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University of British Columbia
Faculty of Science

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Understanding the Effects of Low Oxygen

Hochachka has received the two highest awards for science in Canada: the Killam Memorial Prize in 1993, and the NSERC Gold Medal in 1995.

What happens to the body when it is deprived of accustomed levels of oxygen? UBC zoologist Peter Hochachka has taken this question further than any other scientist. For more than 20 years, he has studied the effects of hypoxia on animals and humans. In the process he has provided the scientific community with considerable new information, and many more questions to ponder.

I met Peter Hochachka in the PET scanning area of the UBC hospital excitedly viewing the latest scans of test subjects with co-researcher Campbell Clark, and planning their submission to *Science*. The scans showed distinctly different before and after pictures of the brains of U.S. marines who had spent two-and-a-half months at altitudes ranging from 3,000 to 4,000 metres.

Clark explained what the differences mean. The scans clearly indicate that after adaptation to low-oxygen conditions, the brains of these marines began to consume energy quite differently. There was a more than 10 percent drop in the energy consumption high up in the brain, and a 15 percent increase in consumption by the cerebellum (or lower brain). "We're seeing change in the frontal cortex, phylogenetically the newest part of the brain, supposedly responsible for our more rational, complex functioning," said Clark.

This discovery, significant on its own, also forms part of a body of research on the effects of low oxygen that Hochachka has been gathering for over two decades. He began his study of hypoxia by looking at the diving responses of animals, and his work is continuing in this area. In some ways Hochachka says he prefers studying animals because their adaptations are so dramatic.

For example, in his study of the diving response cont'd. on pg. 3

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Faculty of Science Awards Scholarships

EVERY YEAR, THE FACULTY OF SCIENCE awards scholarships to several outstanding science students. This year's winners include Christopher Zygmunt Radziminski in Microbiology, Andrew Sheng-Pei Lim in Honours Biochemistry, Albert Yee-Hang Lai in Computer Science, Nicola Kim Jones in Oceanography and Chemistry, and Amy Yen-Ning Huang in Chemistry.

The Faculty of Science Scholarship Fund, and the Dean of Science Opportunity Fund are both supported by donations. The Scholarship Fund enables UBC to attract top science students, while the Opportunity Fund provides the Faculty of Science with funds for special initiatives, such as recruiting and emergency research funding. Support for these funds is always welcome.

First Grad Class for Science One

TWENTY-EIGHT STUDENTS FROM THE INAUGURAL SCIENCE One class of 45 students will be graduating this year. (Shown here are some of the founding members of the Science One Survivors (SOS) Club at the "Tree Dedication Ceremony" back in April 1994. The tree too, is thriving.)

Photo: Science One

According to Science One Director Jülyet Benbasat, several of these students will be continuing their education at graduate schools such as Harvard, MIT, Indiana University, the University of Calgary and UBC. Others are looking at a variety of interesting career opportunities.

Many of the remaining 17 students are in the UBC Co-op Program, in double honours or Engineering Physics, which require an additional year of study before graduation. One Science One student entered Medical School at UBC after his third year, and one has been admitted to law school.

According to Benbasat, "The Science One faculty members are proud to have been a part of the students' formative years at this University. This class of risk-takers participated in a challenging new program which represents the most significant innovation to teaching in the Faculty of Science in twenty years."

Co-op Poised for Further Growth

THE FACULTY OF SCIENCE CO-OP PROGRAM KEEPS GETTING bigger and better, with a record 300 placements for 1997. Co-op director Javed Iqbal has ambitious plans for continued growth, with new co-op programs in the works for earth and ocean sciences, environmental sciences, and biological sciences.

According to computer science student Edna Lee, the Co-op Program has given her a better appreciation for what she is learning in class. "The concepts being lectured on are no longer just abstract and dreamy concepts, but very real." Lee said her grades have shot up over the past two years as a result. She was recently placed at Hughes Aircraft of Canada where she helped maintain and update a test database application.

Currently, co-op is an option for students in computer science, chemistry, physics, statistics, mathematics, microbiology, engineering physics, atmospheric sciences and pharmacology. "The goal is to make co-op an option available to all students in the Faculty of Science within the next five years," said Iqbal.

