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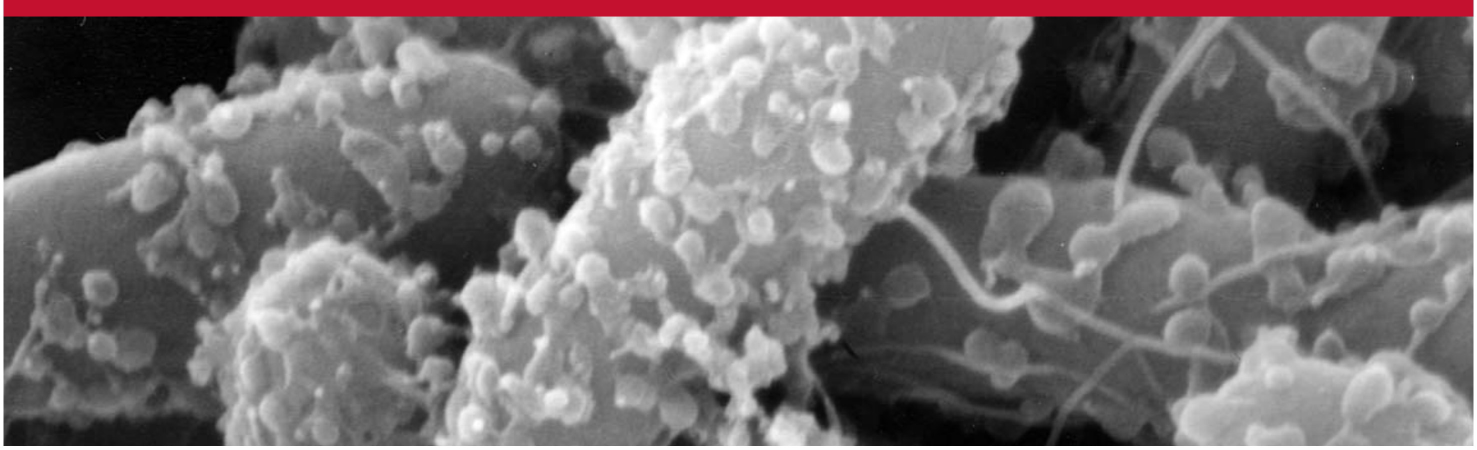

Words from the New Editor

Welcome to Synergy—Journal of UBC Science. This issue launches a new concept with a fresh look and more in-depth articles based on what you, our readers, have asked for. That is—more about the ground-breaking science conducted at UBC in all fields of study.

In this issue of Synergy you will read about progress in drug development, ecological interdependence, seeing versus perceiving, and revolutionary galaxy gazing.

Additionally, we are highlighting the Faculty of Science's ongoing efforts to achieve further excellence in research and in education. For this, we have started two new regular features: "department portraits" and "projects and initiatives."

The Faculty of Science and its nine departments are very proud of our faculty members and the world-class research they conduct. We are therefore continuing the tradition of briefly introducing our new "masterminds" to you, and to point out recipients of national and international awards.

We hope you enjoy this edition of Synergy. We would also like your feedback on the new focus and design. Please take a moment to complete the

short questionnaire and submit your comments, either on the attached reply card or online at www.science.ubc.ca/synergy.htm

We look forward to hearing from you!

Carola Hibsch-Jetter
MSc Physical Geography
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Getting Attention

Seeing is Not Always Perceiving

Understanding human perception has implications for a host of technologies—from computational vision and adaptive interfaces to tele-surgery and interactive computer games. Ron Rensink's research is dispelling previous notions of how we see and what captures our attention.

How can we fail to see something that is right in front of us? How do we perceive what we know to be an illusion as real? Rear-end collisions and the magician's-sleight-of-hand are just two of the disparate phenomena that interest UBC computer scientist and psychologist Ron Rensink. His broadly interdisciplinary research in attentive and pre-attentive processes is forging a new understanding of human perception and consciousness.

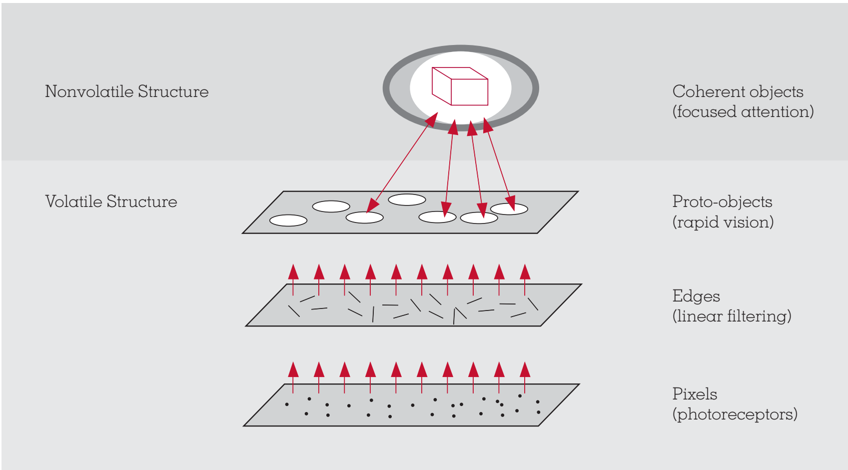
Rensink's seminal work on "change blindness," conducted at Cambridge Basic Research in collaboration with the Massachusetts Institute of Technology (MIT), Harvard and Nissan, examined the issue of why so many drivers involved in traffic accidents failed to see what was right in front of them. The problem, Rensink discovered, had nothing to do with visibility, but whether the driver was paying attention. In fact, in order to see a change—a brake light coming on, a ball bouncing out between parked cars—we must actually focus our attention on it. The more distracted we are—changing a CD, talking on a cell phone—the more difficult this becomes. And with increasingly complex dashboards providing more and more information, how do we design machines that recognize and enhance the limits of human perception?

As a result of Rensink's work, Nissan committed $1.4 million to UBC for fundamental research in human perception and cognition in order to establish the science needed to develop intelligent automobile interfaces. The research collaboration includes faculty from across campus: Computer Science, Psychology, Human Kinetics, and Electrical and Computer Engineering.

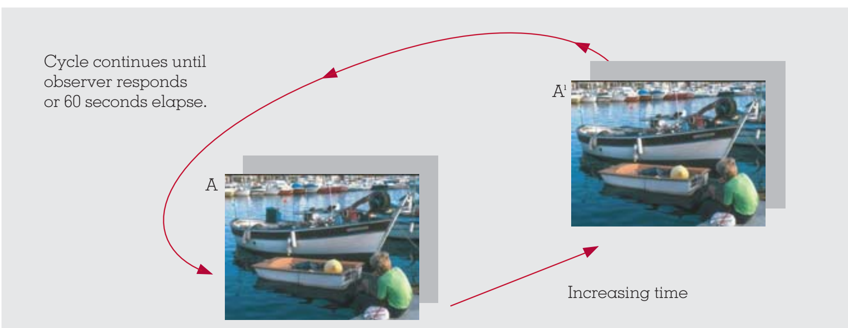
Change Detection and Coherence Theory

How we detect change is an integral part of our attentional and perceptual processes. It is difficult to study because several systems and phenomena are involved. For example, noticing motion can be confused with perceiving change. Additionally, the type of task and the intention of the observer affect how we detect change.

