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Words from the Dean

Photo: Martin Dee

I am delighted to announce the official opening of the Abdul Ladha Science Student Centre (see p. 3). I would like to offer a special thanks to Abdul and Hanifa Ladha and our students for their tremendous confidence in this project, for their investment and vision, and for their important role in making this such a success. Tens of thousands of undergraduate science students will benefit from this space in the years to come.

UBC Science is a community of scholars coming together to discover and to learn. Each year, nearly 2,000 new undergraduate students join our community to explore their passion for science. I want to share with you a few thoughts about learning and science, and how this wonderful new facility will greatly enhance our science student learning experience.

In *Seven Principles for Good Practice in Undergraduate Education,* Chickering and Gamson argue that learning is not a spectator sport. Students become critical thinkers only through actively engaging with scientific concepts and by improving problem-solving and communication skills.

Good learning—like good work—is collaborative and social. Sharing ideas and responding to the reactions of others stimulates thinking and deepens understanding. One of the best ways to test whether you understand a scientific concept is to try to explain it to someone else. For this, the new centre provides the ideal setting, giving our students the opportunity to converse, challenge each other's thinking, and by doing so, learn.

Science is increasingly interdisciplinary and the boundaries between traditional scientific disciplines continue to blur. Computer scientists probe the human genome. Chemists and physicists work side by side to develop new materials. Earth scientists and biologists collaborate to unravel the evolutionary tree of life. Interdisciplinary connections often begin with a simple conversation—like those among our students in the Ladha Centre.

UBC is committed to preparing exceptional global citizens. In the Ladha Centre, students from around the world share their experiences. Through connecting with each other and learning from each other, they can make our world a better place.

Simon M. Peacock
Dean, UBC Faculty of Science

In the News—Science Discoveries and Innovation

Source: UBC Media Releases, 2007

UBC Astronomers Discover Most Distant Star Clusters – Jan 7th
Astronomy professor Harvey Richer and his PhD student Jason Kalirai have uncovered the most distant star clusters ever seen, shedding light on the evolution of galaxies like ours.

Scientists Reveal Dwarf Aquatic Plants' Hidden Ancestry – Mar 14th
Botany professor Sean Graham and co-workers have reclassified an ancient line of aquatic plants previously thought to be related to grasses and rushes. The discovery clarifies what may be one of the biggest misunderstandings in botanical history.

Cold Is Hot in Evolution – Mar 15th
Zoology PhD candidate Jason Weir and Prof. Dolph Schluter, director of the UBC Biodiversity Research Centre, debunk the belief that species evolve faster in tropics.

New Peptide Boosts Body's Own Immunity – Mar 26th
Microbiology professor and CRC in Pathogenomics and Antimicrobials Robert Hancock and his team identified an innate defence regulator peptide that can increase innate immunity without triggering harmful inflammation.

Harnessing Turtle Power – Apr 5th
Human activity and ignorance in the past 50 years has left only 40,000 leatherback sea turtles swimming in our oceans. Now T. Todd Jones, graduate student in Zoology, may have found the key to saving these quietly charismatic animals from the brink of extinction.

UBC Team Key Contributor to Superconductor Discovery – May 31st
Physicists Douglas Bonn, Walter Hardy and Ruixing Liang have contributed to the greatest advancement in superconductor research in a decade by "growing" the purest samples of superconductors to date.

Boring Star May Mean Livelier Planet – Jun 8th
Astronomy professor Jaymie Matthews explored the stable brightness, or "boring" light, from red dwarf star Gliese 581, which may mean better odds for extraterrestrial life in that planetary system.

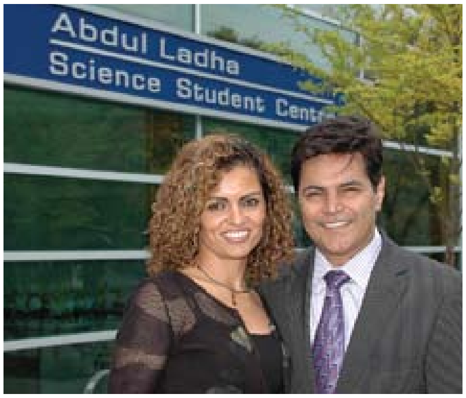
Canada's Space Telescope Celebrates Fourth Birthday – Jun 29th
Canada's first space telescope, the Microvariability & Oscillations of STars (MOST) satellite, was launched June 30, 2003. "MOST is capable of measuring the brightness variations of stars more precisely than any other instrument on Earth or in space," says mission scientist and UBC astronomer Jaymie Matthews.

UBC Gets $12M in New Federal Research Funding – Sep 5th
UBC gains and retains research strength through three new and twelve renewed Canada Research Chairs. Two of the three new chairs were appointed in Science: Ken Harder, CRC in Host-Pathogen Immunogenetics, and Christian Schoof, CRC in Global Process Modelling.

Physics Education Website Nabs International Award – Sep 28th
An international contest has given the top prize to a physics education website launched by Nobel laureate Carl Wieman, who joined UBC earlier this year to lead the $12-million Science Education Initiative.

More Than Classrooms, Labs and Libraries—Science Students' Own Centre

Five years ago, our students voted for making their own long-term financial commitment to help create a social space for all Science undergraduates. Now, it has become a reality: the Abdul Ladha Science Student Centre was officially opened by UBC president Stephen J. Toope, October 4. This $3.4-million high-tech space was made possible by a generous $1.3-million donation from UBC alumni Abdul and Hanifa Ladha (photo), partnering with all Science students and the university. The centre provides a welcoming space for our students to gather, exchange ideas and engage in scientific discussions. "It's fantastic. For years we have been spread throughout campus, making collaboration difficult," says Science Undergraduate Society president Michael Duncan. "It fosters interactions among science students from different fields and stages of their academic careers," says Abdul Ladha. "Whether you're talking about the environment, physics or medicine, science is the precursor."



New and Renewed Commitments—Institute of Math Excellence

The Pacific Institute for the Mathematical Sciences (PIMS) received a $5.5-million, five-year grant from the Natural Sciences and Engineering Research Council. Effective in 2008, this grant includes a 10-percent increase over the previous five-year period. PIMS is a partnership of six universities in BC, Alberta and Washington, which creates research collaborations in mathematics and related disciplines, the mathematics of industry and mathematical education. Director Ivar Ekeland is a professor in the Departments of Mathematics and Economics, and Canada Research Chair in Mathematical Economics at UBC. PIMS involves more than 350 scientists in pure and applied mathematics, statistics, computer science, the physical and life sciences, finance, management, and engineering. Its network includes elementary and high school teachers, government and industry representatives.

This summer, the province of British Columbia provided PIMS with $130,000 to further help Aboriginal students build strong math foundations and to reduce the barriers to success in post-secondary education. In consultation with First Nations schools and the First Nations Education Steering Committee, PIMS had created a program—now to be expanded—that helps teachers in First Nations schools increase student participation in math.

Expanding the Possibilities—Earth Systems Science Building

The Department of Earth & Ocean Sciences at UBC provides the country's most diverse research and training opportunities, encompassing geological sciences and engineering, geophysics, oceanography, and environmental sciences. Our community of earth science researchers and students continues to grow beyond the capacity of the department's current infrastructure. As a result, the Faculty of Science recently proposed construction of a $75-million Earth Systems Science Building

to both maintain, and enable further expansion of, our earth sciences school and research centre. The new facility will incorporate the latest technologies, provide a flexible learning and training environment, and allow for increased research capacity. It will attract more outstanding teachers and researchers. And, it will help us meet the increasing demands of natural resources industries—in particular, the mineral exploration industry's need for highly skilled geologists and earth scientists.

