultimately, in industry biomaterials—requires all of this expertise.

Busycon canaliculatum

Kelletia *pedal gland (stuck against the aquarium glass) "massages" the whelk's egg capsules.*

"This WECB material acts like a stiff spring under less strain, and under greater strain changes properties and behaves like a poor spring but a good shock absorber," explains Shadwick. "We know that it starts off as a highly ordered alpha helical structure, which is usually very stable. The change from stiff to rubbery behaviour should be dramatic enough to break the hydrogen bonds between alpha helical chains, and they shouldn't be able to reform—but somehow they do."

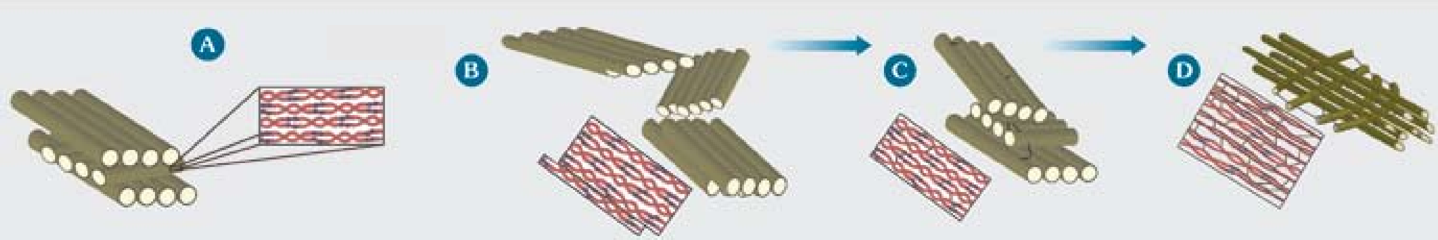
The Key to Self-Healing Materials

Additionally, Shadwick's group found that heating the WECB material or putting it in acidic solution has a similar effect, again suggesting the breakdown of hydrogen bonds to release the alpha helical coils. Yet the material also recovers when cooled, or when the pH value is increased. Other common structural proteins such as keratin in hair have alpha helical structures. However, they do not exhibit this mechanical response to strain, heat or lower pH value. When hair is subjected to the heat and chemicals of a perm, for example, the bonds in keratin molecules break down and take a new shape. Straight hair becomes wavy or curly, and if the resultant curls are too tight or frizzy, the hair will not "reform" to the previous hairstyle without chemical treatment, or until it regrows.

Shadwick's research results suggest that WECB is a rubbery network with a higher-order structure that can be disrupted by heat as well as extension. In further testing, he and graduate student Wes Didier discovered that if the extension process is interrupted, or the temperature reduced, the high stiffness can rapidly reform in the rubbery region. "Such 'self-healing' behaviour is novel in the world of polymer engineering, and this is the primary feature we want to understand and ultimately be able to mimic in synthetic materials," says Shadwick.

Nature's Over-Engineering?

One of the most fundamental questions Shadwick is trying to answer is: If the function of whelk egg capsules is to protect developing embryos from the perils of predators, UV radiation and rough ocean tides, do they really need such unusual and complex material to do so? Could this be a case of biological over-engineering? Shadwick is studying the relationship between the biogenesis of the capsule protein and its unusual



Maturation of whelk egg capsule biopolymer (WECB). *The whelk's ventral pedal gland (VPG) modifies and stabilizes the egg capsule after it is deposited outside the body—generalized structure (A), pre-VPG (B), during VPG (C), and post-VPG (D)—which renders WECB insoluble.*

viscoelastic properties to try to answer these fundamental questions.

"I see two possibilities. One is that the material could be useful in the survival of these animals in a way that we just don't understand yet," Shadwick explains. "Or it is just the nature of the protein, in the same way that we can make mechanical measurements of hair and find interesting properties that have little to do with function." Shadwick makes another observation. Although marine snail egg capsules are in the ocean for a long time, nothing grows on them. And in lab aquariums, other marine life such as crabs and starfish avoid the egg capsules altogether. "The material is probably difficult to rupture, so the mechanical properties may provide a protection against predation," he says.

Marine Snails—Fascinating Facts

- They are large, voracious carnivores that can wreak havoc on oyster and mussel beds.
- They are serial hermaphrodites; smaller snails are male and become female as they grow larger. The exact timing of sea snail sex change is unknown.
- Capsule formation inside the female takes place concurrently with mating, when the smaller male fertilizes the egg of the larger female.
- Larvae have a long gestation period inside the capsule, with no dispersal stage. When they emerge, they look like an adult snail, only much smaller.
- The morphology of the pedal gland affects the shape of the egg capsule, but not the function.

Foot Massage Vulcanization

To better comprehend WECB structure, biomechanical properties and function, Shadwick and colleagues studied the gestation of whelk egg capsules. They discovered that egg capsule properties change as they are manufactured and processed by the snail in a sequence of stages. The capsules are first formed inside the body of the snail, in the nidamental gland. The immature capsules containing fertilized eggs are then deposited outside the snail's body singly, or in a cluster (see photo), depending upon the species of snail. The final processing is an intriguing "outside-of-body experience."

"If you can manage to pull the capsule away from the snail soon after release, it is just like toffee, and has no mechanical integrity whatsoever. You can't measure a force when you extend it," says Shadwick. The reason the material is so pliable, he discovered, is that capsule maturation is not completed inside the snail's body. After the snail emits the capsule, it covers it with its ventral pedal gland (VPG), or flat muscular foot, and massages the capsule in ten-minute intervals. The entire "foot massage" lasts about an hour, after which the snail moves on to the next capsule.

"We know that the maturation process is not merely dependent on spontaneous chemical reactions over time, because if you don't let the animal do this massaging, the capsule doesn't mature into the stiff material," explains Shadwick.

Based on scanning electron microscope comparisons of immature capsules with mature capsules, Shadwick found that the pedal manipulations do not result in major structural changes, as capsule structure is already completed inside the body. Instead, he believes that the VPG massage moulds and stabilizes the soluble precursor proteins by inducing crosslinks and adding matrix. The final product is an insoluble, self-healing polymer that reassembles after being pulled apart (see image above).

The pedal massage seems to act as a vulcanizing process. Rubber, for example, requires curing with sulphur and heat, which organizes the random carbon chains into covalent crosslinks so it can repeatedly recover from strain.