A number of other elements have been found to induce change blindness: image flicker, eye movements (saccades), eye blinks, passing objects, real-world interruptions, and changes made gradually. In his tests, Rensink used the "flicker paradigm," in which subjects are shown an original image alternating with a modified one, with brief blank fields between successive images. Observers had a difficult time detecting change, even



Coherence theory. *Early level processes produce volatile structures quickly and in parallel across the visual field. Focused attention acts as a hand to "grab" these structures and stabilize them. As long as these structures are being held, they form an individuated object with both temporal and spatial coherence.*



Flicker paradigm. *Observers are shown images alternately, in rapid sequence. They will often look at but not see the changing object. However, once attention has "latched onto" the appropriate object, the change is easy to see.*

when they knew it would occur, and even if the changes were drastic and repeated.

Since changes made during a visual disturbance are even more difficult to see, this research challenges previous beliefs that our brain contains a detailed, complete picture-like representation of the scene we are looking at. Instead, Rensink's "coherence theory" of visual perception suggests a more dynamic, "just-in-time" representation. In this model, a continuous low-level scanning process collects information from four or five sources simultaneously, much like parallel processing in computing, and holds it in short-term memory. An object does not appear as distinct and coherent until we focus our attention on it. Since objects are always "there" when requested, they appear as if we are seeing them simultaneously. It is like a refrigerator light, says Rensink. It appears to be on all the time, but it is really only on when requested (i.e. when the door is open).

Adapting Technology to Human Systems

Rensink and UBC colleagues Tamara Munzner, Karon McLean and Brian Fisher (Computer Science), Sid Fels (Electrical and Computer Engineering), and postdoctoral fellow Erin Austen (Computer Science and Human Kinetics) are working to develop multi-modal interfaces that use audition and sound as well as touch and sight. They are discovering that the coherence theory of vision seems to apply to other senses as well. With touch, for example, we only sample pieces of a surface with the pads of our fingers, yet we "feel" the whole surface. "We are finding a great deal of commonality in sensory systems, and in the long run it will help us when we try to combine them in interface design, because they will have similar conventions or 'operating systems,'" says Rensink.

The old idea of the cyborg is gaining new ground, notes Rensink, only implants will not be required, just better human-machine interactions. For example, tele-operations systems are being designed for surgeons that will give them micrometer precision. Other systems are being developed for mining and exploration in underwater or hostile environments. "We can literally augment our abilities far beyond our basic human state." In other words, scientists like Rensink are discovering what philosophers such as Heidegger have said all along, we are both soft and hard wired to extend ourselves—and this drive is innate.

Streamlining Animation

If human visual perception is not based on the construction of detailed, general-purpose representations, but is specialized to the task at hand, then machine vision could be modelled on the same "just-in-time" approach, which would require less memory and computing power.

Rensink is working with Michael van de Panne and postdoctoral fellow Jason Harrison to develop animation using this new visual paradigm. If we do not "see" an entire scene in full detail, then it does not need to be animated that way. And even if we are attending to something, we will only be able to detect a fraction of what actually changes. Other movements, such as acceleration, we are unable to see anyway. "If a character is throwing a hammer, for example, the gait can be wrong or a head movement jerky, but as long as people are only attending to the hammer, and you get that part right, people won't notice," says Rensink. Using this knowledge would cut the cost of animation immensely, particularly in interactive video games, where developers know what users are attending to, and where scenes have to change in real time.

The Enigma of Mindsight

Rensink has also discovered that some observers, approximately 30 percent, can actually feel—or sense—change in their surroundings even though they have no visual experience of it. The phenomenon of "mindsight" was observed using the same flicker testing as with change blindness, but where the observer had the option of two responses: one when they sensed change, and another when they actually saw it. It is as if the observers who can sense change have a warning system that turns off once the object is visually perceived. This distinct mode of perception is based on processes that involve different mechanisms and is not a precursor to seeing. In control conditions, when no change occurred, those people able to sense change could also sense the absence of change. "This indicates that sensing is not an artefact of guessing," says Rensink.

Interestingly, observers who were able to sense were much more comfortable with "letting their non-conscious mind do the walking." For those who could not sense, only "seeing was believing."

Multi-dimensional Research

As well as being broadly interdisciplinary, Rensink's research spans the spectrum of very basic to very applied. Current funding partners include Nissan, Natural Sciences and Engineering Research Council of Canada (NSERC), Canada Foundation for Innovation (CFI) and the Institute for Robotics and Intelligent Systems (IRIS). Nissan has recently established positions for UBC graduate students to work in Japan. Rensink is also courting other industry partners. "We are getting a certain amount of credibility because we have worked successfully with industry," he notes.

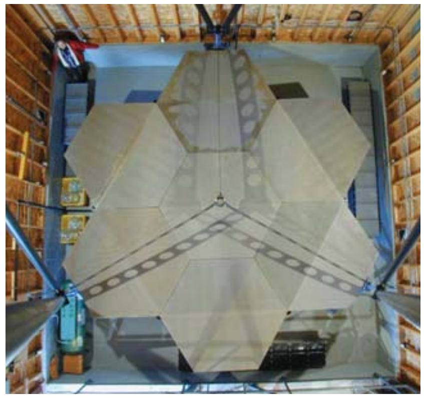
The study of change detection has also become a tool for the study of personality and cultural differences. "What has happened with this work is that it has found its way into the general scientific culture," says Rensink. "These testing methods are now being applied to answer different questions."

Where is Rensink's work heading? The sky—and the imagination—are the limit. He is already collaborating with computer science colleagues on developing more dynamic displays for air traffic control. He is also interested in studying how magicians direct our attention, and the implications this has for potential applications, from more adaptive interfaces to more persuasive advertising. As with any emerging technology, in the right hands it can be extremely beneficial, but in the wrong hands it could have dire consequences. "Whether we ought to do this or not is a big question," he admits. "We should be able to answer that in a year or two."

However, given that the complexity of the world in which we live is increasing at a much greater rate than our biological systems evolve, it seems like a good idea to try to off-load as much as we can on pre-attentional and non-conscious processes. "We have all of these different subsystems at our disposal and we should let them do what they are good at."

"The system that allows us to see can be broken down into the perception of "stuff" versus "things." Initially, we process all of this stuff—colours, motion, shapes—which don't get perceived as an organized whole, or thing, until we attend to it and make it coherent." – Ron Rensink

Liquid Mirror Telescopes
Windows to the Cosmos


The Large Zenith Telescope project began in 1994. The aim was to develop a zenith-pointing telescope employing a rotating liquid-metal primary mirror of at least five metres diameter, with which to conduct astronomical surveys. In order to simplify logistics and reduce cost, the telescope was installed on a hilltop in the UBC Malcolm Knapp Research Forest, approximately seventy kilometres east of Vancouver.

"Revolutionary" liquid mirror telescopes developed at UBC combine Newtonian physics and high-tech optics to allow astronomers to peer back to the beginning of time and study the evolution of galaxies, the history of stars, and the nature of dark energy.