Transforming Learning—Tablet PCs in the Field

What is a powerful way to convey mosses—or bryophytes—onto the minds of students? According to Botany instructor Shona Ellis—via a portable PC. Impressed by her "Classrooms in the Field: Using Tablet Computers to Transform Learning" proposal, HP Canada awarded a 2007 Technology for Teaching grant to UBC. The $75,000 prize includes 20 HP wireless tablet PCs with accessories, a digital camera and a $21,000 stipend. "This high-tech equipment will help our students to learn biological concepts rather than memorize information," states Skylight research associate Joanne Nakonechny, who contributed her knowledge on effective teaching and learning strategies to the project. Ellis adds: "To identify what is important in a new discipline such as plant systematics is often a challenge for our students. This package of HP products will greatly help them to choose their own learning pathway. They can take and upload their own digital images and collect data and observations in the field—right on the spot where we teach this class." Botany's Introduction to Bryophytes is the pilot course for this transformative approach to learning in the field. The tablet software will enable instructors to effectively spend their time facilitating deeper conceptual discussions and helping their students to integrate, synthesize and analyze the on-site data. And the students will become proficient at self-regulating their learning.

Simulating Shadows and Light

Ultra High Contrast Digital Displays

Most video displays only capture a fraction of the detail, contrast and colour intensity that we see in real life. Computer scientist Wolfgang Heidrich has developed computer graphic and display technologies that produce superbly brilliant, life-like images that make current high definition displays look dim by comparison.

Human vision is a marvel of physical engineering. When we look at clouds billowing overhead, or the dazzle of sunlight off the surface of water, or a canary silhouetted against a canopy of green leaves, we don't think about the interplay of light, shadows and geometry that create the vibrant visual world around us. Recreating what we are able to see with the naked eye is the goal of Wolfgang Heidrich, associate professor in UBC Computer Science.

In Heidrich's world of images, understanding the play of light is the key to everything. Most light sources are indirect, and the light bouncing off surfaces such as walls, trees or the ground affect how we perceive textures, colours, shadows, and depth. Photo-realistic simulation of complex materials such as fabric requires not only modelling the microgeometry of individual fibres, but also the microscopic reflection of light bouncing off each fibre.

The challenge, he explains, is that when computer graphics are not modelled on physical laws, images seem flat and unrealistic. "I work on capturing what the real world looks like, using simulations, image-capture technology and software algorithms to produce images in the most realistically possible way."

Heidrich has developed image-based rendering techniques that use calibrated cameras and global illumination to capture and simulate the shimmering warp and weft of silk taffeta, for example. "We can also simulate how light bounces around between different water particles within a cloud," he says. "You get a much more realistic picture than if the clouds are illuminated by a single light source."

High Dynamic Range Display—Lifting Digital Images Out of the Shadows

Clearly we've come a long way since cathode ray tubes and monochrome black-and-white television, where the darkest blacks on the *I Love Lucy Show* were Ricky Ricardo's hair and Lucy's lipstick. Cable companies today tout high definition TV (HDTV) for brighter, sharper, clearer pictures that explode with colour.

In collaboration with UBC physicist Lorne Whitehead, Heidrich has developed a display technology that makes HDTV literally pale in comparison. Their breakthrough technology, high dynamic range (HDR) display, has a contrast up to 500 times higher than conventional displays such as flat panel LCD screen—with up to 50 times brighter white tones and up to ten times darker black tones.

"The whole idea behind HDR is to make the bright areas brighter and dark areas darker, and so create greater contrast that is more comparable to what we see in the real world," says Heidrich.

In the display technology industry, contrast is a measurement that compares the blackest blacks to the whitest whites. The brightness, or luminance, of a fully white screen and the darkness of a completely black screen are measured in a darkroom, and the ratio is the contrast. Current LCD displays have contrast in the range of 200:1 to 500:1. Plasma TVs are even higher, around 700:1 (see sidebar on p. 5). With HDR display technology, Whitehead and Heidrich have achieved contrast in the range of 50,000 to 100,000:1. The result is astounding, even though it is still only about half of what we see in the real world with the human eye—and even if enhanced with contact lenses or designer specs (see diagram on p.5, bottom).

Heidrich's graduate student Allan Rempel, who developed the software algorithms to transform old video footage for viewing on an HDR display, demonstrated

Brightside Technologies display / Dolby Canada

the results. The armour worn by Russell Crowe in *Gladiator* actually glints in the sunlight, rivalling what we would see on a bright day without sunglasses. The colours are intensely vivid, and the deep black shadows add a sense of dimension that makes the actors appear to jump off the screen.

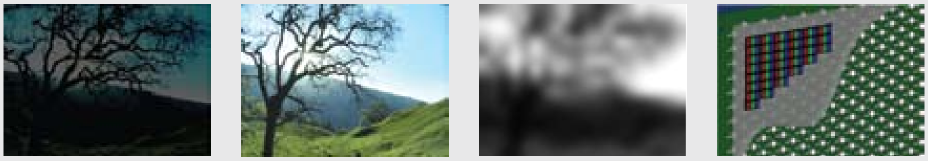
The Innovative "Insight" of HDR

To achieve the brilliant images of HDR, Whitehead, Heidrich and colleagues replaced the single backlight in LCD displays with an array of light emitting diodes (LEDs) that can be programmed to have smoothly varying intensities for different regions of the display.

"The high dynamic range technology works by replacing the white light box with a low resolution area of LEDs—roughly 1,500, which are blurred so you get very soft transitions between areas," explains Heidrich.

Each LED can be controlled individually to make some regions darker and some lighter. Each pixel in the LCD panel can be controlled as well. When the LCD panel is placed over the LED background light, the contrast in the LCD and the contrast in the LEDs multiply to produce contrast that is at least 50 times greater than the best display on the market today.

What seems like a contradiction—the use of low resolution LEDs to get a smooth transition in the light source—actually solved the greatest challenge of the technology. With LEDs, Heidrich explains, you cannot create a really bright white and a really dark black right next to each other, because each LED lights an area of several hundred pixels.



High resolution colour image — *High dynamic range (HDR) display* — *Low resolution luminance modulated second image* — *Low resolution light emitting diode (LED) array*

The innovative "insight" of HDR: *in high dynamic range displays, the single backlight of liquid crystal diode displays is replaced with an array of low resolution light emitting diodes.*

But the innovation that Lorne Whitehead made arose from the realization that the human visual system can't handle these sharp transitions. For example, if you stare at a very bright object and then look away, you will see a dark shadow. This is because the light is scattering inside the human eye to reduce the local contrast of light that hits the retina.

"Since the contrast perception around a local edge is limited to about 150:1, we can get away with these low resolution transition areas of LEDs, even though, globally, the contrast is greatly enhanced," says Heidrich. "That is really the key insight that Lorne had."

Converting Video to HDR On the Fly

"What is most exciting is that we can now take any video and convert it on the fly to high dynamic range, without any preprocessing." The team recently unveiled their "reverse tone mapping" algorithm, which transforms legacy video footage so that it can be viewed on HDR displays—in real time, with no user input.

"We want to be able to take any video from the last 100 years and show it on HDR," says Heidrich, who notes that video camera technology has yet to catch up to their video display capability.

The group has demonstrated on-the-fly video conversion on computers, but their goal is to transfer the technology to the large-screen home-theatre market. Heidrich, Whitehead and Rempel have been working in conjunction with Brightside Technologies Inc., a UBC spin-off company co-founded by Helge Seetzen, Whitehead's graduate student. Brightside was recently purchased by international sound giant Dolby.

"Dolby Canada is now the imaging research centre for all of Dolby. They will be expanding operations here in Vancouver and maintaining a close relationship with UBC," says Heidrich. His research team recently received funding from the Canadian research network Mathematics of Information Technology and Complex Systems, with Dolby as the industry sponsor.

Home theatre video is just one potential market for the technology the group is developing. In a contemporary parallel of hand-colouring an old movie, Rempel is developing an authoring tool that will allow content creators to manually adjust or optimize their video content for HDR.