The UBC Co-op Program is highly successful – 95 percent of students were placed last semester. Students, employers and the university all benefit. Iqbal says the program is a great way to integrate academic and on-the-job learning. "Co-op students can make informed decisions about their future." About 40 percent go on to graduate school, and the rest have no trouble landing good jobs straight out of university.

Year-round Study at Bamfield Marine Station

STUDENTS OF THE MARINE Biology Program, and others studying in the Department of Zoology have been able to do part of their course work at the Bamfield Marine Station during the summer. This year, for the first time, the research and teaching facility is open to students year-round, starting with the upcoming fall semester.

The Station, located in the picturesque village of Bamfield on the west coast of Vancouver Island, was established in 1972 by a consortium of five western Canadian universities, with support from NSERC. A wide variety of marine habitats are accessible from this unique facility.

Great Year for Mathematics Department

IT WAS A BANNER YEAR FOR THE UBC Department of Mathematics, with faculty members and students picking up numerous awards, according to Department Head Ulrich Haussmann.

An interdisciplinary team led by Priscilla Greenwood won the inaugural Thematic Concentration Competition sponsored by the Wall Institute. This award, of up to $500,000, will support research and academic programs including graduate student and post-doctoral fellowships.

Several individuals recently received awards. Joel Feldman was elected to the Royal Society of Canada and was the third-ever recipient of the John L. Synge Award, the top research prize in mathematical sciences in Canada. Michael Ward won the Coxeter-James Prize, which is given annually by the Canadian Mathematics Society to an outstanding Canadian mathematician under 40. Ed Perkins won the G. de B. Robinson Award.

Students in math also won awards this year. Undergraduate Vera Hoffman won the E. Gordon Young Scientist Prize, and Jim Morey and Djun Kim won Sun workstations in the JavaCup programming contest.

According to Haussmann, "A great deal of effort is going into nurturing the budding Pacific Institute for Mathematical Sciences." The Institute, founded by 5 universities in western Canada including UBC, is committed to enhancing mathematical sciences through support for basic research and applications. NSERC has committed $200,000 per annum so far to this collaborative project which is centred in Vancouver.

Understanding Effects of Low Oxygen; cont'd. from pg. 1 of seals, he is discovering how the animals are able to control their heart function and flow of oxygen to specific tissues. Magnetic resonance imaging (MRI) technology is enabling researchers like Hochachka to non-invasively view the working responses of organs to different conditions.

"Some of the first images of the heart were so exciting to the MRI people, I had to calm them down," said Hochachka. "All previous studies of the physiological diving responses have been like a snapshot in time. With MRI, we can achieve continuous monitoring of function for as long as we want through the dive. This is opening up a whole new chapter in the research, and there may be some interesting surprises."

Interesting surprises are not new to Hochachka; he has conducted many unique experiments in the course of his career. For example, when he started studying the effect of hypoxia in humans, he bucked the tradition in this research, which was to bring the laboratory to the subject and do mostly field work. Instead, he flew Sherpas (see sidebar)from the high Tibetan plateau, and Quechua Indians from the Peruvian Andes to UBC for study in the lab.

Hochachka focused on the physiology of these high-mountain dwellers, specifically how their heart functioning has adapted to their low-oxygen environment. Not only has the research led to new information on how human hearts adapt to prolonged limitation of oxygen, but it could also lead to new understanding about the early stages of heart disease, and improved treatment.

Sherpas Uniquely Adapted

Sherpas, who have lived for generations on the high Tibetan plateau, and who regularly trek up to altitudes as much as five miles above sea level, are better adapted to low-oxygen environments than any other humans on earth. What Hochachka discovered when he studied the Sherpas in several university and hospital labs, was that their hearts metabolize differently from the rest of us.

Hochachka's research, published last year in the *Proceedings of the National Academy of Sciences,* shows that Sherpa hearts use glucose rather than fatty acids as their primary energy source. By adjusting fuel preference, Sherpa hearts gain more useful energy from oxygen than do the hearts of lowlanders. Sherpas are also unique in that they do not produce an increased number of blood cells when adapted to high altitudes.

Photo: Peter Hochachka

The six Sherpas, shown here in Tibet, spent six weeks here in Vancouver and other North American cities for the study.