It has been ten years since UBC astronomer Paul Hickson built his first liquid mirror telescope (LMT) in his back yard. What started as a pet project has blossomed into an international collaboration on one of the largest, most powerful and most technologically innovative ground-based telescopes in the world. The Large-Aperture Mirror Array Telescope (LAMA), involves scientists from UBC, the State University of New York at Stony Brook, and Columbia University (New York), and is based on technology developed by Hickson and colleagues at UBC and Ermanno Borra at Université Laval (Québec).

Plunging Newton into Deep Space

Liquid mirrors were originally Newton's idea. Pour any liquid (mercury in this case) into a cylindrical container and rotate it at a constant speed, and the surface becomes a paraboloid—the ideal shape for a telescope's mirror. Only in the last two decades has technology provided the tools (adaptive optics, optical interferometry, CCD cameras) to overcome the practical limitations of using liquid mirrors to probe the oldest and darkest recesses of the universe.

In collaboration with Borra and UBC professor emeritus Gordon Walker, Hickson designed and built a prototype 2.7-metre liquid mirror telescope at UBC in 1993. He has also provided liquid mirrors for the University of Western Ontario, University of California (Los Angeles, UCLA) and NASA. Two Light Detection and Ranging (LIDAR) telescopes (the first one installed in 1995) are still measuring the physical properties in the earth's atmosphere related to light scattering.

The Large Zenith Telescope (LZT) project also involves scientists from the Institut d'Astrophysique de Paris (IAP). The project began in 1994, with seed funding from UBC and major funding from NSERC. From a hilltop in UBC's Malcolm Knapp Research Forest, approximately seventy kilometres east of Vancouver, the 6-metre telescope rotates on a precise vertical axis, pointing at the zenith and scanning the night sky for distant quasars and supernovae. Currently the third-largest optical telescope in North America, the LZT is in the final stages of testing and is scheduled to begin scientific observations this year. Stony Brook, Columbia and IAP are also contributing resources to the project, and will be participating in observations, data analysis and scientific programs.

Luminous LAMA

The next project for Hickson's group is "astronomical" in proportion to the LZT. The Large-Aperture Mirror Array Telescope (LAMA) will consist of a hexagonal arrangement of 66 liquid mirror telescopes, each 6.15 metres in diameter. LAMA's adaptive optics and optical interferometry will collect, relay and combine the light from all the telescopes at a single common focus, to an accuracy of a few tens of nanometres. With the light-gathering power of a 50-metre telescope, extremely high sensitivity, the resolving power of a

70-metre telescope, and angular resolution greater than 25 times that of the Hubble Space Telescope, LAMA will be able to detect the very first luminous objects in the universe.

With the addition of optical mirrors, LAMA will also be able to point and track four degrees in any direction of the zenith without moving the main mirrors. "This will allow us to follow an individual field or object for up to half an hour, and gather much more information," says Hickson. The ability to point to and track—one of several novel features of LAMA—has never been accomplished with any other liquid mirror telescope.

But what can it do that the Hubble and the Next Generation Space Telescope cannot? "Space telescopes are particularly good at detecting in the infrared range, where on Earth the sky is very bright," notes Hickson. However, to detect and measure very faint point sources, large ground-based telescopes have the advantage at shorter wavelengths, where the sky is less bright, because they have a much larger light collecting area than space telescopes.

"The Hubble has been very successful in detecting faint, distant galaxies in redshifts ranging from two or three (see sidebar), but it has only been in combination with the Keck that we have really learned a lot about these objects." (The twin 10-metre Keck telescope in Hawaii is currently the largest ground-based telescope on earth). LAMA's light-gathering power, about 18 times greater than the combined area of both Keck telescopes, will achieve a signal-to-noise ratio—or detect enough photons—to measure the spectrum and gather information about galaxies and supernovae at redshifts of five and greater.

Other groups worldwide are planning very large telescopes, with apertures in the 30- to 50-metre range. However, such a telescope would cost approximately $1 billion and take at least twelve years to build, whereas LAMA can be built much more quickly at a cost of roughly $100 million. And over a year, it will be able to access nearly six percent of the night sky.

LAMA's Daunting Design Challenges

An astrophysicist's dream, however, can be an optical engineer's nightmare. Take the challenge of adaptive optics alone. When light hits the earth's atmosphere, the wave front is bent, so the light must be redirected to a deformable mirror to straighten out the wave. For LAMA, a similar adaptive optics system must be in place for all 66 mirrors.

Then there is the challenge of interferometry, or combining all the corrected beams of light. In the case of only two LMTs, if light is combined incoherently, without pairing wave crests and troughs, the result has only twice the brightness of a single telescope, and no greater resolution. LAMA's high resolution mode requires the wave fronts from each telescope to be in phase. Advanced phase-tracking systems will adjust the mirrors of each of the 66 telescopes instantaneously to ensure that the waves combine constructively to produce positive interference—and highly-resolved images.

In addition, light coming in from different angles will arrive at the focus at different times. Somewhat like a plane circling before being cleared to land, these eager photons must be kept at bay by being bounced off diverting mirrors so that they all arrive at the focus simultaneously, and in sync. These mirrors must move constantly to compensate for the changing path lengths of light as the earth rotates.

Then of course, there is the mercury itself. In order to avoid waves, which further distort the light, the layer of mercury must be as thin as possible, roughly 1.5 millimetres. This means the surface of each dish must be extremely smooth—and identical for all 66 mirrors. Hickson, who is project scientist for LAMA, credits the work and expertise of project manager and optical engineer Bruce

"With LAMA's light-gathering power and resolution we could detect a light bulb at the distance of Mars. We hope to be able to study the evolution of galaxies over 98 percent of the age of the universe."
– Paul Hickson

What is Redshift?

"The distances between galaxies are expanding with the universe, and the result of this cosmological expansion is to change the wavelength of light as it propagates." – Paul Hickson

Most people are familiar with the Doppler Effect, the apparent shift of wavelengths when a fast-moving sound changes pitch, like a jet passing overhead. The same phenomenon affects light as well. When light approaches the viewer, we see shorter wavelengths, and a shift toward the blue end of the spectrum. When light recedes, then we see longer wavelengths, or a shift toward the red end of the spectrum. Cosmological redshift is a similar phenomenon where distant galaxies appear to be receding—and the further away they are, the greater the speed of recession.

This displacement in the lines of the spectra of certain galaxies toward the red end of the spectrum, or cosmological redshift, is notated as z, and represents the general property of the expansion of the universe. To date, a few galaxies and quasars have been found at z ~ 6. These are very rare and unusual objects.

"We would like to be able to observe and study 'typical' galaxies at such redshifts, and to detect the very first objects, which could have redshifts as high as 20," says Hickson. Light from such objects, about 15 billion years away, would have been emitted when the universe was only about two percent of its current age.

Truax from Connecticut. They and colleagues Kenneth Lanzetta, project director at Stony Brook, and Arlin Crotts and David Helfand, astronomers at Columbia University, obviously have their task cut out for them.