Video games are another huge market, since most game engines actually compute HDR images, but then reduce the contrast so they can be viewed on a normal screen. "The problem is in getting the high-contrast data from the computer to display," Heidrich says. "There are several different solutions, but an industry standard has yet to be set. That's the missing link—for now." ■

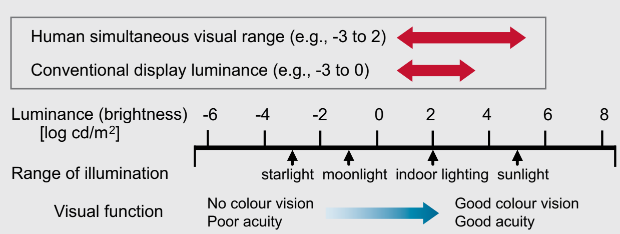
LCD and Plasma Flat Screen TVs—A Visual Display Primer

Today's state-of-the-art flat-screen technology is currently divided into two camps. In liquid crystal diode (LCD) displays, liquid crystal filled pixels are sandwiched between two glass plates. This LCD panel sits on top of a constant white light source. Each pixel contains a red, green and blue sub-pixel. Thin film transistors on the surface material apply an electric current to the liquid crystals, which polarizes the crystals and makes them twist. This twisting blocks light. Depending on the type of sub-pixel, a different part of the white light spectrum will be filtered out to achieve the desired colour. Each transistor is programmed for how much light its red, green and blue sub-pixels transmit, and this produces the brightness and variation of colour.

Plasma display panels, also used in flat panel TVs, contain hundreds of thousands of cells holding an inert mixture of gases (neon and xenon) that turn into plasma, which in turn excites different-coloured phosphors to emit light. The cells, or pixels, act like microscopic fluorescent light bulbs as the light illuminates red, green or blue phosphors in each cell.

Until recently, plasma displays were considered to have superior contrast, colour and resolution. With improvements in LCD technology, such as lower weight, falling prices, lower power consumption, and higher resolution, it has become the most common and diverse electronic flat screen technology in use today. In the next five years, HDR is poised to be the next major display innovation on the market.

Real World Luminance Range and Human Capabilities



Quelling Evolutionary Controversy

Sunflowers Shed Light on Origins of Species

Ever since Darwin, biologists have disputed what defines a species. UBC evolutionary biologist Loren Rieseberg integrates evolutionary theory, high-throughput genomics, bioinformatics, and ecological experimentation to shed new light on the origin and evolution of plant species.

Every high school biology student has had to memorize the different taxonomic groups that make up the scientific classification of plants and animals—kingdom, phylum, class, order, family, genus, species. But the question of what constitutes a species—the smallest or most basic unit in the hierarchy—has been a conundrum for biologists ever since Darwin returned from the Galapagos.

In the 1930s and '40s, scientists espoused the biological species concept, where all individuals or populations that interbreed with each other belong to one species (see sidebar). However, botanists remained sceptical as to whether this concept was applicable to plant species, where some asexual reproduction and hybridization is common.

In a series of papers published in *Science* and *Nature*, UBC botanist and Canada Research Chair in Plant Evolutionary Genomics Loren Rieseberg posits answers to the multifaceted "species question."

"No one had done a statistical analysis of how plant species really compare to animal species in terms of representing reproductive units," says Rieseberg, who is also a member of UBC's Biodiversity Research Centre. In a meta-analysis published in *Nature* in 2006, he screened scientific literature that analyzed over 1,000 species of plants and animals. "The question we asked was whether these papers found distinct phenotypic groups of plants that also represent reproductive species," he says. (A phenotype refers to the physical appearance and molecular structure of an organism resulting from both genetic and environmental influences.)

Their meta-analysis indicated that 70 percent of taxonomic species and 75 percent of phenotypic clusters in plants correspond to reproductively independent lineages, and therefore represent biologically separate entities. "We showed that in plants, these discrete morphological categories do correspond to reproductive ones, and that the degree of correspondence was better than in a good number of animal groups," Rieseberg says.

Gene Flow and Advantageous Alleles

Another plant-specific problem is how the degree of gene flow, or migration of genetic information from one population to another, affects the evolution of species. Mobility is the primary factor influencing the rate of gene flow among populations. Animals and insects have plenty of gene flow because they tend to move around and mate with different populations. In plants, however, mobility is limited to seed and pollen dispersal.

Gene flow prevents the origin of new species (speciation) by combining the gene pools of different populations, thereby homogenizing genetic variation. "If you have enough gene flow between populations, you keep them from differentiating," explains Rieseberg. "Botanists were sceptical that there was enough gene flow among populations of plant species across a geographic range for the species to remain one reproductive unit."

With the introduction of molecular biology in the 1970s and '80s, and the use of molecular markers, however, biologists found dispersal strategies in plants that hadn't been recognized through direct observation, providing evidence that there was more gene flow among plants than previously thought. Even so, only about half of all plant species had enough gene flow to hold their species together.

"Only in the last decade or so have we been able to measure the amount of selection on genes across the genome," states Rieseberg. "Natural selection has played a far larger role in shaping the genome than we ever imagined."

Researchers have found that if an allele, or mutation, provides an advantage to a population, it spreads like wildfire, despite low gene flow. (An allele is an alternate version of a gene occupying a specific location on a chromosome. Alleles control morphological differences such as flower colour and petal shape.)

"Since we see so much selection in the genome, the amount of migration doesn't matter as much," explains Rieseberg. "What holds low gene flow species together is this subset of genes under positive selection."

He admits there is still much more to be understood, such as the role habitat and geography play in the spread of favourable mutations. "The question we are asking now is: In how many cases does a positively

Evolution and the Species Concepts

Evolution refers to the change in the inherited traits of a population over time. These traits are the expression of genes that are copied and passed on to offspring from generation to generation. Genetic mutations can produce new or altered traits, resulting in heritable differences between organisms. New traits can also come from transfer of genes between populations, or species. Evolution occurs when these heritable differences become more common or rare in a population, either non-randomly through natural selection or randomly through genetic drift.

Natural selection was introduced in 1859 by Charles Darwin in *On the Origin of Species*. Today, natural selection refers to the tendency of an allele, or variant of a gene, to become more or less common in a population as a result of its effect on reproduction. Genetic drift is the statistical effect that results from the influence that chance has on the survival of alleles.

A species is often defined as a group of organisms capable of interbreeding and producing fertile offspring. This definition—the biological species concept—was proposed in the 1930s, countering the taxonomic or hierarchal definitions proposed by Linnaeus in the 18th century. Today, biologists use genomics, bioinformatics and ecological experimentation to determine the classification of a species.

selected allele or mutation spread across the entire geographic range of the species? This is really what is required to hold the species together."

One example Rieseberg's lab has found of this type of a positively selected mutation is a gene for copper tolerance, which, for reasons yet unknown, is spread across all populations of the common sunflower.

Their work suggests that positive selection can have two effects. When sweeps are across entire species, positive selection can help hold a species together. If the sweeps are across local populations only, positive selection might create a new species.

"It all depends upon where the alleles stop spreading, so understanding the geography of these selective sweeps is an important topic of research," Rieseberg states.

Stalking the Wild Sunflower

The common, biologically accommodating sunflower is the model plant Rieseberg has been using in field studies and ecological experimentation. An early model for studies of plant hybridization, the sunflower genus *Helianthus* has been the subject of numerous experiments to test the strength of the reproductive barriers that isolate the species. The sunflower is also the only major crop that was first domesticated in North America—a hypothesis that Rieseberg confirmed using molecular markers and the characterization of domestication genes.

There are many practical reasons for studying sunflowers, Rieseberg notes. Domesticated sunflower is a major oilseed crop. Investigating the wild relatives of economically important plants provides the fundamental knowledge that will help understand mechanisms and inspire possibilities for breeding or improving crop species. Work on domesticated species also provides botanists with a wide array of genetic and genomic tools for studying other plants.

Rieseberg has been collaborating with American colleagues to develop genomic resources and tools for the sunflower family (Compositae). It is the largest family of flowering plants and includes lettuce,

Wild (l.) and domesticated (r.) sunflowers are ideal model plants for Rieseberg's speciation studies.

Photos: Jason Rick

thistles, dandelions, asters, daisies, and artichokes.

Hybridization—An Evolutionary Process

Controversy about the role of interbreeding among and between species has led to conflicting views about hybridization among botanists and zoologists. Zoologists often see it as a negative evolutionary force that leads to the production of sterile or inviable hybrids—and perhaps even species mergers—if reproductive barriers are weak.