There are many potential gains from the results of this research. These include a better understanding of heart disease, of human adaptation to the environment over hundreds of generations, and of the effects of hypoxia in general.

At Home in Two Worlds

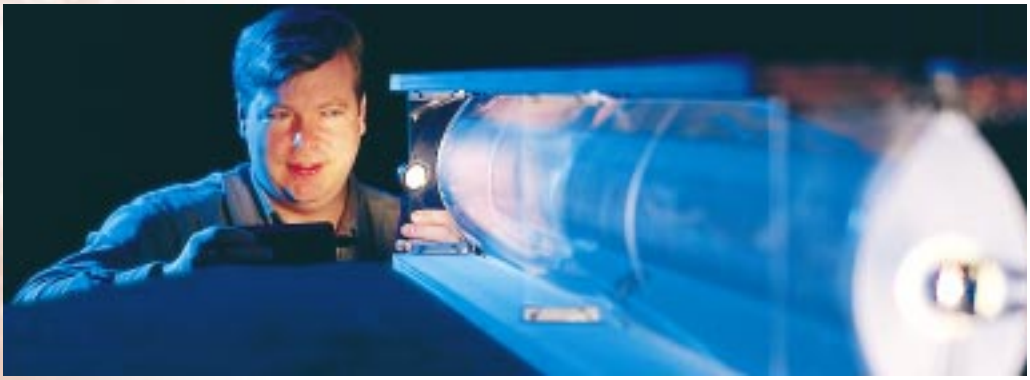
Lorne Whitehead is one of those rare faculty members who appears to be equally at home in the world of industry and academia. He has achieved a high degree of success in both.

To glance at Lorne Whitehead's C.V., it may be hard to believe that all of the accomplishments listed have been achieved by one man (and not a very old one at that). For example, in the area of new inventions, he has 36 patents to his credit, six more now in the application process, and 24 records of invention under active consideration for patents.

Whitehead's career to date could be a model for how to successfully transfer university research to industry. His first invention to be commercialized was the prism light guide system, a technology which was transferred to Vancouver-based TIR Systems Ltd., a UBC spin-off company. Whitehead took a very active role in the company in its early years, and TIR is now thriving on its own.

According to Whitehead, the goal upon founding TIR was to make it the world leading manufacturer of prism light guide-based products for niche markets, and things are going according to plan. 3M Corporation became involved in Whitehead's work in 1985, both from an industrial and academic perspective. In 1993, 3M bought some of TIR's technology for $3.5 million, which it now licenses back to TIR and other organizations according to a joint plan to expand the light guide illumination industry. The Corporation also partially funds the NSERC-3M Structures Surface Physics Chair which Whitehead has held since 1994.

While TIR and 3M are commercializing one aspect of Whitehead's work, there are many other promising research and industrial avenues to explore. "The key to an efficient light pipe is microprisms," said Whitehead. When the light pipe was patented, it was not possible to build precision microstructures and Whitehead had to resort to crude conventional plastic molding methods until 3M's micro-replication made the invention practical. Now 3M has extended this manufacturing capability in a number of areas, opening up exciting new avenues of exploration in Whitehead's lab.



Whitehead currently divides his time between research and teaching within the Department of Physics & Astronomy at UBC, and continuing involvement with technological business activities initiated as a result of his discoveries.

One result of this UBC-3M collaboration was the accidental discovery of a way to make sound using elastomeric microstructures. If this specialized elastomeric surface has metal pressed against it, and AC voltage is applied, the micro air pockets between the rubber and metal can tolerate a very high electric field. This unique technology has commercial applications and was recently spun off to a new company, GMW SpeakerTape Corporation.

There are many other potential applications for the technology developed in Whitehead's research lab – from using microstructures to reduce drag on airplane wings, to improved screens for laptop computers. Already, Whitehead and 3M's technology can be found in most newer laptop computer screens – prismatic material channels the light so it is twice as bright when looked at straight on, but without using extra power.

Whitehead is currently dividing his time between many different, but related interests all aimed at furthering both the knowledge and practical uses of precision microstructures. He has found a way to integrate academic research with industrial development so that everybody wins.