"The challenge will be to make the tracking system, the adaptive optics and the interferometry work together—for all 66 telescopes," admits Hickson. The initial phase of development and funding will involve construction and testing of a six-mirror prototype, which should take four to six years, at a cost of $8 to $10 million.

Evolving Galaxies, Exploding Supernovae and Perplexing Dark Energy

The scientific goal of LAMA is not to be everything to all astronomers. Instead, the research has three main foci. First, scientists want to study how galaxies form, merge and evolve. Secondly, they will investigate distant type II supernovae (produced by explosions of massive stars), to shed light on the history of stars, the formation of elements and the nature of dark energy. Third, is the search for extrasolar terrestrial planets.

In the last decade, surprising studies of supernovae have shown that the expansion of the universe is accelerating. "We would expect that mutual gravitational attraction of everything in the universe would slow down expansion," Hickson explains. Scientists have termed this negative or repelling force "dark energy." With a larger sample of much older supernovae, astronomers will be able to research into the expansion history of the universe in order to learn more about the physical properties of dark energy. To date, there are only about 100 supernovae being studied, and only at $z \sim 1$.

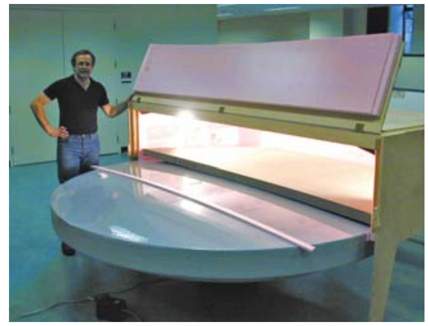
A Window into Other Worlds

UBC astronomers are known worldwide for innovation under pressure—the pressure of limited funding in a high-budget field. For example, the MOST satellite (see Synergy 8.1) was successfully launched last July. UBC astronomers have also been very good at detecting new celestial bodies. Brett Gladmann (also Synergy 8.1) has discovered new moons around Neptune and Uranus. And Gordon Walker has pioneered the detection of new planets by measuring the gravitational tug of the planet on the star, which causes the light to wobble and thus be detected.

Astronomers—and just about everyone else—would like to know if there are other terrestrial planets that can support life. These are more difficult to detect than the larger, Jupiter-like planets, because they have a lower mass. The earth's pull on the sun is not nearly as strong as Jupiter's, notes Hickson, hence the difficulty in detecting earth-like planets. So far, these new planets are all relatively massive and close to their parent star. While MOST will help astronomers to actually see them, LAMA will be able to determine whether they have atmospheres. It will also be able to detect even smaller planets that are more likely to support life as we know it.

When an orbiting planet moves in front of the parent star, as observed from Earth, a small amount of the starlight is absorbed by the molecules in the planet's atmosphere (if it has one). By obtaining high-quality spectra of the star during this period, and measuring this minute effect, LAMA could detect oxygen or other molecules if they exist in the planet's atmosphere. Since the main source of oxygen in the earth's atmosphere is produced by plant life, it is reasonable to assume that where there is oxygen, there is life. Hickson notes that by the time LAMA is built, a large number of these planetary systems will have been discovered.

"We will be able to point to these stars, which are also ideal targets for the adaptive optics, and gather information about the planet's composition and atmosphere," Hickson says—with all the clarity of vision and resolution that one would expect from an astronomer.



The 6-metre aperture of the Large Zenith Telescope (LZT) makes it the third-largest optical telescope in North America. Its rotating liquid mirror, weighing approximately three tonnes, is the largest ever built. The LZT has seen first light and is now undergoing a program of testing and engineering.

Cationic Peptides

Nature's Dynamic Defence System

Antibiotic-resistant super bugs and wily viruses such as SARS and West Nile are plaguing populaces and health care professionals alike. Microbiologist Robert Hancock and his lab are working to understand how the body's own defence mechanisms can be harnessed to fight infectious disease.

In microbiology labs around the world, scientists are urgently working to discover the key to fighting a growing roster of drug-resistant and often deadly infectious diseases. Canada Research Chair in Microbiology and Genomics, Robert Hancock directs the UBC lab that is working at the forefront of antimicrobial research.

"The last new class of general antibiotics to be developed was the quinolones in the 1960s, says Hancock, noting that ciprofloxacin is a popular drug of that class. Some antibiotics, such as tetracycline, do not even kill bacteria; they merely stop it from growing. A person's own immune system must kill off the pathogenic cells—a Catch-22 if immunity is already weakened by illness. Moreover, recent antibiotic drugs have very restricted activity and higher toxicity.

Two common super bugs are found in hospital environments, where they infect—and threaten—the already vulnerable. *Staphylococcus aureus* causes skin and lung infections, and food poisoning. *Pseudomonas aeruginosa* causes lung, bladder and systemic infections, and is the most common cause of death in people with cystic fibrosis. Both have mutated into resistant strains.

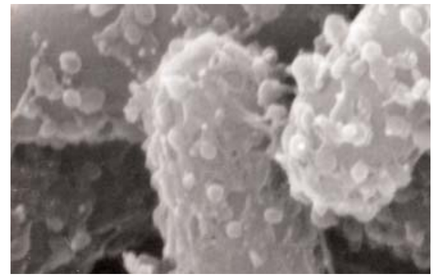
Since 1979, with funding from the Canadian Cystic Fibrosis Foundation, Hancock and his team have been studying the mechanisms of antibiotic uptake and resistance in the outer membrane of *P. aeruginosa*. They observed that certain natural cationic peptide compounds interact at sites on the outer membrane of the bacteria, causing a destabilization of the membrane and uptake of the peptide into the bacterial cell. Their research on "self-promoted uptake" led to the discovery of the unique properties of cationic antimicrobial peptides, short chains of amino acids that act as "nature's antibiotics."

Nature's "Self-promoting" Antibiotics

Cationic peptides are found in all cells of our body, but in larger concentrations in the intestine, places where there is inflammation, and in neutrophils—the kamikaze cells of the immune system that are dedicated to finding foreign organisms and eliminating them from the body. The range of antimicrobial activity of these peptides is remarkable. They can exhibit activity against bacteria, viruses, fungal pathogens, parasites, and even HIV and cancer.

Since the UBC group first started working on cationic peptides, over 600 have been identified by labs around the world. Despite their variety of origins, these peptides are all amphiphilic; they contain approximately 50 percent hydrophobic (membrane soluble) and 50 percent hydrophilic (water soluble) amino acids and typically have a net positive charge. They attack bacteria and other pathogens, which have a negative charge on their cell membranes, by folding into shapes such as alpha helixes that allow them to infiltrate the cell without destroying the membrane.

Somewhat like a three-dimensional jigsaw puzzle, these positively-charged molecules interact with the negatively-charged outer membrane in Gram-negative bacteria, or the thick cell wall in Gram-positive bacteria, which lacks the outer membrane. In Gram-negative bacteria, they then neutralize the charge over a patch of membrane and create cracks through which the peptide can cross, leaving the membrane blistered but not yet killing the cell. Once the peptide has crossed the outer membrane



Particles of the cationic peptide antibiotic CEMA "sitting" on the bacterium Escherichia coli. *CEMA, derived from insect antimicrobial peptides, causes a remarkable disruption of the usually smooth bacterial surface. Scanning electron microscopy enables us to see these structures—the actual bacterial size is around one micrometer.*

"Cationic peptides are amazing in their ability to kill microbes and regulate innate immunity. And these functions are synergistic." – Robert Hancock (or diffused through the cell wall of Gram-positive bacteria) it interacts with the negatively-charged surface of the cytoplasmic membrane, and then enters and kills the cell.