Botanists, on the other hand, see hybridization as an important part of the evolutionary process. Some botanists, for example, suggest that hybridization might be nature's way of allowing a species to adapt more quickly to new or changing habitats. Rieseberg's data suggest that several large-scale ecological transitions in the sunflower took place in less than 60 generations—a mere blink in evolutionary time.

Hybridization may also lead to the formation of new species, Rieseberg explains in a recent review in *Science* in 2007. Hybrid speciation is more common in plants than animals because in plant hybrids fertility is often restored by polyploidy—when the chromosomes of the hybrid plant are duplicated. This allows proper pairing among chromosomes and also creates a barrier to reproduction between the new hybrid species and its parental species.

Rieseberg has shown that sometimes new hybrid species can form without the duplication of chromosomes that underpins polyploid hybrid speciation. This alternative form—called homoploid hybrid speciation—occurs less frequently because there is no instantaneous means by which a new homoploid hybrid species can become both fertile and reproductively isolated from its parental species. Although once thought to be restricted to plants, several examples of animal homoploid hybrid species have recently been documented.

Rieseberg has studied homoploid hybrid speciation in both the laboratory and greenhouse. By recreating the birth of three ancient hybrid sunflower species, Rieseberg was able to show that the process was more repeatable and deterministic than previously thought. This work confirmed that one of the key features is massive chromosomal rearrangement, which helps to produce reproductive isolation. Another key feature is very strong ecological selection. The three recreated hybrid sunflower species possessed traits that were strongly favoured in new habitats—sand dune, desert floor or salt marsh. Rieseberg's research thus confirms a view championed by UBC zoology professor Dolph Schluter—that speciation may frequently be driven by ecological selection.

"By analyzing the genomes of the three hybrid species, we were able to illustrate that it was the combination of genes from the parental species that allowed the new species to adapt to novel habitats," explains Rieseberg. "This was an important result because it showed that, in sunflowers at least, hybridization did play a creative role in evolution." ■

Identifying Patterns in Randomness

Pictorial Clues Help Prove Mathematical Theorems

When we think of mathematics, abstract numbers and equations come to mind. Yet for mathematicians like Alexander Holroyd, pictures play an increasingly important role. He uses visual tools to help prove exceedingly difficult theorems underlying mathematical models.

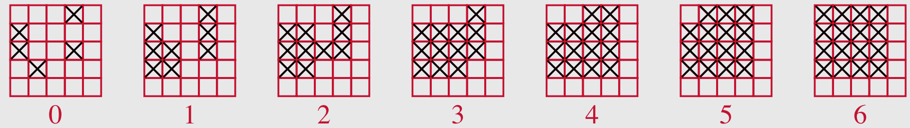
People have always been fascinated with probability. A roll of the dice, the toss of a coin—games of chance in one form or another have been around for millennia. Today, in almost every research field, scientists are interested in the likelihood of events occurring, and in developing models to study them. UBC mathematician Alexander Holroyd is interested in proving, beyond a doubt, some of the astonishing behaviour that probabilistic models exhibit.

One of the most fascinating things about probability theory is the nature of random events. When enough random events are considered together, mathematicians can identify order, or patterns, in the randomness. And these patterns can be studied and predicted.

"Take a large system of interacting random objects, with perhaps very simple rules about how they interact," says Holroyd. "We try to understand how global behaviour arises from these local interactions."

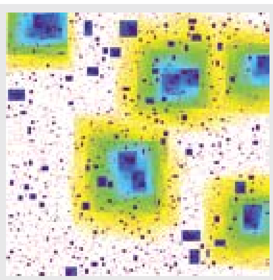
Bootstrap Percolation and Nearest Neighbour Infection

With flu season upon us, the concept of infection takes on a very specific meaning. However, for probability theorists like Holroyd, infection refers to a conceptual model of how certain objects can interact. Cellular automaton models have numerous applications in physics, biology and information technology. Every cell in a model has the same rule for updating, based on the states of other cells in its neighbourhood. Different rules lead to different models. One such model that Holroyd is studying is called bootstrap percolation, which has been applied to physical problems such as computer storage arrays and crack formation. "Bootstrap percolation is a very simple model for spread of infection. Consider a square grid of cells, each of which can be healthy or infected. Initially, infected cells are distributed at random. These cells stay infected forever. A healthy cell becomes infected if it has at least two adjacent infected neighbours, either to the north, south, east, or west," he explains. The concept is easy to see on a 5×5 grid (see figure above).



Bootstrap percolation on a 5×5 grid at time steps 0 to 6. Infected cells are shown by Xs.

The intriguing behaviour of bootstrap percolation becomes evident when two key parameters—grid size and probability of a cell being initially infected—are varied. The results provide insight into concepts such as phase transition and nucleation. When the grid is large, a small change in the probability of initial infection has a dramatic effect on the behaviour. For example, on a 300×300 grid, with 4 percent of cells initially infected, the infection typically remains localized to a few cells. At 5 percent, all cells typically become infected (see below).



The colours indicate time of infection: red (initial), black (earliest) to dark blue, light blue, green, and yellow (latest).

The question Holroyd has been studying is: What determines whether the entire square eventually becomes infected? Mathematicians had known for some time the answer to that question depends on the size of the grid "*L*" and the proportion "*p*" of cells initially infected, but they had not been able to identify the exact nature of the transition. The closest they came was in 1989, with a theorem that, in the limit for large grids, the transition occurred for *p* somewhere between two constants each divided by the logarithm of size of the grid (i.e., between $c1/\log L$ and $c2/\log L$).

"Everyone believed that the transition in fact took place at $c/\log L$ for a single constant *c*, but no one had been able to prove it," says Holroyd. Computer simulations suggested that this constant's value would be $c=0.245$ plus or minus 0.015."

In 2003, Holroyd proved the theorem that the transition occurs at exactly $c/\log L$ with $c=\pi^2/18=0.548311\ldots$, more than twice the value predicted by simulations. Thus, pure mathematics proved what computer simulations could not. The discrepancy, he explains, occurs because convergence to the limiting threshold *c* is extremely slow. One would need to simulate a grid the size of at least $10^{20}\times10^{20}$ cells to observe a transition close to this limiting value. What triggered Holroyd's insight was his observations of grid simulations over time and understanding the mechanism behind the nucleation centres that led to the entire grid becoming infected.

"I had been working on this problem for some time and was stuck. Then I went on a hiking trip and suddenly realized how to prove it." Like many creative or scientific insights, Holroyd's epiphany on bootstrap percolation needed time to percolate.

Self-Organizing Traffic

The Biham-Middleton-Levine Traffic Model, apparently inspired by rush-hour traffic in Tel Aviv, is another cellular automaton model that Holroyd is analyzing. The model is again built on a square grid representing one-way streets, where traffic flows either north or east and cars move at one-step intervals along the grid. Intersections are either occupied or empty, and all traffic lights operate in phase. In the first step of the model, all cars facing north try to move up one space. Some can move and some are blocked. In the second step, all east-facing cars similarly try to move.

When cars are scattered randomly across a 200 × 200 grid at an initial density of 10 percent, after roughly 20,000 steps, traffic is freely flowing with no cars ever having to wait. Amazingly, with 30 percent density, the cars eventually line up so that traffic is again freely flowing. The image (right) shows diagonal bands of blue and red cars that all manage to avoid each other. (Anyone who has been to Rome will have experienced a similar phenomenon.)

"This is a wonderful example of self-organization," says Holroyd. "Without any external influence and with nearly one-third of the intersections full, the cars manage to align into one of the few configurations that would enable them to flow freely."

Not surprisingly, at 80 percent density, all cars quickly become jammed. However, even at only 34 percent, all cars become completely stuck in traffic. Until quite recently, it was believed that there was a sharp transition, somewhere around 30 to 33 percent, between freely flowing and completely jammed behaviour. But more recent simulation studies suggest the existence of further intermediate behaviour. For example, the picture at 32 percent shows remarkable semi-regular geometric patterns of jams feeding into each other, so all cars move some of the time and wait some of the time.

An example of both phase transition and self-organization, this traffic model is very interesting both to mathematicians and to other scientists, but rigorous mathematical progress has so far been very difficult. "It is fascinating because you start with complete randomness, and you end up with something that is very structured," states Holroyd, who was involved in proving that the cars get jammed at high density. "It seems ridiculous that there is all this amazing behaviour, but so far all we can prove is the simplest thing."