"We know that the capsules are composed of one predominant protein," says Shadwick. "Currently, Herbert Waite and Scott Wasko at University of California, Santa Barbara, work on the sequencing of this protein. We can then make recombinant peptides using different parts of the sequence to find out what each part does. The next step would be to use this research to design synthetic self-healing polymers."■

Electrospinning Synthetic Fibres

In electrospinning, an innovative approach to creating fibres, a solution of polymer is passed through a large electric field, which forces the charges in the protein to line up so that the solution can be drawn into fibres. Robert Shadwick and graduate student Carla Corbett have been working with Frank Ko, director of the Advanced Materials and Process Engineering Laboratory at UBC and an expert in electrospinning process. "We have started spinning fibres from the initial soluble protein in marine snail egg capsules," says Shadwick. The idea is to see if we can treat these fibres with crosslinking agents to create something that actually has the properties we see in the mature capsule—which is a reverse direction of tackling the problem. The challenge is testing mechanical properties of the fibres, because at the nanoscale they are simply difficult to grab, pull and measure. "This is just another step in the process of trying to develop a biomimetic material. It is exciting, because everything we are doing is new."

Shape Shifting
Geometric Tools for Computer Modelling

Computer modelling is used in almost every industry and area of study, yet many modelling tools are difficult for non-expert users to operate. UBC computer scientist Alla Sheffer is developing geometric tools to help solve practical problems in computer graphics and modelling.

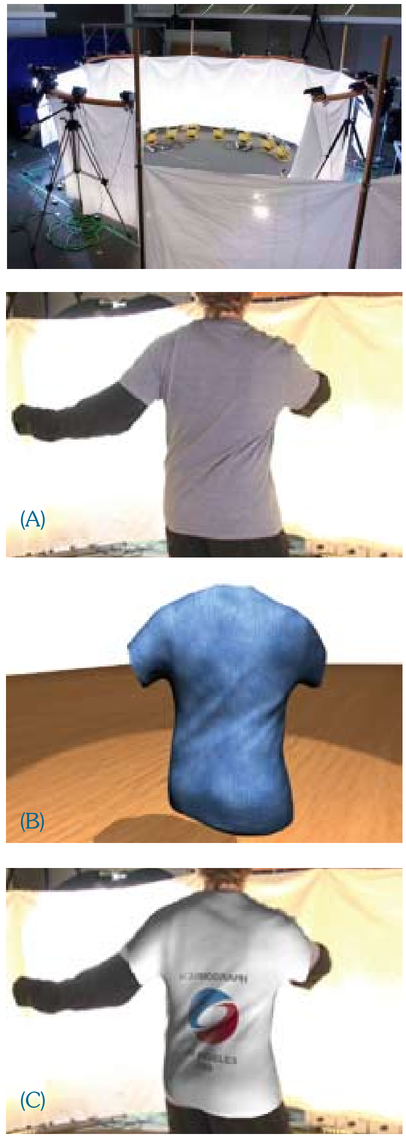
When a painter observes an object, colour is most likely the first thing she sees. When a graphics researcher observes an object, the first thing she sees is geometry. “In order to represent real-world objects on a computer, you must first describe their shape. And to describe their shape you must describe their geometry,” says Alla Sheffer, associate professor in Computer Science. This is the first step in translating real-world objects into digital ones. But try to define the shape of a shoe or the folds of a dress in geometrical terms and the challenge becomes obvious.

The standard way to represent shapes on the computer is with meshes of triangles or polygons. In the real world, however, objects are not composed of discrete shapes; they are continuous geometric forms, and their shape can change as they move over time.

Capturing the Movement of Cloth

One of the most difficult challenges in computer graphics is the creation of realistic virtual characters. Believable models of the garments worn by the characters are critical to achieving realism. Graphics experts often simulate the behaviour of garments on a moving character using the physics of cloth movement, but simulation is time consuming and requires an in-depth knowledge of physics, as well as computer and artistic skills.

Sheffer’s approach is to capture the movement of real garments and convert it to a computer representation. One reason why researchers want to capture real cloth as opposed to simulating it is to recreate the impact on the motion of different fabric types and garment cuts. A summer cotton dress, a woollen coat, a silk negligee, or a fleece jacket all look and behave very differently on a body in motion.



Capturing the movement of cloth.
The movement of real garments is captured by sixteen cameras positioned in a circle around the subject (top image) and converted into a computer representation: (A) one of sixteen views from the camera array, (B) reconstructed T-shirt geometry; (C) original garment is replaced by a rendering of the captured geometry with different appearance characteristics.

State-of-the-art garment capture methods use markers printed on specifically designed garments in order to track their geometry as they move through space. The cost of creating such tailor-made garments can be prohibitive for many users and significantly restricts the set of garments that can be captured.

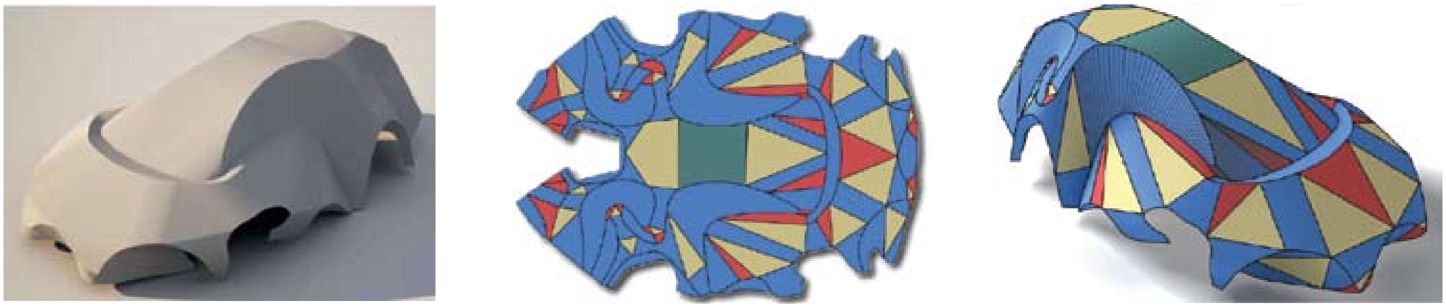
Sheffer, UBC colleague Wolfgang Heidrich, doctoral students Derek Bradley and Tiberiu Popa, and Tamy Boubekeur from Technische Universität Berlin demonstrated the first markerless garment capture method for garments in motion. It involved videotaping a person moving while wearing the garment, using sixteen high-resolution cameras positioned in a circle around the subject. “With enough cameras, you can capture and triangulate a fairly reliable 3-D representation of the entire garment over time,” says Sheffer.