The Research Team

Whitehead is currently working with several graduate students who are furthering his basic research. For example, recent masters graduate Mike Donaldson pioneered a new type of micro-structured light guide that does not require a tube to pipe light. The project has received an Edith Guth Award of Merit from the Illuminating Engineering Society of North America for excellence in the field of illumination research.

Another student, Wei Su, has taken up a more theoretical problem: how perfectly could you make a prism light guide, assuming the construction was mathematically perfect and there was no light absorption? According to Whitehead, her answer bodes well for long-term research in the field.

Three other graduate students, Alison Clark, Michele Mossman, and Dmitri GrandMaison are studying the basic mechanical and electromagnetic physics of elastomeric structures. Research engineers Peter Kan and Robin Coope are studying applications of these concepts in several new devices.

Discovering the Brain's Caretakers

Most people consider the fruit fly nothing but a common pest. To Vanessa Auld, assistant professor in UBC's Zoology Department, and head of a developmental neurobiology lab, the ubiquitous Drosophila *is the perfect organism to help shed new light on the complex workings of the peripheral nervous system in humans.*

DISCOVERING PARALLELS IN THE NERVOUS SYSTEMS OF humans and fruit flies might seem a bit Kafkaesque for some, but Vanessa Auld considers them simply variations on a theme. "It makes logical sense," states Auld. "If you are going to set up a complex system, you might as well just use it over and over again."

She attributes her postdoctoral work with Dr. Cory Goodman at the University of California (Berkeley) to steering her in the direction of *Drosophila* and developmental neurobiology. Auld's primary area of research is on glia and how they interact with neurons. Although her work concentrates on the peripheral nervous system, glia are also the most predominant cells in the brain, outnumbering neurons by a ratio of 50 to 1 in some areas of the human cortex. Therefore, their function is extremely important to both the peripheral and central nervous systems.

Glia could be described as the custodians of the nervous system, a combination of valet, cook, housecleaner, and security guard. "I like to tell my students their function is 'To Serve and Protect'," says Auld.

One of their main functions is the production of myelin, the protective sheath around the axons of nerves which allows for the fast and efficient transfer of impulses. Glia supply nutrition to the neurons, clean up damaged cells, excess ions and neurotransmitters, and in general, keep everything calm and regulated so that the brain can function, even under stress or extreme conditions.

Auld's research examines the role played by gliotactin – a protein isolated from *Drosophila* glia – in setting up the blood-brain barrier in insects. This protein allows the wrapping of axons which forms the physical barrier between the blood of the insect and the nerve. The blood-brain barrier is the critical filter between the body's blood supply and the brain. Although glia don't form the blood-brain barrier in humans, they are involved in setting it up.

Vanessa Auld's research on mutating the glia in fruit flies recently earned her a five-year Howard Hughes Medical Institute International Research Scholarship.

Auld credits much of the work to her diligent lab team of six students, a technician and a post-doctoral fellow. Their multi-disciplinary approach uses genetics, cell biology, molecular biology and electron microscopy – assisted by a lot of coffee – to help find the *Drosophila*-vertebrate connection.

Understanding how the nervous system develops could lead to discoveries about its navigation and protection mechanisms, as well as its regenerative capacities. Although there are possible industrial applications, such as in the pesticide industry, Auld says these applications come only after basic research. "People don't make large industrial discoveries looking for something specific. It is always serendipitous."

Glia guidance system – a fantastic voyage.

In the embryonic nervous system the glia set up a navigational highway or road map which help the axons to grow towards their targets. The pathway travelled from the tip of the finger to the brain in adult humans, for example, is extremely long and complex, and yet the sensory neurons rarely take the wrong turn. This is one of the glial characteristics which fascinates Vanessa Auld, and her laboratory is examining how glia (dark spots at left) act as some of these navigational clues by looking at what happens if they are removed. The simple structure of *Drosophila* glia make them very easy to mutate and clone, and this is an integral part of the research. "If we know what cues are involved in getting the axons to their proper targets, we may be able to take advantage of those cues to help with regeneration if the nervous system is damaged." Although primarily involved with the peripheral nervous system, Auld's research could help to shed light on devastating diseases of the central nervous system, such as multiple sclerosis.