The Stunning Geometry of Random Sorting Networks

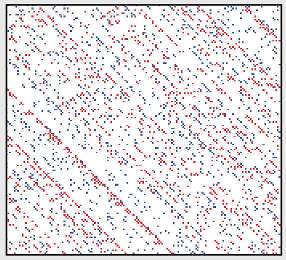
Sorting networks are of interest to mathematicians because of their elegant structure, and have potential applications in database sorting and access, secrecy and cryptography. A sorting network is a way of reversing the order of a list of items, using the minimum number of nearest neighbour swaps. For example, to get four items in reverse order by exchanging neighbouring pairs one at a time requires six swaps.

"One question you could ask is: What does a typical sorting network look like? Interesting things happen when you increase the number of items, say up to 2,000," Holroyd explains.

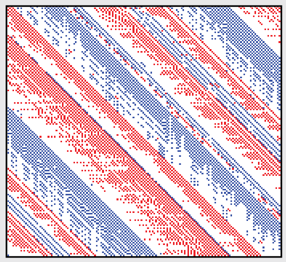
When the four items or objects are followed over time, you get trajectories that resemble routes on a subway sign; with 2,000 items, the trajectories form sweeping curves that resemble the twisted fibres in twine. Different viewpoints, such as a graph of the positions of the items, show other amazing geometrical patterns: a circle, ellipse or 45-degree line, depending on the time frame (see simulations at www.math.ubc.ca/~holroyd/sort/).

Working with other mathematicians in Toronto and Israel, Holroyd has succeeded in proving some of these properties, and is working on the others. "We believe that the key is to understand the geometry of sorting networks as paths in a high-dimensional sphere," says Holroyd.

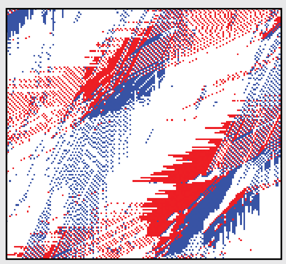
Although Holroyd's research is pure mathematics, the area of probability theory has applications in almost every scientific discipline. Holroyd will be taking leave for a term to work with Microsoft's Theory Group in Seattle. "The math group there undertakes pure research with a slant to applications in computer science," Holroyd says. "Along with UBC, it is one of the best places in the world to work on probability theory." ■



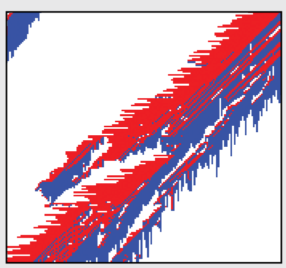
Density: 10% cars



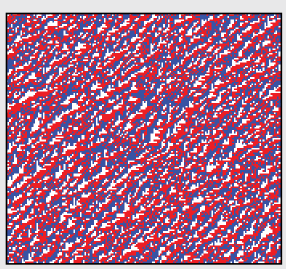
Density: 30% cars



Density: 32% cars



Density: 34% cars



Density: 80% cars

Self-organizing traffic: *traffic model after 20,000 steps.*

Biodiversity and Ecosystem Function

An Interdependent Dance Among Species


Photo: Martin Dee

UBC ecologist Diane Srivastava is studying the dynamic interdependence of species and ecosystems. Her work tackles both sides of the biodiversity question: how biodiversity affects ecosystem function, and how habitat loss affects biodiversity.

The famous line in Joni Mitchell's song *Big Yellow Taxi*, "You don't know what you've got till it's gone," is an apt refrain for ecologists, biodiversity researchers and anyone who cares about the future of this planet. The rate at which species are going extinct is currently higher than at any other time in the past, yet the health of ecosystems—and of the planet—depends upon the abundance of species all along the food chain, which in turn depends upon healthy habitats. What happens when a link is broken somewhere along the chain?

Diane Srivastava's research is helping to determine both the effect of species loss on ecosystems and of habitat loss on biodiversity. "Think of an ecosystem as an engine that is producing oxygen and the plant and animal biomass that we harvest for our own needs. It also works to break down dead material and improve soil fertility," explains Srivastava, a member of UBC's Biodiversity Research Centre. When one part of the engine breaks down, the ecosystem doesn't function properly, ultimately affecting species and habitats (see sidebar).

Species Loss and Ecosystem Function

Biologists have pondered the environmental effects of species loss for decades, but it has only been since the 1990s that researchers have focused on the importance of species diversity in regulating the flux and flow of energy and matter essential for ecosystem survival. While seminal studies suggested that species loss does negatively affect ecosystem functions, early work was controversial and deemed idiosyncratic by critics. After more than a decade of research, a significant number of studies emerged to allow Srivastava and a group of colleagues from across North America to perform a rigorous meta-analysis of the combined data. The group analyzed the results of 111 studies, involving field, greenhouse and laboratory experiments for a wide variety of organisms and ecosystems in which the diversity of species was manipulated. The data were summarized by trophic group—or where a species is in the food chain. Producers, such as plants and algae, constitute the first group, followed by herbivores, predators, and detritivores (animals and insects that consume decomposing organic matter).

Their discovery, published in *Nature* in 2006, confirmed that species loss results in reduced ecosystem function. Most significantly, they found that it didn't matter if the species studied were aquatic or terrestrial, animal or plant, predator or prey, or where they were on the food chain—the effect held true for all systems and species.

"The most important thing to come out of this meta-analysis is that, overall, as we lose species in an ecosystem, the system doesn't function as well as it should," Srivastava says. "Rates of biomass and oxygen production slow down. Rates of decomposition slow down, and energy passes more slowly between trophic levels."

In turn, they found that a higher number of different species positively affects the standing stocks of all four trophic groups, increasing biomass and abundance. In a grassland, for example, the more diverse the community, the faster plants grow and move nutrients through the food web. Biologists view this fast production of biomass as a good thing, much like high turnover for a restaurateur.

Srivastava and colleagues also analyzed the roles of individual species in ecosystem functions. Their meta-analysis has shown that although some loss of ecosystem function could be attributed to losing a single best species, loss of interactions between species is also important. Different functions might require more than one species. "In a forest, we might be interested in its timber value, on how good it is at taking up greenhouse gases or preventing soil erosion," she says. "Each of those functions might require different key species, and it is often not evident what those key species are."

Their work supports both sides of a current biodiversity debate, in that ecosystem function is affected by both the loss of a dominant species and by having fewer species in the system. In a subsequent analysis, recently published in the *Proceedings for the National Academy of Science*, Srivastava and colleagues have shown that, at most, a single key species could only account for half of the diversity function effect in ecosystems. The balance of function disruption is due to interactions between species.

Biodiversity—Why Does It Matter?

Change the word "spice" to "essence," and the old adage—variety is the essence of life—states just why biodiversity is so essential to the health of all living organisms and ecosystems on Earth.

Biodiversity refers to the variety and abundance of all life—the range of genes, species and ecosystems that are all interconnected in one global system. The health of species, ecosystems and the entire planet depends upon the variety of living organisms and their interactions with each other in ecosystems and across landscapes.

All ecosystems—whether a pond, a desert or a forest—function by using energy to produce biomass (animals and plants), ultimately decomposing and recycling dead material in the process of renewal and production. Energy transformation and biochemical cycling are the main processes that define ecosystem function. The rates of transformation and cycling determine an ecosystem's health or productivity.

When biodiversity is lost, the rates of production and decomposition slow down, in turn threatening the health of all species in the system. The greatest cause of biodiversity loss on Earth is human activity.

Probing bromeliads' miniature ecosystems: *damselfly larvae (right, top) prey on other insect larvae, returning essential nutrients to the plant.*

"It is the way that all species work together and do slightly different things that gives better overall performance in production and decomposition. Saving a key species is important, but it is not enough," Srivastava states.

Predator, Prey and Host Co-dependence

Biologists have discovered many examples of two species interacting to increase each others' chances for survival. Deep in the Costa Rican rainforests, Srivastava and PhD student Jacqueline Ngai discovered a rare example of co-operation among several species.