Cameras! Action! Synchronization!

Off-the-shelf video cameras provide relatively inexpensive and reliable hardware for motion capture. First, the video data is analyzed to extract three-dimensional point clouds that capture the shape of the garment at each time frame. These clouds are then converted into triangular meshes representing the per-frame geometry. During this last step, there arise two problems that need to be addressed.

The first is occlusion. If you want to capture the motion of a shirt and the wearer places his arm in front of the body, the cameras no longer see the front of the shirt. The second problem is capturing the garment movement. “To reconstruct the movement, for every point on the garment in one frame we need to know where it moved to in the next frame, or, in other words, we need a correspondence between garment points in consecutive frames,” explains Sheffer. The movement information can then be used in graphics modelling tasks; for example, to replay the video sequence but change the texture of the shirt as the video is being played.

“So we have the question of how to do both completion—or filling in the blanks



Digital paper model. *Developable surfaces can be unfolded into the plane with no distortion. The patch decomposition of this car model into curved (torsal) ruled surfaces shows planes in yellow, cylinders in green, cones in red, and tangent surfaces in blue.*

when the garment is occluded—and the correspondence between frames," says Sheffer. "I think correspondence is a bigger issue because it requires a more detailed geometric knowledge of garments."

If you observe two points on a moving garment, the points change their distance in space as the fabric folds and flows. However, if you take any small piece of a garment, the surface distance between two points along that surface—or geodesic distance—does not change. "This observation gives us the tools to find the correspondence between the garment frames across time, because you want the points to travel in space in such a way that the surface distances between them don't change," she explains.

By using the geodesic distance between points as one key parameter, and natural boundaries of the garment—such as the edge of a sleeve or neckline—as the other parameters, Sheffer and her colleagues were able to "gracefully" fill in the missing garment geometry and produce smooth garment movement across time.

From Shoes to Skyscrapers—Dealing with Developable Surfaces

You can always tell a good pair of shoes by the fineness of the stitching, the quality of leather and number of pieces of leather the shoes are made from. A shoe with fewer seams or pieces usually reflects finer workmanship—and more intriguing geometric properties. Sheffer and her students tend to look at shoes and ask "Are they developable?"

Developable surfaces, namely those that can be unfolded into the plane with no distortion, are present in most objects made from fabric, paper, leather, or metal and wood sheets. "Objects made of paper are completely developable because paper doesn't stretch," explains Sheffer. "Leather is pretty close to a developable surface, but not completely since it has a bit of a stretch." She points to a pair of shoes she bought, and which she then replicated in her research (see below).

Intriguingly, it is very difficult to visualize how to turn a flat shape into a curved three-dimensional developable one by bending it. Using existing tools to model developable surfaces is equally challenging. Again, Sheffer uses geometry and a good dose of common sense to help solve the problem. She and her colleagues have created an intuitive sketch-based approach for modelling developable surfaces, which can be used by non-experts to generate sophisticated surfaces.

The key to their approach lies in utilizing unique geometric properties of developable surfaces. "Consider a piece of paper rolled into a cylinder," explains Sheffer. "Any point on the surface of the cylinder will be on a straight line connecting the top and bottom edge, or boundaries of the cylinder." This property is true for every developable surface. If you take a flat surface and curve it, you can define any point on the surface by a line that connects it to the boundaries. Even more interestingly, these lines, or "rulings," lie on the local convex hull of the surface. In general, a developable surface consists of a union of planar and curved (torsal) parts (see above). Existing methods for modelling these beguiling shapes consider only the special case of curved developable surfaces and are further restricted to modelling four-sided areas. If you have a boundary that looks like the toe of a shoe, for example, current models cannot incorporate it. Developable surfaces require an expert to discover the structure and separate the curved and planar parts.

Developable surfaces—modelling a shoe from sketched boundaries: *(A) upper boundary sketched over a foot model, (B) extracted contours, (C) structure of developable surface with curved parts shown in blue and planar parts shown in white, (D) final model of leather shoe.*

"Realistically, developable surfaces have a number of planar surfaces and the tools out there now don't allow you to model these areas. Instead, you need to figure out where the curved parts are, model them separately and then piece them together and add the planar areas in," says Sheffer. "You really need to understand differential geometry to be able to do that."

Sheffer and her group have presented the first algorithm for modelling developable surfaces that can interpolate arbitrary boundaries and compute smooth, predictable surfaces. "All a user has to do is draw a boundary, and the algorithm does the rest," she says. From shoes, chairs and table lamps, to gazebos and buildings like Canadian architect Frank Gehry's magnificent Guggenheim Museum Bilbao—the new method developed by Sheffer and colleagues could help designers, architects and artists create masterpieces without having to master geometry. ■

Mastering Microfluidics

Small, Powerful, Precise Tools for Biomedical Research

Biophysicist Carl Hansen develops microfluidic technology to help biomedical researchers study the complex molecular dynamics in cellular networks and cell-to-cell variations in cellular response. These tiny but powerful tools can monitor and modulate single cells en masse—eventually leading to advanced diagnostics and treatment.

Recognizing and understanding the interplay of environmental influences with an organism's genome and development is a critical aspect of systems biology. Another is coming to terms with heterogeneity. No two cells are the same. Even if they are identical genetically under the same conditions, they behave differently, and traditional chemical screening techniques cannot detect these cell-to-cell differences.

Biological systems are very different from physical systems, explains Carl Hansen, UBC assistant professor in biophysics and biotechnology. The heterogeneity, or variability, of cells makes them very difficult to measure and analyze. If you look at an average of cells in a sample, you don't capture what is happening in small but often critical populations of cells, which may have a critical effect on the whole system. "It is becoming increasingly clear that reductionism doesn't work. Understanding gene function requires us to address the surrounding network architecture," he says.