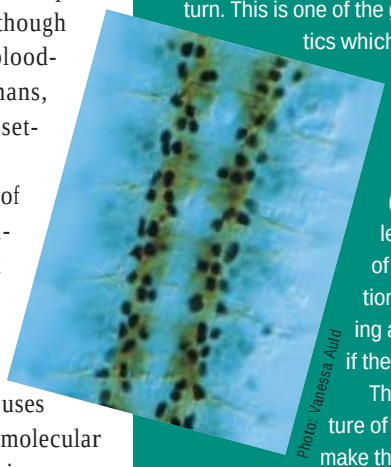


Photo: Vanessa Auld

Changing Data into Information

If the word statistics conjures up images of boring rows of numbers, think again. "Changing data into information," is John Petkau's succinct description of the job of a statistician, and he finds it anything but boring.

WHAT DREW PETKAU TO THE FIELD OF STATISTICS WAS ITS combination of elegant mathematical modeling and real-world practicality. "Statistics is typically a very collaborative discipline which can be applied to any field of endeavor from zoology to fine arts. As a statistician, there's always the opportunity to learn something new."

Petkau's work over the past ten years has been part theoretical and part practical. He is involved in a study of the effects of air pollution on respiratory health, and also in clinical trials for new drugs to treat multiple sclerosis (MS).

Currently, MS research is Petkau's main focus. The field was relatively quiet until about four years ago, when new compounds were discovered that significantly reduced the rate of MS attacks. This has caused a flurry of activity that is leading to new treatments for the debilitating disease.

Petkau works in collaboration with Don Paty, head of the UBC MS Clinic and MS/MRI Research Group in the Faculty of Medicine. One of his roles is to assist in the design of clinical trials. Petkau underscores how critical it is that the trials be set up in a way that yields usable data – clinical trials can take years and cost plenty. It is a shame when such efforts go to waste due to poor research design.

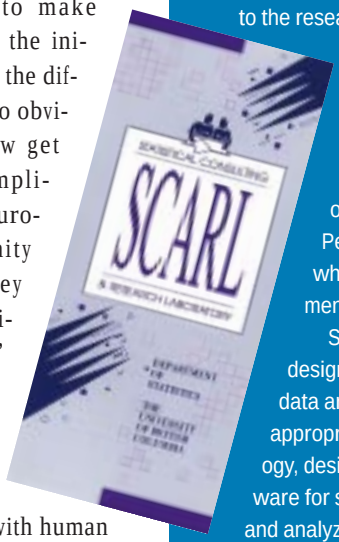
Petkau's job is essentially taking raw data and making sense of it, not only for himself, but also for the researcher who has presented him with the data. Essential parts of this job include planning the study that leads to the data, and if necessary, developing new methods to properly analyze the data.

In the initial testing of the new compound that was discovered to have a marked advantage over then-current treatment modalities, it was relatively easy to prove the benefits since they were so dramatic. However, researchers in the field are currently working to make improvements on the initial discovery, and the differences are not so obvious. "Things now get much more complicated and the neurological community has realized they need to get statisticians involved," said Petkau.

Another project he is currently involved in also has to do with human health. Petkau is collaborating with Sverre Vedal of the Respiratory Division of the Faculty of Medicine in interpreting data on air pollution and respiratory health. A study, carried out in Port Alberni tested 200 school children on a daily basis for two years, monitoring lung function and various respiratory symptoms. At the same time, air pollution readings were taken at two sites in the town every day.

A huge amount of data has been gathered, and researchers hope to answer a number of questions based on the information they have painstakingly collected. However, turning that mountain of data into something meaningful is no easy task. It is just the type of job a statistician like Petkau loves.

Assisting Research in British Columbia



The Statistical Consulting and Research Laboratory (SCARL) is a valuable service UBC statisticians and staff provide to the research community… within UBC and beyond. "We can help with problems that will enable researchers in virtually any discipline to do their own work better," said John Petkau, director of SCARL, which is run by the Department of Statistics.

SCARL services include designing experiments before data are collected, advising on appropriate statistical methodology, designing methodology or software for specific statistical tasks, and analyzing data to make it concise and informative. SCARL has been operating at UBC for more than 20 years.