Bromeliads are rainforest plants with tightly interlocking leaves—forming a vessel-like structure that collects water. These plants grow on trees, anchoring their roots to the trunks. As they are not rooted in soil, the bromeliads must obtain nutrients such as nitrogen from dead tree leaves that fall into their self-made 'ponds'—which also act as miniature ecosystems for over 60 species of aquatic insects (see image above).

Srivastava and Ngai initially hypothesized that the insects assist the bromeliads to obtain nitrogen from the fallen leaves decomposing in their vessels. They found that this was, in fact, the case—bromeliads absorbed over ten times more nitrogen in the presence of insects. Surprisingly, however, this mutual facilitation between insects and bromeliads depended upon the presence of one key insect—the damselfly. The other insect species need nitrogen to fuel their rapid growth. The damselfly larvae, which develop more slowly, stop the export of nitrogen from the plants by eating the other insect larvae and returning the nitrogen to the bromeliads through excretion (nitrogen from feces is absorbed through specialized structures on bromeliad leaves).

Ngai's and Srivastava's findings—that insects facilitate nutrient uptake by bromeliads, but only if detritivores and predators are both present—were published in *Science* in 2006. "The importance of predators in this process was a complete surprise to us," says Srivastava.

This discovery is particularly significant given that under anthropogenic pressures ecosystems are predicted to lose disproportionately more predators than any other group of species. Srivastava's research on the mechanisms of bromeliad ecosystems, where predators drive important ecosystem processes, can provide valuable insight into the effects of human activities on natural systems.

In many parts of Canada, for example, the losses of habitat for large predators such as wolves and bears, and changes in human activity such as hunting for big game rather than for food, have resulted in an explosion of elk and deer populations. In Banff National Park, the loss of wolves has resulted in more elk, which in turn have overgrazed aspen in the area. "This is a good example of a trophic cascade, where you pull off one trophic level on the top—in this case predators—and the one immediately below explodes, causing stress on species further down the tropic chain."

Of Mites and Moss

Humans, Srivastava notes, are in a trophic category of mammalian predators all our own. Human activity has radically altered landscapes in terms of habitat loss, fragmentation and disturbance. Srivastava and colleague Brian Starzomski have studied another miniature ecosystem in coastal British Columbia to ask the other side of the biodiversity question: What are the effects of habitat loss on species?

In a recent study, they created miniature moss landscapes differing in size and shape. Local patches in each landscape were subjected to simulated drought disturbances, similar to natural drought cycles in moss habitat on coastal BC. They then studied the effects of this manipulation upon microarthropod (mite) communities, observing the effects of isolation (how close patches are to each other) and connectivity (how easily individual mites can move between patches). They discovered that when moss landscapes were fairly intact, mite populations could recover relatively quickly from drought. However, as landscapes were progressively fragmented, a threshold was passed where the mites were unable to recover and went locally extinct.

"Ecosystems today are facing multiple stressors, and sometimes it is not one stressor in particular that is important, but a combination of stressors," Srivastava explains. "In order to understand the effect of habitat disturbance or loss on species, we need to understand the effects of multiple stressors working together." ■

Faculty of Science: Kudos

Martin Barlow, Prof., Mathematics
- Jeffery-Williams Prize 2008, Canadian Mathematical Society

David Brydges, Prof., Mathematics, and CRC in Mathematical Physics
- Elected Fellow, Royal Society of Canada

Andrea Damascelli, Asst. Prof., Physics & Astronomy, and CRC in Electronic Structure of Solids
- Sloan Research Fellowship, Alfred P. Sloan Foundation

Donald Douglas, Prof., Chemistry
- Elected Fellow, Royal Society of Canada

Brett Finlay, Prof., Michael Smith Labs and Microbiology & Immunology
- Order of British Columbia, Lieutenant-Governor of BC

Nassif Ghoussoub, Prof., Mathematics
- Jeffery-Williams Prize 2007, Canadian Mathematical Society

Mark Halpern, Prof., Physics & Astronomy
- Group Achievement Award, NASA

Robert Hancock, Prof., Microbiology & Immunology, and CRC in Pathogenomics and Antimicrobials
- Killam Prize, Canada Council for the Arts

Carl Hansen, Asst. Prof., Physics & Astronomy
- Career Investigator Award (biomedical scholar), Michael Smith Foundation for Health Research

Grant Ingram, Prof., Earth & Ocean Sciences, deceased (see p. 16)
- Fellow, Canadian Meteorological and Oceanographic Society
- Fellow, Oceanography Society

Brian James, Prof. Em., Chemistry
- Paul N. Rylander Award, Organic Reactions Catalysis Society

Reinhard Jetter, Assoc. Prof., Botany and Chemistry
- Arthur Neish Young Investigator Award, Phytochemical Society of North America

Izabella Laba, Prof., Mathematics
- Krieger-Nelson Prize, Canadian Mathematical Society

Donald Ludwig, Prof. Em., Mathematics
- Foreign Honorary Member, American Academy of Arts and Sciences

Jaymie Matthews, Assoc. Prof., Physics & Astronomy
- Order of Canada, Governor General of Canada

Daniel Pauly, Prof., Zoology, and Dir., UBC Fisheries Centre
- ECI Prize 2007, International Ecology Institute

Edward Perkins, Prof., Mathematics, and CRC in Probability
- Elected Fellow, Royal Society of London
- National Killam Research Fellowship, Canada Council for the Arts

Rachel Pottinger, Asst. Prof., Computer Science
- Denice Denton Emerging Leaders Award, Anita Borg Institute for Women and Technology

Angela Roskams, Assoc. Prof., Zoology
- Career Investigator Award (biomedical senior scholar), Michael Smith Foundation for Health Research

George Sawatzky, Prof., Physics & Astronomy, and CRC in Physics and Chemistry of Nanostructural Materials
- Henry Marshall Tory Medal, Royal Society of Canada

Laurel Schafer, Assoc. Prof., Chemistry
- Sloan Research Fellowship, Alfred P. Sloan Foundation

Ruth Signorell, Assoc. Prof., Chemistry
- Sloan Research Fellowship, Alfred P. Sloan Foundation

Vesna Sossi, Prof., Physics & Astronomy
- Career Investigator Award (clinical senior scholar), Michael Smith Foundation for Health Research

Roland Stull, Prof., Earth & Ocean Sciences
- Fellow, Canadian Meteorological and Oceanographic Society

Richard Tosdal, Dir., UBC Mineral Deposit Research Unit (MDRU)
- Leo Derikx Synergy Award for Innovation (awarded to MDRU), NSERC

Bill Unruh, Prof., Physics & Astronomy
- Honorary Doctor of Science, McMaster University

Vinayak Vatsal, Prof., Mathematics
- Coxeter-James Prize, Canadian Mathematical Society

Carl Walters, Prof., Zoology
- Timothy R. Parsons Medal, Fisheries and Oceans Canada

Carl Wieman, Dir., UBC Carl Wieman Science Education Initiative, and Prof., Physics & Astronomy
- Oersted Medal, American Association of Physics Teachers

Supporting Math's Brightest—The John Collison Memorial Scholarship

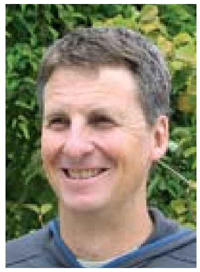
The John Collison Memorial Scholarship in Mathematics has been awarded to ten senior undergraduate students since its inaugural year 2006. "I value the opportunity to take risks and challenge myself in my undergraduate years," says Andrew Wilson (photo), one of the 2007 recipients. Friends and colleagues remember John Collison—UBC mathematics graduate, successful publisher, and loyal friend with a passion for flying. To pay tribute to his accomplishments and love

for solving complex problems, the Madison Group donated $100,000 to endow the Collison scholarship. This annual award supports outstanding Honours Mathematics students at UBC with an interest in physics or engineering, aeronautics and varsity sports. "It's wonderful to be acknowledged for pursuing mathematics and physics in addition to music, writing and athletics, especially since the connections between these fields are often overlooked," says Wilson.

New Masterminds: Brain Gains at Science


Chau


Goheen


Hickey


Tanaka


Schoof


Sigurdson

The Faculty of Science welcomes our new faculty members.