To help biomedical researchers decode the complex interaction of genes and proteins that create and sustain living systems, Hansen has to think big and work small. Big, in terms of being at the forefront of systems biology, an emerging research field that studies the interacting networks of genes and proteins comprising all organisms, from a yeast cell to a human being. Small, in terms of developing microfluidic tools that allow researchers to isolate and study the reactions and interactions of single cells in different biochemical environments simultaneously (see text box).

"Soft" Plumbing Yields Firm Results

The field of microfluidics was spawned by the integrated circuit (IC) industry, using the same micromachining tools that create microchips in the production of miniature fluid channelling devices. The most common application of this technology is inkjet printing. Since its emergence, the field has promised to revolutionize molecular biology, DNA analysis and proteomics.

However, hard materials such as silicon and glass used to build microchips are not well-suited for making hermetically sealed valves required for manipulating the nanolitre volumes of solution needed for analyzing cells. "Electronics is all about moving charge around, so a transistor is the fundamental technology," Hansen explains. "Molecular biology is about moving fluids around, so a valve, or fluid switch, is a fundamental component from which larger functionality can be built."

Hansen and his lab are developing multilayer soft lithography (MSL) which uses replica moulding of non-traditional "soft" materials to create highly integrated networks with thousands of active valves, pumps and logic gates. "The reason MSL is so robust and reliable is because the whole device is soft—about 100,000 times softer than silicon. Even if I had an imperfection nearly the size of the channel itself, I just close the valve and it deforms around it to make a seal."

Not only is it reliable, but MSL is cheap and fast—from computer design of a device to working prototype takes a few days. "Once we have a valve, or fluid switch, we can put three of them together and make a pump to move fluids along a channel. Once we have a pump, we can make a mixer," says Hansen. "We can also make valves in binary structures, so we can control a large number of channels with a small number of valves to allow fluidics multiplexing. This is similar to addressing one of 6 million transistors in a Pentium chip with only 64 pins."

Some Biomolecular Basics

Genomics: The study of genes and their function in an organism's entire genome, or all the hereditary information encoded in deoxyribonucleic acid (DNA).

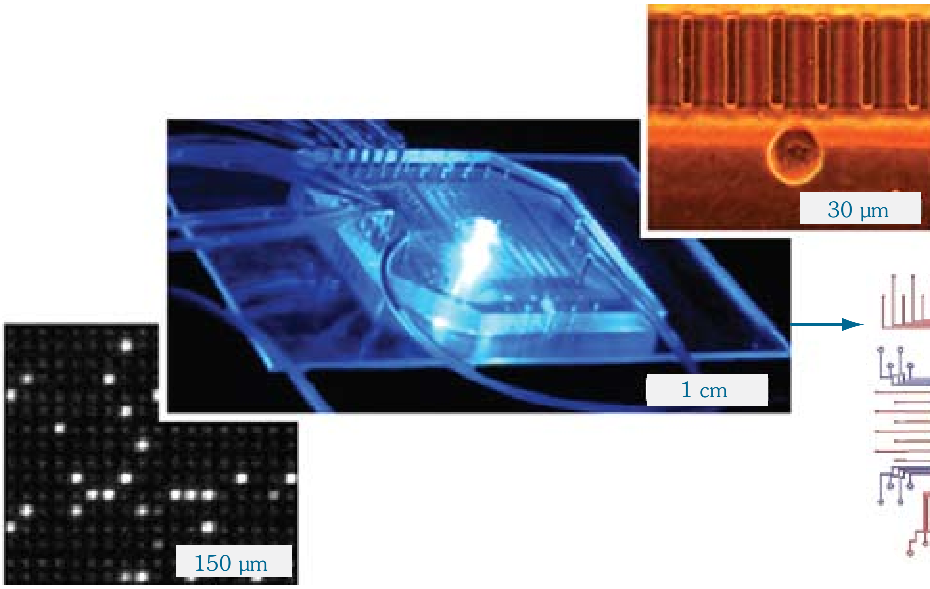
Proteomics: The study of the structure and function of all proteins encoded by the genome of an organism.

Polymerase Chain Reaction (PCR): A powerful technique in which DNA polymerase is used to amplify a piece of DNA by in vitro (test tube) enzymatic replication. PCR is used in molecular biology to generate millions of copies of a DNA piece in order to decipher the sequence, analyze the function of genes, and perform genetic manipulations for the study of genomics and proteomics.

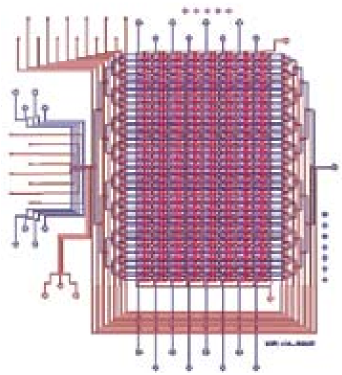
High-Throughput Single Cell Analysis of Protein Signalling

Understanding how cells interact and communicate with each other (cell signalling) is one of the most complex problems in molecular biology. Particularly challenging for signalling studies is the ever-present cell-to-cell heterogeneity, which cannot be captured in genomic analysis, where typically a large (>106) number of cells are observed simultaneously. Multilayer soft lithography (MSL) is poised to revolutionize next-generation DNA sequencing and analysis—tools crucial for genomics and proteomics.

UBC biophysicist Carl Hansen is developing technologies that couple live-cell microscopy with microfluidic control over the chemical environment. His group's current device can monitor eight strains, or genetic mutations, simultaneously in 32 different chemical environments. "We can do 256 live-cell imaging experiments and generate millions of data points in a day, and that allows us to ask new and quantitative questions about how gene knock-outs affect cellular response and variability under conditions of time-variant stimulus."



Soft microplumbing for biology.
Bright spots indicating the successful digital PCR detection of single molecules (left); microfluidic device for high-throughput imaging studies of single cells (centre); single mammalian cell in microfluidic device (right).



Micromachining tool for biomedical research:
Schematic of microfluidic device.

MSL is the technology platform behind all of the research projects in Hansen's lab. Their work exploits new capabilities in microfluidics to further a broad range of biological and biomedical research, including stem cell science, medical diagnostics, proteomics, single cell analysis, and genomics.