Some recent inquiries at SCARL provide a glimpse of the diversity of subject areas in which statisticians can assist. Clients have approached SCARL for help with everything from the effect of public speaking skills training for treatment of social phobia to evaluation of ship-hull performance; from development of an expert system for how judges determine the pain award for whiplash victims to the effect of packaging techniques on the quality retention of prawns. "Anytime someone is trying to quantify something, ideally there will be a statistician involved," said Petkau.

"Let Curiosity Reign"

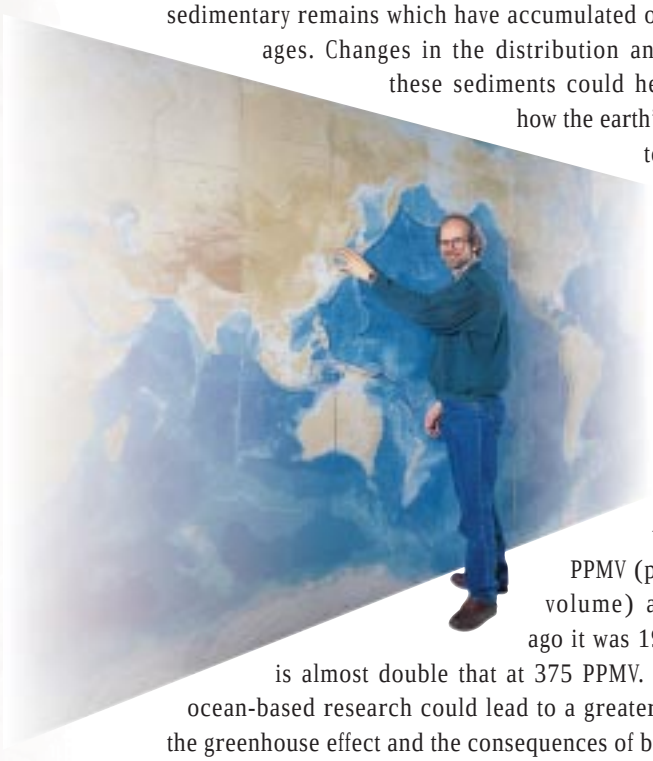
If looking into the past is a way to discover our future, Tom Pedersen's study of the history of organic sedimentation on the ocean floor should lead to vital clues about the relationship between climate change and the environment. As a scientist who focuses on basic research, but whose work has also led to important industry applications, Pedersen is a fervent believer in the necessity of pure science – to foster curiosity for the sake of discovery.

According to palaeoceanographer Tom Pedersen, we should be on the downward slope towards the next ice-age, perhaps in the next 20,000 years or so. For most of us, this seems incomprehensibly remote from our present existence. For Pedersen, the study of glacial remains over the last 150,000 years is recent history. What much current research is suggesting, however, is that the ice-man might not 'cometh' after all. Pedersen hopes to find out if this is so, and why.

"For the past two and a half million years, the earth – or at least Canada – has been covered with ice more often than it hasn't," says Pedersen. Some of the questions he is trying to answer are: How did the ocean interact with the rest of the earth's systems during the cyclical glacial and inter-glacial periods? Was the ocean responding, or was it responsible? And exactly how might the ocean have caused the carbon dioxide content in the atmosphere to decrease so dramatically during glacial periods?

Photo: Lorax Environmental Services Limited

Many of the answers lie at the bottom of the sea, in the organic sedimentary remains which have accumulated over the last 20 ice ages. Changes in the distribution and composition of these sediments could help us understand how the earth's climate responds to rapid changes in the composition of the atmosphere. Prior to the year 1700, or before the Industrial Revolution, the carbon dioxide content was about 285 PPMV (parts per million by volume) and 18,000 years ago it was 190 PPMV. Today, it is almost double that at 375 PPMV. Pedersen says the ocean-based research could lead to a greater understanding of the greenhouse effect and the consequences of burning fossil fuels.



Tom Pedersen recently received a Killam Faculty Research Fellowship, He is one of the scientists whose work appeared in the latest report of the Intergovernmental Panel on Climate Change.

Pedersen's research team is working around the world – off the coasts of Japan, Alaska, Chile, Vancouver Island, California, as well as the in the equatorial Pacific and the Indian Ocean – to try to discover the solutions.