Multiple Kill Mechanisms

Hancock's lab was the first in the world to make the groundbreaking and controversial discovery—cationic peptides have multiple killing mechanisms that involve enzymes, cell division, and DNA, RNA and protein synthesis. "They are designed to interact with membranes, but they also interact with multiple targets in the cell," says Hancock. These multiple modes of attack render bacteria less susceptible to antibiotic resistance, which is the result of target protein mutation. Cationic peptides also work much more quickly than conventional antibiotics, and they are lethal to pathogens even at their lowest concentrations. Since the host eukaryote cells have positively-charged lipids on the surface, the peptides only interact with the microbe invader. "This is important, since you don't want an antibiotic that kills the patient," Hancock remarks.

Deaths from Gram-positive hospital super bugs, such as methicillin-resistant *Staphylococcus aureus* (MRSA), have been increasing dramatically. Recently, untreatable strains of the Gram-negative bacteria *Pseudomonas aeruginosa* have been found in Asia. None of the latest antibiotics have any activity against Gram-negative bacteria, notes Hancock. Their extra outer membrane makes them more difficult to treat with conventional antibiotics. In contrast, the unique uptake mechanism of cationic peptides is particularly effective against Gram-negative bacteria.

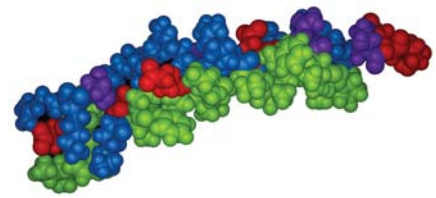
As founding scientific director of the Canadian Bacterial Disease Network (CBDN), Hancock's mandate was to move research from the bench into industry labs as quickly as possible so that the community can benefit from treatment. He credits the Network, along with the Canadian Institutes of Health Research (CIHR), for funding much of his basic research. In 1991, the UBC spin-off company MicroLogix reconfigured itself to develop antimicrobial cationic peptides for therapeutic use. Other peptides produced in the Hancock lab have been licensed by Helix BioMedix Inc. to develop therapies for lung infections and wound healing.

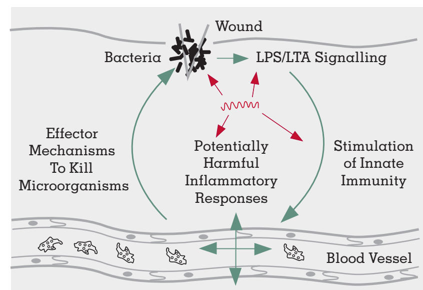
Enhancing the Body's Immune Response

As well as antimicrobial activity, cationic peptides play a unique role in regulating innate immune response. Previous methods of harnessing the immune response for therapeutic use have failed because they also boost the body's inflammatory response. Sepsis is a serious inflammatory syndrome that affects 700,000 people in North America every year—and kills 140,000. It occurs when dead bacteria release endotoxins, signalling molecules that stimulate host cells to release pro-inflammatory cytokines, which in turn trigger the septic cascade. "The antibiotic works but the patient dies, either from multiple organ failure or a drastic lowering of blood pressure," Hancock remarks.

Hancock and UBC colleague Brett Finlay, a joint professor in the Departments of Biochemistry, Microbiology and Immunology, as well as the Biotechnology Laboratory, have been studying the distinct and varied functions that cationic peptides have in the immune response. They designed peptides with no antimicrobial activity at all, and demonstrated that they interact directly with the host cells to turn on two types of genes: one set reverses the septic or inflammatory response, and the other set helps to resolve infections.

Hancock and Finlay's research has furthered the understanding of immunity and led to the development of novel therapies. In 2001, they co-founded





Model of the human peptide LL-37, which is involved in defence against infections.

Innate immunity is an immediate non-specific defence against microbes. The process is triggered when bacteria enter the body through a lesion and release surface signals (LPS/LTA). Cationic host defence peptides (spiral structure) can interact directly with the bacteria to kill them, with LPS/LTA to suppress excessive signalling and potentially harmful inflammation, or with host cells to stimulate mechanisms killing the microbes.

Inimex Pharmaceuticals to commercialize discoveries made by UBC scientists. Working with Hancock's former graduate student Monisha Scott, they developed peptide compounds that demonstrated protection against both Gram-positive and Gram-negative bacteria in animal models. "The advantage of this therapeutic strategy is there is no antibiotic resistance, since these compounds act on the host, not the pathogen," Hancock says.

The research of Hancock, Finlay and colleagues in the functional genomics of cationic peptides has garnered a $27-million grant—the largest ever awarded by Genome Canada. The Functional Pathogenomics of Mucosal Immunity is a joint project with scientists from UBC, SFU and the University of Saskatchewan who have been involved in major advances in understanding host-pathogen relationships.

Hancock recently received the Aventis Award from the International Science Conference on Antimicrobial Agents and Chemotherapy—the top international award for antibiotic research.

Cationic peptides are promising to be the next big breakthrough in antibiotic therapy. Their range of antimicrobial activity and their role in the up-regulation and control of the innate immune response could also lead to new therapies for inflammatory diseases such as arthritis, as well as serious viral and fungal infections.

"We really don't know yet whether they will work against viruses and fungi, but I suspect they will," says Hancock. "We'll see."

Understanding Ecological Interdependence
From the Ground Up

How does species loss upset the delicate balance of nature, and what does this mean for the survival of life on this planet? Biodiversity research is beginning to unravel this intricate, interconnected web. For botanists such as Roy Turkington, work literally starts from the ground up.

For over twenty years, a group of UBC field biologists has been working in the Kluane region of Canada's boreal forest to study the interaction between populations of predators, herbivores, plants, and the soil—feeding groups referred to as "trophic levels." Zoologist Charles Krebs studied snowshoe hares to determine why their population fluctuates over ten-year cycles, and how this affects predators that feed upon them. Botanist Roy Turkington and his field team have been studying the role that herbaceous plants play in this system.

"You have a boreal forest living on 250 mm precipitation a year, half of which is snow. This is the same amount of rainfall as in the Negev Desert in Israel," says Turkington. "The question is: How does that amount of rainfall support a forest with all this flora, particularly since the soil is extremely nitrogen poor?"

Top-Down or Bottom-Up?

Turkington and his group of researchers have been studying the ecological mechanisms that control the composition, diversity and stability of plant communities in the Skakwak Trench near Kluane Lake in the south-western Yukon. They tested three hypotheses, based on the mechanisms of competition, herbivory and soil fertility. Was vegetation controlled by nutrient availability (bottom-up control), herbivores (top-down control), or both? And what happened to individual plant species when the community was subjected to various manipulations?