Through joint funding of Western Economic Diversification Canada, Genome BC, and UBC, the Hansen lab is currently building a dedicated nanofabrication facility that will allow for both the prototyping and production of microfluidic devices. This lab will be the only facility of its kind in Canada, and, along with Stanford, one of only two in North America.

Digital PCR for Advanced Diagnostics

Accurate clinical diagnosis and prognosis of disease such as cancer requires the ability to detect and measure the abundance of certain strains of nucleic acid—either DNA or RNA—in cellular tissues. Digital polymerase chain reaction (PCR) is the current gold standard technology in molecular biology. "PCR is a very powerful tool but limited in its ability to detect rare mutations or resolve small differences between molecules because it picks up background noise or sample contamination," explains Hansen. "You have to be a wizard to reliably amplify a single molecule in a conventional format in a macroscopic volume."

For Hansen, a macroscopic amount of liquid is much smaller than test-tube sized. Conventional PCR uses 96 well-plates, in which every reaction is around 50 microlitres. Even so, it is extremely difficult to amplify a single molecule, and conventional reagents at that small volume are expensive—roughly $1.00 per assay.

Hansen and his lab are developing digital PCR technology that that uses microfluidics to reduce sample volumes exponentially, and thereby improve accuracy. The state-of-the-art in digital PCR is a device sold by Fluidigm, which uses soft valve technology to allow for reactions in ten nanolitre volumes at a density of approximately 10,000 reactions per chip.

In terms of many diagnostic problems, however, this is not enough. Hansen's group is working with industry partner Fluidigm to improve the economy, precision and sensitivity of digital PCR by going 1,000 times smaller—to ten picolitre volumes, or the volume of roughly ten cells—with 1 million "wells" on a single chip. Compartmentalization of a single molecule in a 10-picolitre well results in a highly effective concentration, which

continued on next page

Safe Detection of Down's Syndrome

Down's syndrome is one example of a diagnostic application for digital PCR. Children with Down's syndrome have an extra copy of chromosome 21, resulting in impaired cognitive ability, physical growth and development. Depending upon the age of the mother, between one in 100 to one in 1,000 fetuses will test genetically positive for Down's syndrome. In amniocentesis, currently the definitive test for Down's syndrome, fetal cells are collected from the amniotic sac inside the uterus. It is an invasive and dangerous procedure for both mother and child.

Clinicians and researchers have discovered that during the first trimester of pregnancy, between 2 to 6 percent of DNA cells from the developing fetus end up in the mother's blood stream. The ability to detect small imbalances in chromosome number within a large background of maternal DNA raises the possibility of non-invasive testing. Very recently, two strategies have been advanced for this purpose. The first is based on shotgun sequencing of DNA, which is expensive. The second is based on detecting unique sequences of RNA arising from genetic variability between the mother and the fetus, which is difficult to generally apply and requires more complex biochemistry. "In principal, by performing millions of reactions in pL volumes, digital PCR provides an economical test to directly measure DNA differences in the abundance of less than 1 percent," says Hansen. Ultimately, this work could lead to a simple, economical, and highly accurate blood test for Down's syndrome.

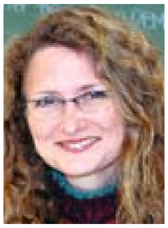
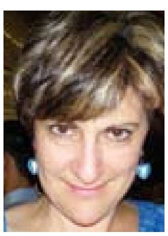
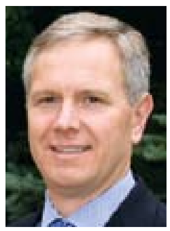


Photo: Elaine Simons

Botany senior instructor Shona Ellis was appointed **Director of General Science**, July 1, 2008. General Science is one of the largest BSc programs at UBC. It allows graduates to pursue a broad spectrum of careers. "These are exciting times for science undergraduate education at UBC," states Ellis. "Many programs are currently going through curriculum reform, including this program." General Science will offer students the opportunity to investigate and increase proficiency in a number of areas in science, and will prepare them for career-directed studies such as education, medicine, law, and journalism. A highly creative post-graduate teacher herself, Ellis will lead structural change for innovative learning outcomes of the program. Students will have the opportunity to take a combination of required and student-selected courses—providing them with a strong foundation for pursuing their interests. "We intend to offer our students the flexibility and breadth they find appealing, yet support them with newly developed courses and program structure."



Statistics professor Nancy Heckman was appointed **Head of the Department of Statistics**, July 1, 2008. Internationally recognized for her work in non-parametric regression, Heckman was elected to the International Statistical Institute (1999), and is a Fellow of both the American Statistical Association (2001) and the Institute of Mathematical Statistics (2003). She has been involved in the Faculty of Science's recent working climate assessment, and in efforts to transform the department's largest introductory course as part of the Carl Wieman Science Education Initiative (see p. 16). "I'm very much looking forward to working with Dr. Heckman to advance statistics at UBC, which includes not only our Department of Statistics, but also statistics groups in the broader UBC community," noted dean Simon Peacock. Heckman takes over from Prof. William Welch, who stepped down this summer after five years of providing excellent leadership to the department.
www.statistics.ubc.ca



Microbiology & Immunology professor Jim Kronstad was appointed **Director of the Michael Smith Laboratories**, July 1, 2008. Kronstad is an internationally renowned scientist with expertise in the molecular genetic analysis of fungal pathogens. Dedicated to the Michael Smith Laboratories' (MSL) founding mission of promoting biotechnology research and teaching at UBC, Kronstad plans to expand the scope of the laboratory to include research on globally significant challenges such as bioenergy production. Kronstad was one of the original faculty members recruited to the MSL (formerly the Biotechnology Laboratory) by founding director and Nobel laureate Michael Smith. Kronstad succeeds medical geneticist Philip Hieter at the helm of the MSL.
www.michaelsmith.ubc.ca

Chemistry professor Steve Withers was appointed **Director of the Centre for High-Throughput Biology (ChiBi)**, April 1, 2008. Recently established, this multidisciplinary research unit develops and applies high-throughput methods in a variety of biological systems, combining expertise across the physical–life sciences interface. CHiBi faculty members hold a departmental appointment within the faculties of Science or Medicine and teach within that unit. www.chibi.ubc.ca

The **Carl Wieman Science Education Initiative** appointed the following Science Teaching and Learning Fellows (STLFs) this past year: Jennifer Duis, Chemistry; Erin Lane, Earth & Ocean Sciences; Jared Taylor and Harald Yurk, Life Science programs; Costanza Piccolo, Mathematics; James Day, Louis DeLaurier, Jim Carolan and Peter Newbury, Physics & Astronomy. Currently, eleven STLFs support the Science departments' implementation of evidence-based education advancements.
www.cwsei.ubc.ca

Zoology professor Barbara Evans was appointed **Dean of the Faculty of Graduate Studies**, November 1, 2007. As a comparative zoologist, Evans took an interdisciplinary research approach, including a wide range of experimental techniques ranging from histology, biochemistry, endocrinology, and physiology of animals. Some of her research was done in collaboration with UBC Killam Professor in Zoology David Jones. Evans came to UBC from the University of Melbourne, Australia, where she was Dean of the School of Graduate Studies, and Pro Vice-Chancellor, Research Training.