Albert Chau, Asst. Prof., Dept. of Mathematics; BSc Mathematics, Queen's University, Kingston, Ontario, Canada; PhD Mathematics, Columbia University, New York, NY, US. Prior appointment: Asst. Prof., University of Waterloo, ON, Canada. Research: I study partial differential equations and differential geometry. I am particularly interested in the application of geometric evolution equations, which provide powerful analytic tools used to deform the shape of abstract space. www.math.ubc.ca

Jacob R. Goheen, Asst. Prof., Dept. of Zoology; BSc Wildlife Biology, Kansas State University, Manhattan, KS, US; MSc Wildlife Science, Purdue University, West Lafayette, IN, US; PhD Biology, University of New Mexico, Albuquerque, US. Prior appointment: Post-doctoral Assistant, Dept. of Zoology, University of Florida, Gainesville, FL, US. Research: I am interested in the community and population ecology of animals. Specific research topics include animal–plant interactions, assembly of ecological communities, and the impacts of human activities on native communities and populations. www.zoology.ubc.ca/~goheen

Kenneth A. Hickey, Asst. Prof., Dept. of Earth & Ocean Sciences; BSc Geology and Zoology, Auckland University, Auckland, New Zealand; MSc Structural Geology, Auckland University, Auckland, New Zealand; PhD Structural-Metamorphic Geology, James Cook University, Townsville, Australia. Prior appointment: Research Associate, Mineral Deposit Research Unit, Dept. of Earth & Ocean Sciences, UBC. Research: My main research interest is flow of hot metalliferous fluids and the genesis of hydrothermal mineral deposits in the earth's crust. Sensitive mineral thermometers help track the paleothermal signature of fluid flow and better define vectors toward economic concentrations of metals. www.eos.ubc.ca/about/faculty/K.Hickey.html

Hirohisa A. Tanaka, Asst. Prof., Dept. of Physics & Astronomy, and Research Scientist, Institute of Particle Physics; AB Physics and Mathematics, Harvard University, Cambridge, MA, US; PhD Physics, Stanford University, Stanford, CA, US. Prior appointment: Research Scholar, Princeton University, NJ, US. Research: I am currently researching the properties of the neutrino, the most abundant, yet possibly least understood, fundamental particle in the universe. The properties of the neutrino may hold clues to how the universe evolved to its current state from the Big Bang. www.phas.ubc.ca/~tanaka

Christian Schoof, Asst. Prof., Dept. of Earth & Ocean Sciences, and Canada Research Chair in Global Process Modelling; MSc Physics and PhD Applied Mathematics, Oxford University, Oxford, UK. Prior appointment: Research Associate, Dept. of Earth & Ocean Sciences, UBC. Research: Future sea level change hinges on the behaviour of the ice sheets in Greenland and Antarctica. My research aims to improve models for ice sheet dynamics through the use of mathematics, focusing on their complex flow behaviour. www.eos.ubc.ca/about/faculty/C.Schoof.html

Kris R. Sigurdson, Asst. Prof., Dept. of Physics & Astronomy; BASc Engineering Physics, Simon Fraser University, Burnaby, BC, Canada; CASM Theoretical Physics, University of Cambridge, UK; PhD Physics, California Institute of Technology, Pasadena, CA, US. Prior appointment: Member and Hubble Fellow, Institute for Advanced Study, Princeton, NJ, US. Research: I study the universe's past, evolution and future. In particular, I build and test theoretical models of dark matter, dark energy and the early universe, and develop new observational probes of the universe. www.physics.ubc.ca/~krs

The Carl Wieman Science Education Initiative appointed four Science Teaching and Learning Fellows this summer: Brett Gilley and Francis Jones, Earth & Ocean Sciences; Tamara Kelly, Life Sciences (Zoology); and Beth Simon, Computer Science. These fellows support the department's implementation of evidence-based education improvements. Sharing expertise in both disciplinary knowledge and science education methodology, they help introduce faculty members to new teaching and assessment tools. www.cwsei.ubc.ca

Mathematics professor Rachel Kuske was appointed **Head of the Department of Mathematics**, July 1, 2007. www.math.ubc.ca

Computer Science professor Anne Condon was appointed **Associate Dean, Faculty Affairs and Strategic Initiatives**, July 1, 2007. www.science.ubc.ca

Chemistry professor David H. Farrar was appointed **UBC Provost and Vice-President Academic** this September. BSc and MSc, Chemistry, University of Toronto, ON, Canada; PhD Chemistry, University of Western Ontario, London, ON, Canada; Prior appointment: Deputy Provost and Vice-Provost Students, University of Toronto. Farrar has received numerous research awards and has generated five patents. www.vpacademic.ubc.ca

Portrait: The Department of Zoology

Since the first course in elementary zoology was offered at UBC in 1917, Zoology has grown to become the fourth largest department in the Faculty of Science. It now has 42 professors (including 11 cross-appointments), eight instructors, nine lecturers, 39 post-doctoral fellows and research associates, 20 associate and adjunct members, and 140 graduate students. Through the Biology Program, approximately 1,600 to 1,700 Science undergraduate students are taught by Zoology faculty members every year, jointly with Botany and Microbiology & Immunology; with close to 400 students majoring per year.

Our master's and PhD students are primarily registered in the Zoology graduate program, but we also participate in the Neuroscience, the Genetics and the Cell and Developmental Biology graduate programs. Prestigious awards won by our graduate students and post-doctoral fellows include the Dobzhansky Prize (International Society for the Study of Evolution), the Canadian Council of University Biology Chairs Prize, Michael Smith Foundation for Health Research Fellowhips, and the NSERC Howard Alper Award for the top post-doctoral research fellow in Canada.

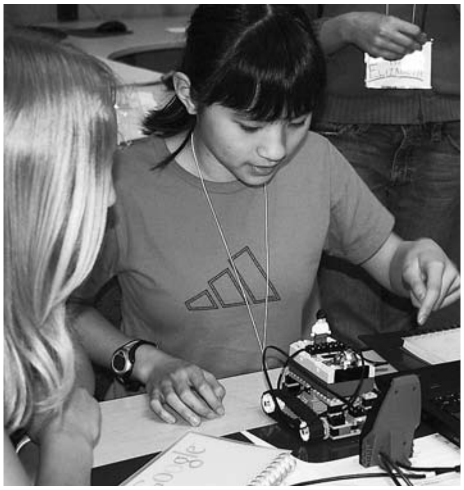
Zoology focuses research in four areas: ecology and conservation biology, evolutionary biology, comparative physiology, and cell and developmental biology. Our researchers explore fundamental mechanisms on the molecular and cellular level, processes within and among whole organisms, and their interactions with the environment. While our scientists use modern approaches to gain deeper insights into biological processes such as how cells develop and communicate with each other, and how new species arise, we also conduct research that addresses pressing 21st-century questions such as What has gone wrong in cancerous cells and how can we prevent or cure this? What are the physiological determinants of a species range? How should our fisheries be managed? What are the consequences of biodiversity loss? How will climate change impact the biosphere?

Our researchers collaborate in cross-campus and national networks such as the Biodiversity Research Centre, Fisheries Centre, Life Sciences Institute, Biomedical Research Centre, ICORD: International Collaboration on Repair Discoveries, Brain Research Centre, Michael Smith Laboratories, Canadian Institute for Advanced Research, Stem Cell Network, and BC Cancer Agency.

Among the many awards earned by our faculty members for their research excellence, the most prestigious include the Japan Prize (Science and Technology Foundation of Japan), the International Cosmos Prize (Expo'90 Foundation, Japan), Elected Fellow of the Royal Society, London (two), Member of the Order of Canada (three), and Elected Fellow of the Royal Society, Canada (fourteen).