The methodology involved fertilization, herbivore exclusion, and fertilization plus exclusion of herbivores. Among the many observations the group made was that long-term fertilization caused a shift from an herb-dominated to a grass-dominated community, along with a massive invasion of fireweed. Some plants in the "rare" category, such as goldenrod, experienced the least amount of change with the increased nutrient levels. However, lupines and anemone (an uncommon species in the plots) were the most negatively affected by fertilization, with anemone having the highest (80 percent) mortality rate even without competition from other plants.

Surprisingly, herbivores had little effect on the plants, and other work (Krebs et al.) showed that the increased abundance of food due to fertilization had no effect on snowshoe hare cycles. The botanists' research shows that herbaceous plant abundance in the boreal forest is indeed regulated from the bottom—or ground—up, while the zoologists in the Kluane Ecosystem Project demonstrated that herbivore populations tend to be regulated from the top down, by predators.

The "Nitty Gritty" of Density Dependence

Positive density dependence among the populations of species in any community—whether crop, meadow, or large urban centre—means that as the density of a group increases, so does the probability that individuals will survive

Studying density dependence demands a lot of painstaking work, whether in the boreal forest of Canada (left) or in the Negev Desert in Israel (right). The latter research site is located in the Wilderness of Zin (below). Thus, Roy Turkington is among few plant ecology researchers in the world to have their study site cited in the Bible—it was part of Moses' route with the Children of Israel during the Exodus.

and thrive. Negative density dependence means that as density increases, so too does the probability of death or disease.

Since 1992, Turkington, Deborah Goldberg, Linda Olsvig-Whitaker and Andrew Dryer have been studying the role of density dependence in the Negev Desert in Israel. The desert is home to a host of annual plants that have a short growing season, from December to April. Most of the seed, nearly 99 percent for the following year's growth, remains in the top two millimetres of sand.

"What Linda suggested was brilliant," says Turkington. "If you scrape off all the sand in a square-metre plot to about half a centimetre and put it in a bucket, you can literally walk away with next year's community. In effect we can do community transplants!" By sifting out the seed, and spreading it over proportionally smaller or larger plots (from 1/4 sq. metre to four square metres) they could study the effect of positive or negative density dependent change on the entire community—and at different precipitation levels.

Hauling Sand to the Desert

Mountains of sand were removed from three sites, each with different precipitation levels. "Four to five students worked the whole summer sifting sand that we scraped from the sampled plots in the dunes," Turkington says. Once sifted, the group replanted the seed in test plots that contained no residual seed. To do this, they brought in 600 tonnes of sand from virgin dunes to fill giant plant pots.

"We actually dug what is probably the biggest sandbox in the world: 30 trenches, each one metre deep, two metres wide and five metres long, or 300 one cubic metre plots." The group was then able to manipulate the density of entire communities of annual plants, as well as their irrigation levels. They also quantified the emergence, survival and final size of individual plants in each community—a total of more than 30,000 plants.

Over three years, the group discovered that most plant communities revert to their original density, regardless of which density was imposed artificially, and they return faster under dryer, harsher conditions. "Now we are trying to determine if they go back to their original composition as well," says Turkington.

Back in the boreal forest, graduate student Mike Treberg is taking the work on density a step further. He recreated 63 plots with an average composition of plants for the study area, and then manipulated the density of individual species in each plot—plant by plant—either removing or adding plants to get the target percentage. "What we will see after four years, when these communities readjust to whatever state they are going to readjust to, is which species wins, and which species loses."

Previous research in density dependence studied the function and growth of one species at a time. The Negev project is the first time a study has involved the density of an entire community. It has also challenged earlier theories that competition among plant communities was lower in the desert, and that it was predominantly competition for light. "It really all happens below ground," says Turkington. "It is competition for nutrients and water, and this competition is even more intense under harsher conditions."

Biodiversity Knockout Experiment

Just as biomedical research knocks out genes to examine their function in the organism, The Biodiversity Knockout Experiment (BIOKO), will remove species to determine their function in an entire ecosystem. The proposal, spearheaded by zoology professor Anthony Sinclair, was awarded $16.25 million by the Canadian Foundation for Innovation (CFI), to establish The Biodiversity Research Centre at UBC, and to build the facilities and infrastructure needed to undertake this research on a global scale.

Turkington's student Jenny McLaren has already started. Again working in the boreal forest at the Yukon site, she has set up 80 square-metre plots to see what will happen when she removes different functional groups. From some plots, for example, she is laboriously removing grasses by coating them with herbicide—leaf by leaf. From others she is removing grasses and fungi, and from other plots she is removing broadleaf plants (dicots) and then fungi as well.

What is obvious from talking to Turkington and others in the field is that biodiversity research is painstaking, and results are slow. But it is crucial if we are going to understand the consequences of changing ecosystems and diminishing species.

"In the bigger scheme of things we would like to remove small mammals, birds and insects," says Turkington. "If we get promising results from the Yukon, we plan to continue the BIOKO project with colleagues in Israel, the Serengeti, and New Zealand to understand the effects in different systems all over the planet."

Boreal Forest Facts

- The boreal forest is one of Earth's major ecosystems that remains relatively undisturbed by human activity.
- Globally, boreal forest comprises one-quarter of the world's closed canopy forests.
- The boreal forest in Canada constitutes almost one-third of the northern circumpolar band of boreal forest.

Portrait: The Department of Earth and Ocean Sciences

The Department of Earth and Ocean Sciences (EOS) began to take form in 1996 with the merging of Geological Sciences, Geological Engineering, Geophysics, and Oceanography, and it was completed with the addition of the Atmospheric Science program in 1999.

The research interests of the 38 faculty members span from core to stratosphere and reach back into the deep time of Earth history, a scope seen in few other universities. The department is structured around solid earth and environmental earth sciences, the latter focusing on the fluid and biological components of the earth's near surface.

EOS is striving to establish five main research facilities in order to encourage a multidisciplinary, teamwork approach to science that balances observation, experimentation and computer modelling:

- The Pacific Centre for Isotopic and Geochemical Research (PCIGR)
- The Geophysical Disaster Computational Fluid Dynamics Centre
- The Environmental Earth Sciences Facility
- The Biological and Chemical Oceanography Facility
- The Solid Earth Research Laboratory.

Much of EOS research relates directly to the resource needs and well-being of our society. Consequently, the department is linked with industry, government and the local geological engineering community through various research endeavours such as:

- The Mineral Deposits Research Unit
- The Drugs from the Sea Program
- The POLARIS Project (probing the origin of deep earthquakes in the Pacific NW).

The department has a strong commitment to excellence in teaching and learning. Particularly, the new first-year courses span all EOS research interests and appeal to students in every faculty. There is a broad, general-interest majors program in earth sciences as well as honours programs in atmospheric and geological sciences, geological engineering, geophysics and oceanography.

EOS alumni have had a major influence on the evolution of the department, specifically through Stewart Blusson's support of PCIGR and Ross Beaty's donation of an entire museum. The new Pacific Museum of the Earth is an inspiration to young people. It provides education outreach with resources and teaching space for schoolteachers, and is also a potential bridge to the education of new earth science teachers through the Faculty of Education.