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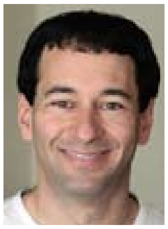
facilitates amplification and detection of each molecule. "Conventional PCR can detect a 30 percent difference in molecules of a sample. With digital PCR at ten-picolitre volumes, we can unambiguously detect a 1-percent difference," says Hansen. "In areas of cancer research, metagenomics, pathogen detection, and prenatal diagnostics [see sidebar p.10], this precision translates into early detection and the ability to see very rare molecules."

Hansen's research has applications in several fields, including biomarker discovery, drug development, environmental genomics, personalized medicine, and stem cell research. "One thing I like to stress is that we are working on applications, so we know most of our projects will work in principle before we start," he says. "We have been very fortunate at UBC to have access to a group of outstanding life science researchers who see the potential of this technology. In my mind, this is the most important ingredient for success."■

New Faces in the Faculty


Angel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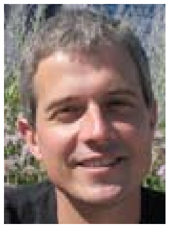
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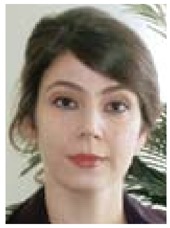
Khosravi


Magyar


Martone


Raussendorf


Silberman

UBC Science welcomes our new faculty members.

Omer Angel, Asst. Prof., Dept. of Mathematics; BSc Mathematics, Technion, Haifa, Israel; PhD Mathematics, Weizmann Institute, Rehovot, Israel. *Prior appointment:* Asst. Prof., University of Toronto, ON, Canada. Research: I work in the field of probability and its applications, particularly to combinatorics. I study the large-scale behaviour of random systems and the interface between discrete structures and their scaling limits. I have worked on random walks, random graphs and particle systems. www.math.ubc.ca/~angel

David Close, Asst. Prof., Fisheries Centre and Dept. of Zoology; Distinguished Science Professor of Aboriginal Fisheries; Dir., Aboriginal Fisheries Research Unit at the Aquatic Ecosystems Research Laboratory; BSc Fishery Resources, University of Idaho, Moscow, ID, US; MSc Fisheries Science, Oregon State University, Corvallis, OR, US; PhD in Fisheries Science, Michigan State University, East Lansing, MI, US. *Prior appointment:* Principal Investigator, Pacific Lamprey and Freshwater Mussel Research and Restoration Projects, Department of Natural Resources, Tribal Fisheries Program, Pendleton, OR, US. Research: I am interested in interdisciplinary research in the areas of aquatic ecology, fish physiology, chemical ecology, and traditional knowledge. As the new director of the Aboriginal Fisheries Research Unit, I will link together traditional knowledge and fisheries science to advance knowledge for fisheries management. www.zoology.ubc.ca/person/close

Christoph Hauert, Asst. Prof., Dept. of Mathematics; MSc Theoretical Physics, University of Bern, Switzerland; PhD Theoretical Physics, Christian-Albrechts-Universität, Kiel, Germany. *Prior appointment:* Research Assoc., Program for Evolutionary Dynamics, Harvard University. Research: The question of how co-operative behaviour could have evolved has challenged scientists across disciplines. I'm using the mathematical framework of game theory to model interacting agents and to identify conditions under which altruistic behaviour can evolve within a species. www.math.ubc.ca/~hauert

Mahta Khosravi, Asst. Prof., Dept. of Mathematics; BSc and MSc Mathematics, Sharif University of Technology, Tehran, Iran; PhD Mathematics, McGill University, Montreal, QC, Canada. *Prior appointment:* J.J. Sylvester Asst. Prof., Johns Hopkins University, Baltimore, MD, US. Research: My research focuses on analysis, spectral geometry and related problems in analytic number theory. www.math.ubc.ca/~khosravi

Akos Magyar, Assoc. Prof., Dept. of Mathematics; BSc Mathematics, Eotvos Lorand University, Hungary; Master's and PhD Mathematics, Princeton University, NJ, US. *Prior appointment:* Assoc. Prof., University of Georgia, Athens, GA, US. Research: I am interested in problems showing that complete disorder is impossible. I study arithmetic properties of dense sets of the integers or integer points in different settings, using the Fourier analytic approach to obtain quantitative results. www.math.ubc.ca

Patrick T. Martone, Asst. Prof., Dept. of Botany; BSc Biology and Mathematics, Duke University, Durham, NC, US; PhD Biomechanics and Phycology, Stanford University, Palo Alto, CA, US. *Prior appointment:* Post-doctoral Fellow, Hopkins Marine Station of Stanford University, Monterey, CA, US. Research: I am interested in the functional morphology, biomechanics and evolution of intertidal seaweeds, and currently focus on the mechanics of joints in "articulated" calcified macroalgae that allow otherwise rigid fronds to bend (but not break) under crashing waves. www.botany.ubc.ca/martone

Robert Raussendorf, Asst. Prof., Dept. of Physics & Astronomy; Diploma in Physics, University of Heidelberg, Germany; PhD in Physics, Ludwig-Maximilians-Universität Munich, Germany. *Prior appointment:* Post-doctoral Fellow, Perimeter Institute for Theoretical Physics, Waterloo, ON, Canada. Research: I am interested in quantum computation driven by measurement processes. My research also focuses on stabilizing quantum computers against quantum noise (decoherence). www.physics.ubc.ca/~raussen