Zoology's community outreach involvement includes Shad Valley, a summer enrichment program for senior secondary students; Let's Talk Science, which partners elementary and high school teachers with graduate student volunteers; the BC Biology Instructors Program, an annual meeting to discuss post-secondary teaching and curriculum; science fairs and scientists-in-the-schools programs; and more. The Department of Zoology has a long history of research and teaching excellence coexisting with an atmosphere of remarkable collegiality and co-operation across and beyond disciplines, ranks and community boundaries. www.zoology.ubc.ca

Connecting Women and Girls With Computing—The Jade Project



GirlSmarts is a day-long computer science workshop for grade six girls—increasing awareness and computing fun for girls and young women. (Photo: Gayle Mavor)

"I've been hooked on computer science (CS) since taking my first programming class in college," says Anne Condon, who holds the NSERC/GM Chair for Women in Science and Engineering at UBC. As a CS professor, however, Condon is concerned that many students—particularly female students—stay away from math- and technology-related fields. "They don't readily perceive the vast opportunities a CS training provides in disciplines such as health sciences or the arts—and for making a difference in our world."

It is no surprise, then, that Condon was instrumental in establishing Jade, an initiative to increase the representation and success of women in physical and mathematical sciences and in engineering. Jade has spawned several projects promoting awareness and computing fun for female students at all ages. Connecting with Computer Science is an introductory CS course, cross-listed with UBC Women's Studies. Students learn about fundamental concepts in CS and their relevance to the visual arts, linguistics and biology. Examples of women and men, who have developed exciting applications, also encourage undergrads to major in CS or combine CS with another discipline.

Other projects include GirlSmarts, a CS workshop for grade six girls and a rewarding opportunity in teaching and outreach for our CS graduate students; the Canadian Distributed Mentor Project, which supports research experiences for undergraduate women in CS and related fields; and the Jade Bridges Program, which funds a network of leaders who help increase the participation of women in the physical sciences and engineering across BC and the Yukon. www.jadeproject.ca

Co-op Programs—Tapping Into Science Talent

Wondering how an honours pharmacology student like Shane Lloyd, who earned his BSc from UBC this year, would—and could—go on to fulfill his dream of doing space flight–relevant biomedical research? He was a bright student, certainly. But as—or more—pertinent is the fact that he made the most of his university experience.

During an eight-month co-op work placement in a NASA-funded research lab in South Carolina (US), Lloyd explored the adverse effects of zero gravity on the skeletal system of astronauts. Another co-op work placement abroad—in the Medical University of Vienna (Austria)—had him investigating the effects of a novel protein drug associated with diabetes on fat and muscle cells. As a "side effect" of the Vienna placement, he learned to speak German. Lloyd says the co-op programs have opened up a world of opportunities for him.

Co-ops offer a win-win experience for both Science undergraduates and employers. While students gain from a network of professional contacts and experience a real-world working environment, employers can tap into fresh talent. Employers are looking for highly motivated students who learn readily and mesh well with their team approach.

The co-op programs not only provide students with hands-on experiences in industry, business, government, or public service—in BC, Canada and abroad—but they also integrate a variety of community-building activities and training workshops. For more information, visit www.sciencecoop.ubc.ca.

Science 101—Exploring the Natural Laws of Our World

Our students and faculty reach out to inner city residents who have historically had difficulty accessing a university education. Science 101 is a four-month, non-credit, barrier-free course that introduces its students to the major disciplines of science, including biology, chemistry, earth and ocean sciences, physics, and astronomy.

On field trips and in the lab, the participating students explore the science behind the world's natural forces and aspects of their own everyday lives.

Through courses such as Mathematics of Evil, Basic Structures of Life, and Chemistry of Food, the students learn concepts from various scientific disciplines, broaden their experience in their community—and have fun with science.

Every year the program engages close to 50 Science volunteers, from undergraduate students tutoring, to graduate students and faculty members lecturing and guiding field trips. It is a truly rewarding experience for everyone involved. For more information, go to Outreach at www.science.ubc.ca.

Community Relationships—Fuelling UBC Science

To advance science it takes more than outstanding students, engaged educators and dedicated researchers—the Faculty of Science at UBC relies on the patronage, involvement and support from alumni, friends and industry.

Building links with community enables our faculty members to conduct outstanding research and provide an exceptional student experience.

UBC Science is partnering with alumni and the community to build support for the Faculty's priority projects. These include:

- The Carl Wieman Science Education Initiative—seeks to transform the way science is taught and learned at the undergraduate level (www.cwsei.ubc.ca).
- The Earth Systems Science Building—a new home for Canada's leading department of earth sciences and an investment in tomorrow's mineral exploration and earth science leaders (more on page 3).
- The Beaty Biodiversity Centre and Beaty Biodiversity Museum—a new centre for groundbreaking research, and a biodiversity-focused museum that brings UBC's outstanding natural history collections into public view (more on page 16).
- The Science and Environmental Sustainability Initiative—seeks partnerships to promote the role scientific research plays in sustainable enterprise, addressing complex issues such as climate change, "green" manufacturing and resource extraction.
- Support for Students and Basic Scientific Research—establishes scholarships for undergraduate and graduate students, and professorships for faculty, to advance new knowledge and scientific discoveries that, ultimately, benefit our society.

Whatever your interest, be it an investment in students or fuelling research, we are most grateful for each cash gift, donation of securities, estate pledge, or donation of personal property.

Thank you to those who have supported UBC Science in the past and those who continue to do so. Please do not hesitate to contact André Zandstra at 604-822-8686, or e-mail development@science.ubc.ca, if you wish to discuss how you can help.

People at UBC Science: In Memory of Grant Ingram

The UBC and science communities mourn the sudden death of R. Grant Ingram.

We lost a valued faculty member, a distinguished scientist, a dedicated administrative leader—and a wonderful gentleman, whose optimistic spirit and easy smile made our world a better place.

"Many UBC students' and colleagues' lives have been touched so marvellously by Grant. His scholarly contributions to the world of earth and ocean sciences, along with truly remarkable administrative service to this university, are accomplishments that bring tremendous pride to all who have known him," said UBC president and vice-chancellor Stephen J. Toope.

In his ten years at UBC, Prof. Ingram performed outstanding services in our community as the founding principal of St. John's College, as associate dean of Strategic Planning and Research, as dean *pro tem* in the Faculty of Science, and, most recently, as principal of the College for Interdisciplinary Studies.

Before joining our community, Grant Ingram was chair of the Institute of Oceanography and a professor in Atmospheric and Oceanic Sciences at McGill University, where he attained his bachelor's and master's degrees in Science. He earned his doctorate in the Massachusetts Institute of Technology and Woods Hole Oceanographic Institution (Massachusetts, US) joint program.

Earlier this year, Grant Ingram was named a fellow of both the Oceanographic Society (US) and the Canadian Meteorological and Oceanographic Society in recognition of his long-term service and contributions to ocean sciences in Canada and around the world. For more than three decades, he advanced our understanding of ocean physics, focusing on the link between the physical environment and

Photo: Janis Franklin

marine biological populations in northern and Arctic oceans, and on the effects of climate variability and climate change.

In honour of Prof. Grant Ingram, we have established the R. Grant Ingram Memorial Scholarship in Oceanography at UBC. If you are interested in contributing to this scholarship fund, please contact the UBC Development Office at 604-822-5345.

Taking Shape, Sharing Science—UBC's Biodiversity Centre and Museum

Photo: Chris Harley

Biodiversity is about the variety of thriving organisms and ecosystems.

The Faculty of Science is building a new home for our biodiversity experts. Earlier this year, we broke ground for construction of the Beaty Biodiversity Centre. The centre will feature a museum, inviting the greater community to learn about the significance of biodiversity. The Beaty Biodiversity Museum will house UBC's extensive biological collections—crucial resources for the centre's world-class team of zoologists, botanists, microbiologists, and ocean scientists, who will come together under one roof to advance biodiversity research. Through showcasing these unique specimen collections, the museum will connect British Columbians with their natural history. UBC's fossil, invertebrate (including insects and shells), fish, amphibian, reptile, bird, mammal, and plant collections are wonderful resources for enriching biodiversity knowledge. While we look forward to their public debut in 2009—and to many more educational activities, such as the Discovery Laboratory—we are already presenting the ongoing, highly acclaimed Biodiversity Lecture Series. For updates on public lectures and to learn more about the Beaty Biodiversity Museum and the progress of this exciting project, please visit www.biodiversity.ubc.ca.

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