For further information visit:
www.eos.ubc.ca

Projects and Initiatives: The Science Student Centre

The Faculty of Science (FoS) at the University of British Columbia (UBC) is more than classrooms, labs and libraries. It is a place for students, teachers and researchers to gather, exchange ideas and collaborate. Recently, the university and the undergraduate science students—through the Science Undergraduate Society (SUS)—identified the creation of a facility that science students can truly call their own as the ideal means to encourage activities outside of the classroom.

The newly proposed centre for science students represents some of the most imaginative thinking and development on campus today. The 6,700-square-foot structure will establish a utile venue located in the heart of the FoS complexes. Consisting of ground-level, main and second floors, and a rooftop patio, this space will also include study rooms, internet terminals, the SUS office, an assembly area, social space and a lunch area, and various other resources for science students.

Through annual SUS dues, the students have agreed to contribute 40 percent—or approximately $700,000—to this $1.75 million project. In addition, UBC has committed to share in the building cost. However, to make this dream come true, the planned centre required external philanthropic support.

Enter Abdul Ladha. Mr. Ladha is a graduate of UBC, an entrepreneur and a long-time supporter of the FoS. Upon learning about the proposed facility and the associated funding gap, he generously pledged $750,000 to ensure the science student centre becomes a reality. Mr. Ladha has a strong history of supporting the FoS, including purchasing computer equipment and funding Science student bursaries through his family foundation.

Abdul Ladha pledged major support for the proposed science student centre.

Both the SUS and the FoS deeply appreciate Mr. Ladha's gift in support of this facility. Thanks to his donation, the Abdul Ladha Science Centre is set to begin construction in early 2004 with a projected completion date of January 2005.

The creation of the centre fills a much-needed void in the science student social and educational experience at UBC. Each day hundreds of students will directly benefit from Mr. Ladha's commitment.

New Masterminds: Brain Gains at Science


Abraham


Acton


Coombs


DiBacco


Fast


Heyl


Jetter


Kennepohl


Leander

Whether the new faculty members hold a Canadian Research Chair, an interdisciplinary appointment across departments, a junior or senior position—this means yet another great brain gain for the Faculty of Science.

Ninan Abraham, Assist. Prof., Depts. of Microbiology & Immunology, and Zoology; PhD Biochemistry, University of Ottawa, Canada. *Research:* My interests are in cell biology and immunology. Changes in interleukin-7, a growth factor for lymphocytes, can cause immuno-deficiency or lymphomas.
We use genetic models to understand the intracellular signalling processes that contribute to these diseases.
www.microbiology.ubc.ca/nabra.htm

Donald Acton, Instructor, Dept. of Computer Science; PhD Computer Science, UBC. *Research:* I am interested in distributed systems and operating systems. Prior to joining UBC I worked in industry designing distributed systems infrastructure.
www.cs.ubc.ca/people/profiles/acton.html

Daniel Coombs, Assist. Prof., Dept. of Mathematics; PhD Applied Mathematics, University of Arizona, Tucson, USA. *Research:* Dynamics of cell signalling, especially including effects of spatial inhomogeneity, biological elastohydro-dynamics applied to bacterial swimming, and virus-host interactions and evolution.
www.math.ubc.ca/~coombs

Claudio DiBacco, Assist. Prof., Dept. of Earth & Ocean Sciences; PhD Oceanography, University of California, San Diego, USA. *Research:* Biological Oceanography. We combine larval behaviour, physical oceanographic processes, and analytical chemistry techniques to address questions about larval dispersal/transport in estuarine and exposed coastal habitats, to ultimately assess population connectivity and metapopulation dynamics.
www.eos.ubc.ca/public/people/faculty

Naomi M. Fast, Assist. Prof., NSERC University Faculty Award, Dept. of Botany; PhD Biochemistry, Dalhousie University, Halifax, Canada. *Research:* My research focuses on genome evolution in single-celled eukaryotes. In particular, we examine the effects of genome size reduction on genome organization, the spliceosomal machinery, and intron density and length.
www.botany.ubc.ca/fast.html

Jeremy S. Heyl, Assist. Prof., Canada Research Chair, Dept. of Physics & Astronomy; PhD Astronomy and Astrophysics, University of California, Santa Cruz, USA. *Research:* How can fundamental physics inform our knowledge of astrophysics and vice versa? My current studies focus on compact objects: neutron stars and black holes. Understanding the nature of these objects and their phenomena pushes our knowledge of the laws of nature to the limits. www.physics.ubc.ca/~heyl

Reinhard Jetter, Assist. Prof., Canada Research Chair, Depts. of Botany and Chemistry; Dr rer nat (PhD) University of Kaiserslautern, Germany. *Research:* We investigate plant surface waxes: their biosynthesis, accumulation during organ development, contribution to the physiological function as a transport barrier for water and volatiles, and ecological role in plant-insect interactions.
www.botany.ubc.ca/jetter.html
www.chem.ubc.ca/personnel/faculty/jetter

Pierre Kennepohl, Assist. Prof., Dept. of Chemistry; PhD Chemistry, Stanford University, CA, USA. *Research:* Application of spectroscopic methods to the identification and characterization of reactive intermediates involved in biological and homogeneous catalytic processes, paramagnetic resonance and X-ray spectroscopic studies of sulphur radicals in proteins, and X-ray spectroscopy of transition metal catalytic systems.
www.chem.ubc.ca/faculty/kennepohl

Brian S. Leander, Assist. Prof., Canadian Institute for Advanced Research Scholar, Depts. of Botany and Zoology; PhD Evolutionary Cellular Biology, University of Georgia, Athens, USA. *Research:* Our research deals with the discovery and characterization of organismal diversity and with comparative analyses of complex ultrastructural systems in marine protozoa and enigmatic metazoan, using electron microscopy, light microvideography and molecular phylogenetics. These studies provide the foundation for understanding the evolutionary history of life, the common properties of all eukaryotic cells, and the key innovations associated with broad patterns of morphological change.
www.botany.ubc.ca/bleander/home.html

Jennifer A. Love, Assist. Prof., Dept. of Chemistry; PhD Chemistry, Stanford University, CA, USA. *Research:* Research in my group focuses on the development


Love

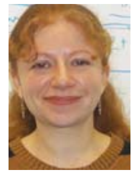

Maddison


Madison


Maldonado


Mitchell


Oser


Sheffer


Shurin


Welch

of new transition metal catalysts and reactions of broad utility in organic synthesis. This program combines mechanistic investigation with both organic and inorganic synthesis. www.chem.ubc.ca/faculty/love

Wayne P. Maddison, Prof., Canada Research Chair, Depts. of Zoology and Botany; PhD Biology, Harvard University, Cambridge, USA. *Research:* I develop methods that use phylogeny to understand evolutionary processes. Phylogeny of spiders is reconstructed and used to understand their behavioural and chromosomal evolution. www.salticidae.org/wpm

Kirk W. Madison, Assist. Prof., Dept. of Physics & Astronomy; PhD Physics, University of Texas, Austin, USA. *Research:* Quantum materials research with ultra-cold atomic gases. www.physics.ubc.ca/~madison