Lior Silberman, Asst. Prof., Dept. of Mathematics; BSc Mathematics and Physics (Amirim Honours Program), Hebrew University, Jerusalem, Israel; PhD Mathematics, Princeton University, NJ, US. *Prior appointment:* Member, Institute for Advanced Study, Princeton, NJ, US. Research: My research spans several areas of mathematics, including number theory, metric geometry and group theory. I focus on problems in representation theory, dynamical systems, analysis and combinatorics. www.math.ubc.ca/~lior

Building on Science

Interdisciplinary Degree 'Sparks' Integration Technologies

COGS, or Cognitive Systems, is a multidisciplinary program at UBC involving the departments of Computer Science, Linguistics, Philosophy, and Psychology. Its students study existing intelligent systems such as perception and language, the creation of new systems such as machine vision and machine intelligence, and the design of interfaces between different intelligent agents such as humans and computers.

"By combining human and machine intelligence, our students are better equipped to support human understanding and problem solving," says Ron Rensink, COGS academic advisor and professor in the departments of Computer Science and Psychology.

Chad Trytten, a 2006 Science graduate in Cognitive Systems: Computational Intelligence and Design, helped evolve a student start-up company—conceived in UBC's Koerner's pub one night in April 2006—into a company to watch.

Trytten, along with Economics alumnus Harbir Boparai and four other UBC graduates in Genetics, Computer Science, Electrical Engineering, and Computer Engineering, founded Spark Robotics Technology Inc. The six were part of UBC's Thunderbird Robotics Team, which developed an unmanned ground vehicle for the 2005 DARPA (Defense Advanced Research Projects Agency) Grand Challenge. Mining Engineering professor and DARPA team founder John Meech excited the students about the possibilities for using robots to perform tedious, onerous or dangerous tasks.

Trytten also cites COGS professors Alan Mackworth, Ron Rensink and Eric Vatikiotis-Bateson as significant mentors in developing the technological approach for the DARPA competition—and for subsequent Spark endeavours.

At start-up, Spark's intent was to develop autonomous robotics for industries that operate in hostile environments or face labour shortages. In just two years the company has doubled in size, rebranded as Spark Integration Technologies Inc., and

Co-founders Tony Angerilli, Ken Mackay and Chad Trytten (from left to right) spark new ideas on integration technology.

been sponsored by the US Department of Defense (DoD) through their Foreign Comparative Testing Office. This is a highly competitive program—several hundred companies applied—to evaluate foreign technologies of strategic interest to the US DoD for procurement.

Today, Spark is positioned as the creator of DIOS™ – Distributed Integration Operating Schema™. DIOS is a middleware platform that simplifies the way information is exchanged between disparate software and hardware components to accomplish a goal. This technology can be leveraged by original equipment manufacturers of robotic vehicles, industrial equipment and consumer electronics, and by systems integrators in enterprise infrastructure, health and medical sciences, defence and security, and any project that requires combining a diverse set of components. DIOS can, for instance, simplify the way in which multiple robotic platforms share differing sensory information and allow communication between disparate C4ISR (command, control, communications, computer, intelligence, surveillance, and reconnaissance) systems.

DIOS allows multiple incompatible specifications to exist simultaneously and communicate seamlessly. This dramatically decreases the likelihood of integration failure, reduces development time and cost, and future-proofs both new and legacy components.

In COGS, Trytten learned that the human brain and body employ amazing diversity and that nature does not prefer an "elegant, universal" solution, but rather uses the best approach to a given problem, independent of the system as a whole.

Similarly, Spark chose to ignore the conventional 'wisdom' of forcing all workers and technologies to adhere to a single standard. Spark's four developers chose four different programming languages, four different operating systems, three different hardware architectures, three different communication networks, and they represented information according to individual preference—not surprisingly, all in different ways.

"Sometimes we get so focused on finding a standard by which to communicate and work together that we forget that the point of being on a team is to have different points of view," Trytten says. "I realized that the hard part of co-operation is not the idea of co-operating, but the 'how.' For system integration, that how is made much easier by letting each component be developed independently—enter DIOS."

Connecting with Science

Geneticist and Educator David Ng Splices Science Literacy with Creativity

Source: Adapted with permission from the article by Meg Walker published in UBC Reports, Vol .54, Sep. 2008

David Ng, science teacher, researcher-writer and director of UBC's Advanced Molecular Biology Laboratory (see text box), wants to produce science-literate creative thinkers, from professional scientists to elementary school kids. Ng has had "an enormous amount of flexibility just to try things" during the nine years he's been at AMBL.

He teaches two upper-level courses in molecular biology, and leads workshops on molecular biology for researchers. A 2003 workshop for scientists in Lagos, Nigeria, opened his eyes and got him interested in development and global sustenance. Ng says, "I took lots of notes to gather my thoughts and that led to the first article I wrote for the general public. It got published [in *Maisonneuve* magazine], so it paved the way for an interest in writing." Articles in several general-interest publications (*McSweeney's*, *The Walrus*) followed. All are connected to the central concept of "talking science," though usually in unexpected ways. Imagine a fictional yet scientifically sound conversation between the Von Trapp children and a geneticist, for example.

His interest in writing segued to a website for the UBC Terry project, which connects undergraduates in the sciences and the arts to promote discussion of global issues and social responsibility. "Dave is very creative and he's involved in the literary aspect of science, which is a very important part of this project," says Allen Sens, a political science professor and chair of the International Relations Program. Through Terry, Ng and Sens now co-teach a second-year interdisciplinary science and arts course (ASIC 200) based on the belief that global problems can only be solved by educated people who understand how both science and society work.

Ng had been interested in trying to reach out to elementary schools and thought that writing was an angle that could draw younger children into science. This led to the Science Creative Literacy Symposium. Eight pairs of UBC graduate students, one from Creative Writing and one from Science, designed their own templates to use during a two-week pilot project in May. With MFA poetry student Shannon Woron and David Kent, a PhD candidate studying blood stem cells, a class looked at slides about body organs and wrote down comparisons to the images, learning both scientific facts and the concept of similes. Then the children wrote love letters to different body parts, shaped after Elizabeth Barrett Browning's poem "How Do I Love Thee? Let Me Count the Ways."