Even though he is not an applied scientist, Pedersen acknowledges the importance of partnering with industry to come up with environmental solutions. "I believe the university's role is strongest in pushing back the boundaries of basic science," says Pedersen. "Industry will take care of the applications."

Cleaning up

Tom Pedersen's research into aquatic contamination is tangential to his work in palaeoceanography, and it has led to important applications for the disposal of mine waste. Primarily industry-funded, his research on the chemical behaviour of mine waste in lakes and in the ocean strongly suggests that sulphide-rich mine tailings do not react significantly when submerged under water. With a single mine producing tens of thousands of tonnes of tailings per day, this is an important discovery, since standard industry practice has traditionally been to dispose of them on land.

According to Pedersen, tailings deposits on land can represent environmental time bombs, since sulphide minerals are easily oxidized. With the help of the sulphur-oxidizing bacterium *Thiobacillus* ferrooxidants, the tailings react with oxygen in the atmosphere to produce sulphuric acid and a soup of dissolved metals that seep into surface runoff and ground water, destroying flora and fauna. "Britannia Creek is a good example," notes Pedersen.

Creating reservoirs to keep tailings submerged or carefully placing them on the sea floor could prove to be a much safer solution once the necessary chemical, biological, oceanographic and engineering studies are undertaken.

This research has helped former student Jay McNee launch his own company, Lorax Environmental Services Ltd., which provides research and consulting services to the mining industry. Lorax and Pedersen received a joint grant from the Science Council of B.C. to undertake a two-year research and development program. The work is partly supported by Placer-Dome Inc. and will be carried out at UBC. Lorax now employs six people, including partner Dr. Ali Sahami, and Alan Martin – both former members of Pedersen's research group at UBC.

AMPEL receives equipment donation

AMPEL (Advanced Materials and Process Engineering Laboratory) has received a large equipment donation from TRIUMF. According to AMPEL director and Physics & Asronomy Professor Tom Tiedje, the new microfabrication equipment, worth over $1 million, will be used for making electronic and optical devices, and for micromachining.

Bonn Wins Herzberg Medal

Douglas Bonn is winner of the 1997 Herzberg medal awarded by the Canadian Association of Physicists for outstanding achievement by a physicist 40 years of age or younger. Members of the UBC Department of Physics and Astronomy have won five of the last nine Herzberg awards. Last year's winner was UBC's Bill Unruh.

Did you know…

that in 1996/97 the Science Faculty won every on-campus research award for which they applied? Members of the Faculty of Science also swept the Killam Awards this year.

Affleck Captures CAP-CRM Prize

UBC Physicist Ian Affleck won the 1997 CAP-CRM Prize in Theoretical and Mathematical Physics. The award, given jointly by the Canadian Association of Physicists and the Centre de Recherches Mathematiques, recognizes excellence in the fields of theoretical and mathematical physics. Affleck's research focuses on the area of overlap between elementary particle theory and condensed matter theory.

Auld Wins Howard Hughes Research Award

Biologist Vanessa Auld (featured in this issue) was recently awarded a Howard Hughes Medical Institute International Research Scholarship. This prestigious award provides Auld with US $55,000 per year for five years.

New Royal Society Fellows

Julian Davies of Microbiology and Immunology, and Nick Pippenger of Computer Science were among the Faculty of Science members elected this year to the Royal Society of Canada. Davies heads the UBC Department of Microbiology and Immunology, and the West-East Centre for Microbial Diversity, as well as conducting research into microbes and which would lead to the development of new antibiotics. Pippenger's research focuses on theoretical computer science, particularly complexity theory, and related mathematics.

Cominco Chair in Minerals and the Environment

Leslie Smith of the Department of Earth and Ocean Sciences was recently named Cominco Chair in Minerals and the Environment. His research focuses on groundwater hydrology, including mathematical modeling of fluid flow, with applications to problems in groundwater contamination, hydrological processes in waste rock pile, and the design of groundwater monitoring networks at hazardous waste management sites.

Student Wins NSERC Award

Timothy Chan, a student in the Department of Computer Science, won the 1997 NSERC Doctoral Prize for his Ph.D. thesis. At 19, Chan completed one of the most remarkable theses seen in computational geometry in many years.

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