Maria T. Maldonado, Assist. Prof., Canadian Research Chair, Dept. of Earth & Ocean Sciences; PhD Biology, McGill University, Montreal, Canada. *Research:* We investigate the physiological mechanisms and regulation of trace metal acquisition by marine phytoplankton and the role of trace metal availability in controlling the ecology and evolution of marine phytoplankton and bacteria. www.eos.ubc.ca/research/geochem/maldonado.htm

Ian M. Mitchell, Assist. Prof., Dept. of Computer Science; PhD Scientific Computing & Computational Mathematics, Stanford University, CA, USA. *Research:* I study ways of quickly and correctly designing the hidden or embedded computers and protocols that run many modern devices—from airplanes to cell phones—using scientific computing methods, such as partial differential equations and optimization. www.cs.ubc.ca/~mitchell

Scott M. Oser, Assist. Prof., Canada Research Chair, Dept. of Physics & Astronomy; PhD, University of Chicago, IL, USA. *Research:* My research is in the area of particle physics, especially neutrino physics. I lead groups at UBC working on the Sudbury Neutrino Observatory (SNO) in Canada, and on the K2K and JHFnu neutrino experiments in Japan. www.physics.ubc.ca/~oser

Alla Sheffer, Assist. Prof., Dept. of Computer Science; PhD Computer Science, Hebrew University, Jerusalem, Israel. *Research:* My current research focuses on digital geometry processing and evolves around meshes (polygonal model representations). The main application areas of this research are computer graphics, scientific computing and computer-aided engineering applications. www.cs.ubc.ca/~sheffa

Jonathan B. Shurin, Assist. Prof., Dept. of Zoology; PhD Ecology and Evolution, University of Chicago, USA. *Research:* I am a community ecologist studying the processes that control diversity and abundance of organisms, especially in fresh waters. In addition, we investigate food web structure and function, comparing distinct ecosystems. www.zoology.ubc.ca/~shurin

William J. Welch, Prof., Dept. of Statistics; PhD Mathematics, Imperial College, University of London, UK. *Research:* My research has been primarily in design of experiments involving complex computer models of systems. More recently, I have worked on data mining, with applications in pharmaceutical drug discovery. www.stat.ubc.ca/people/will

Just recently also the following new faculty members were appointed.

Leticia Aviles, Assoc. Prof.,
Dept. of Zoology.
www.zoology.ubc.ca/zoology/z/aviles
Robert Bridson, Assist. Prof.,
Dept. of Computer Science.
www.cs.ubc.ca/~rbridson
Eric Cytrynbaum, Assist. Prof.,
Dept. of Mathematics
Ivar Ekeland, Prof., Dept. of Mathematics
Erin Gaynor, Assist. Prof.,
Dept. of Microbiology & Immunology
Marc Horwitz, Assist. Prof.,
Dept. of Microbiology & Immunology
Kalle Karu, Assist. Prof.,
Dept. of Mathematics
Charles Krasic, Assist. Prof.,
Dept. of Computer Science;
www.cs.ubc.ca/people/profiles/krasic.html
Evgeny Pakhomov, Assist. Prof.,
Dept. of Earth & Ocean Sciences
Paul Rasmussen, Sr. Instructor,
Dept. of Chemistry
Dominik Schoetzau, Assist. Prof.,
Dept. of Mathematics.
www.math.ubc.ca/~schoetzau
Fei Zhou, Assist. Prof., Dept. of Physics
& Astronomy.
www.physics.ubc.ca/php/directory/research/fac-1p.phtml?entnum=281

Faculty of Science: Kudos and News

In 2003 members of the Faculty of Science again won numerous national and international awards

Fellow of the Royal Society of Canada
- James V. Zidek, Prof. of Statistics
- Daniel Pauly, Prof. of Zoology
- Marc Bustin, Prof. of Earth & Ocean Sciences

Member of the Order of Canada
- David Jones, Prof. of Zoology

Queen's Golden Jubilee Medal
- Ronald M. Clowes, Prof. of Earth & Ocean Sciences

Fellow in the American Physical Society
- Doug Bonn, Prof. of Physics & Astronomy
- Matthew Choptuik, Prof. of Physics & Astronomy
- Walter Hardy, Prof. of Physics & Astronomy
- George Sawatzky, Prof. of Physics & Astronomy

Fellow of the Institute of Mathematical Statistics
- Nancy E. Heckman, Prof. of Statistics

Fields Prize for Mathematics, Centre de Recherches de Mathématique
- Edwin Perkins, Prof. of Mathematics

Coxeter-James Prize, Canadian Mathematical Society
- Jingyi Chen, Prof. of Mathematics

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

National Learning Infrastructure Initiative (NLII, EDUCASE) Fellowship
- Cyprien Lomas, Research Associate, Faculty of Science, Skylight: The Science Centre for Learning and Teaching

Krieger-Nelson Prize, Canadian Mathematical Society
- Leah Keshet, Prof. of Mathematics

John Simon Guggenheim Fellowship
- Dolph Schluter, Prof. of Zoology, and Canada Research Chair

President's Medal, Society for Experimental Biology
- Colin J. Brauner, Prof. of Zoology

Aventis Pharmaceuticals Award, American Society for Microbiology
- Bob Hancock, Prof. of Microbiology & Immunology

BC Biotechnology Award for Innovation and Achievement
- Brett Finlay, Prof. of Microbiology & Immunology

Fisher Scientific Award, Canadian Society of Microbiologists
- Francois Jean, Prof. of Microbiology & Immunology

Fry Medal, Canadian Society of Zoologists
- William K. Milson, Prof. of Zoology

Beverton Gold Medal, Fisheries Society of the British Isles
- Tony Pitcher, Prof. of Zoology

Criddle Award, Entomological Society of Canada
- Rex Kenner, Prof. of Zoology

J.P. Tully Medal in Oceanography, Canadian Meteorological and Oceanographic Society
- Steve Pond, Prof. Emeritus of Earth & Ocean Sciences

Tuzo Wilson Medal, Canadian Geophysics Union
- Garry Clarke, Prof. of Earth & Ocean Sciences

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Photo courtesy of Martin Dee

John Hepburn at helm as new dean
John W. Hepburn, professor of the UBC Departments of Chemistry, and Physics & Astronomy, was appointed dean of the Faculty of Science November 1, 2003. Dr. Hepburn came to UBC as head of the Chemistry Department in 2001. He began his academic career at the University of Waterloo in 1982 as assistant professor of Chemistry and Physics and became chair of the Department of Chemistry in 1998.

Maria Klawe now at Princeton
After fourteen years at UBC, first as head of the Department of Computer Science, then as vice president for student and academic services, and finally, as dean of Science, Dr. Klawe is now dean of the School of Engineering and Applied Science at Princeton University, USA. She also holds a professorship in their Department of Computer Science.

New "Science"- Websites
www.science.ubc.ca Re-invented. Explore the UBC world of science.
www.essential.science.ubc.ca A great resource for all science students.
www.skylight.science.ubc.ca The Science Centre for Learning and Teaching.
aboriginal.science.ubc.ca Aboriginal science students concerns and issues.

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