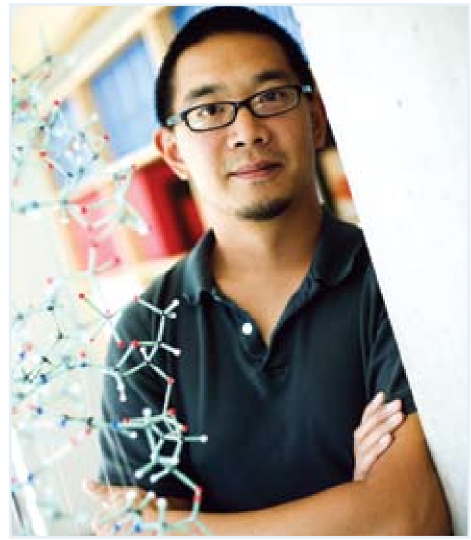

Photo: Eugene Lin

Ng moved to Canada from England at age 12, with an interest in science already sparked by many visits to London's Natural History Museum. He has lived in Vancouver since then, studying his way up through undergraduate and graduate degrees at UBC. James Kronstad, director of the Michael Smith Laboratories, says he thoroughly supports the many levels of outreach that Ng does, because of the public money that goes into the research. "David's got the personality and the interest to do this. He brings a level of credibility because he did a PhD at UBC in molecular biology, and he knows how to engage an audience."

AMBL—UBC's Michael Smith Labs Reaching Out

The Advanced Molecular Biology Laboratory (AMBL) is the education arm of the Michael Smith Laboratories (MSL)—and a physical space on the UBC campus specifically designated for interactive science outreach. In addition to unique training programs for researchers, AMBL caters to 2,500 high school students a year through outreach initiatives such as:

- **The field trip program** that allows 50 classes a year to conduct molecular biology experiments in MSL's state-of-the art labs, with added focus on the ethics, politics, economics, and culture surrounding the science.
- **The Most Exceptional Escapades in Science** conference, which brings high school students from across the lower mainland to MSL for hands-on experiments and tales of scientific adventure from some of UBC's leading researchers.
- **The Science Creative Literacy Symposia,** a field trip program for grade six and seven students that blends scientific research with reflective creative writing.

For UBC students, **Terry**, an affectionate name for Terra, the Earth, is an interdisciplinary project focused on global issues and global citizenship that comprises a speakers series, a creative and literary website (www.terry.ubc.ca), the second-year Arts and Science Integrated Course (ASIC 200), and a new, upcoming "Terry talks" event, where students are given a high-profile platform to communicate their passions and desires to an audience of their UBC peers.
www.bioteach.ubc.ca

People at UBC Science

Bruce Dunham Improves Probability of Learning Stats

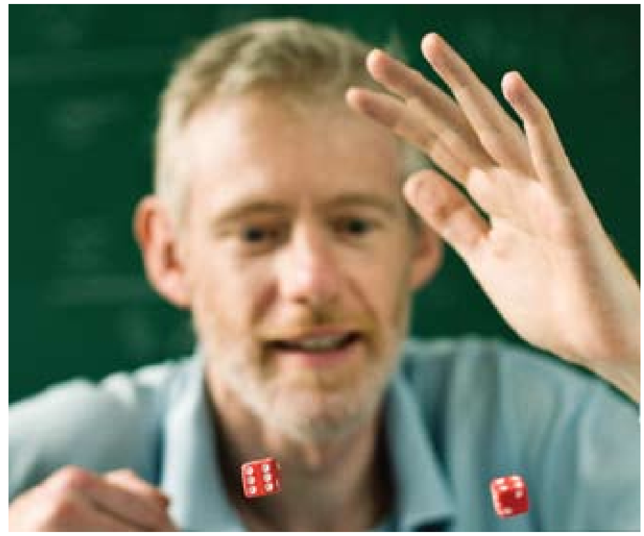
Photo: Martin Dee

After teaching statistics for over fifteen years, UBC instructor Bruce Dunham is working harder than ever to reach students. He is rethinking how he teaches—with some help from the Carl Wieman Science Education Initiative (CWSEI)—and liking his odds.

"Students are a very dynamic entity and students in 2008 are not the same as those 20 years ago," says Dunham. "As a result, our educational goals are essentially moving targets—and we must move with them."

"The Department of Statistics graduates 30 to 40 majors a year," says Dunham, who co-teaches a second-year introductory course to more than 800 science majors each year. The department also offers introductory courses tailored for arts and engineering students. However, Dunham says, "For hundreds of students coming through our classrooms, these courses are likely the first and only statistics course they'll ever take."

The field of statistics is probably the discipline most impacted by the availability of modern computers. Says Dunham, "Many calculation techniques we used to teach students to do by hand are no longer required and more emphasis has been put on statistical concepts. But it's increasingly clear that most students simply aren't grasping—and retaining—these fundamental concepts."Working with the CWSEI, Dunham assessed what students remember six months after taking his course. Students may remember how to solve certain problems, but when probed about the steps taken, he found they could not articulate their thinking. Seed funding from the CWSEI made it possible for Dunham and his co-instructors Nancy Heckman and Eugenia Yu to begin instituting changes and documenting their progress. Personal Response Systems—or "clickers"—were used in the classroom. "The clickers told us what everybody is thinking, not just the top students or those who readily volunteer their answers in a large class," says Dunham. "Students get confused in ways I never knew before."

The team of instructors has overhauled lab activities to target concepts that students routinely have difficulty with. Some labs encourage students to ponder difficult concepts through hands-on exercises before showing up for a lecture.

Dunham also experimented by offering part of his office hours as a drop-in workshop for small teams of students to work on problems with minimum guidance from him. "Ultimately, they learn more by examining a problem from all sides, talking about different approaches, and working through it together," he says.

"There are misconceptions hard-wired into students' minds, from whatever source they may have obtained them," says Dunham, who is helping set up a campus-wide forum for instructors teaching a dozen statistics courses in other departments. "By understanding the ways in which students go wrong and the underlying reasons, we increase the odds of not only leading students down the right track, but showing them how to follow sound logic and solve problems in the future."

Source: Adapted with permission from the article by Brian Lin published in UBC Reports, Vol .54, Sep. 2008

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