*Advancing Research and Teaching in the University of British Columbia Faculty of Science*

UBC Science Synergy

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# Searching for Beauty

*Beauty, symmetry and elegance are terms that bring to mind a dancer, a flower, maybe a work of art. Mathematics is not a common association to these terms, except in the minds of people like Ian Affleck, a theoretical physicist who tackles some of the most difficult problems he can find in his field, not just for the challenge, but also for the experience of beauty.*

***High-temperature super-conductivity is a problem that has generated volumes of scientific literature from around the world over the past decade, and to date, no definitive solutions. "It is one of the great theoretical challenges of physics," said Affleck, UBC Physics professor and a Fellow of the Canadian Institute for Advanced Research.***

Ian Affleck feels he has the best of both worlds. As a theoretical physicist, he can apply "beautiful, symmetrical mathematical ideas" to some of the basic questions of the universe. However, he has moved from the most fundamental of the physical sciences, elementary particle theory, which is the study of the very smallest particles of matter, to more directly observable phenomena found in the field of condensed matter theory.

"With elementary particle theory, I felt it was getting very mathematical, and further away from experiments," said Affleck. "I was attracted to the beauty of the mathematical form, and became fascinated by the possibility of applying these same ideas to areas that were more directly observable."

Affleck made the switch to condensed matter theory about ten years ago, shortly before starting as a professor of physics at UBC and hasn't looked back. He gets to work with the same elegant mathematics, but on phenomena that are directly observable. The results of his work are not only interesting on a theoretical level, but may have some practical usefulness as well.

One area that Affleck is working on is the theoretical understanding of high-temperature superconductors. Gaining a greater understanding of the nature of these complex materials could have practical, as well as intellectual, benefits. High-temperature superconductors have a variety of potential applications, including use in electromagnets for medical imaging, power grids, and new kinds of switches. As more is known about the nature of these devices, an increasing number of applications, many not yet envisioned, will become feasible.

Potential applications are one of the driving forces behind all the research into high-temperature superconductors. The intellectual challenge is another. "These new materials have very different properties from other superconductors. They have *cont'd. on pg. 3*

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## Science Student Wins National Art Competition


Steve Wong, a graduate student in microbiology, won a national art competition earlier this year held by the Pacific Salmon Foundation. His acrylic painting of a salmon was reproduced as a stamp to be attached to all saltwater fishing licenses in 1996.

Artists from across Canada were invited to submit a painting of any type of salmon. Proceeds of the sale of the stamps will be used to enhance salmon stocks.

Wong, who has been painting since he was 14, has won several national art competitions, including B.C. Outdoors, and Canadian Wildlife Artist competitions. His work mainly focuses on fish. He said fishing is also a hobby of his so he knows how to paint fish realistically, and how to get the details right.

Wong is nearly finished his Masters thesis in microbiology, and will pursue science as a career, but plans to keep fishing and painting as hobbies.

## Science First! Lectures Offered

The Faculty of Science has launched a series of lunch-time seminars aimed at exciting students' interest in science. Zoology professor Lee Gass started off the series Sept. 19 with a talk entitled *Where's the Science in Science Education?*

His goal is to "get students to understand how science operates and what science is as a human endeavour." He'd like them to "know in their bones that any creative process starts from a profound appreciation of our ignorance."

Several other science professors will also participate and speak informally to students about their research, why they became scientists, and what science means to them. Check out our website (http://www.science.ubc.ca/) for times and locations. Everyone is welcome.

According to Associate Dean of Science Jülyet Benbasat, the series is part of a concerted faculty effort to get students, especially those in first year, to rethink what it is about science that excites them most. "We're all putting more emphasis on enhancing the life skills of students and getting them to learn science for science's sake, rather than memorizing specific details which will, in many cases, be outdated in a few years."

Benbasat said the series is one part of a whole new vision that has been developed over the past 15 months by a 28-member committee of science professors, students and alumni. The committee's work was recently released in a comprehensive Strategic Planning Report, which includes many initiatives to enhance student learning and their ability to solve problems using knowledge from various disciplines. Benbasat said that the lunch-time seminar series is a precursor to many new initiatives that will be instituted to realize the Faculty's new vision.

## UBC Math Students Win in Java Cup

Two UBC graduate students in Mathematics, Djun Kim and Jim Morey, were among the winners in this year's Java Cup, an annual worldwide contest held by Sun Microsystems.

Contestants are required to write applications in the Java programming language. More than $1 million worth of prizes was awarded this year.

Kim won a $30,000 SPARC workstation for his interactive UBC campus map. The concept won second prize in the Java Cup's Internet/Web Agents division. Kim has since had an inquiry from Spain, where the application may be used as a front end to monitor harbour traffic. The map can be found on the Web at http://sunsite.utk.edu/winners_circle/internet/INGZP26A/applet_html.

For Morey, this was his second win in the Java Cup. Last year, he won a portable Sun workstation for his interactive proof of the Pythagorean theorem. This year, he won a SPARC desktop workstation and top prize in the entertainment and games section of the Java Cup for Copycat, a 3-D game.

The goal of Copycat, which has varying degrees of difficulty, is to use the least number of moves to replicate a 3-D design. Morey hopes the game will expose young people to challenging mathematical concepts that will give them the motivation to learn complex math. The game can be downloaded for free from http://sunsite.utk.edu/winners_circle/entertainment/ENZYKBAD/applet_html.

## Science One Update

*Science One*, an interdisciplinary sciences program for first-year students, is now in its fourth year. The first *Science One* students will be graduating this coming Spring. *Science One* alumni seem to benefit from the experience, excelling in their courses in ensuing years.

One former *Science One* student, Hamish Hwang, was admitted into Medicine at UBC after his third year in Biology. Two *Science One* grads, Fahreen Dossa and Paula Sharp, spent the summer working in NRC labs as participants in the National Research Council/Women in Engineering and Science program. Another, Karen Cheng, is among 25 young women across Canada selected for participation in NRC/WIES this year.

There are 72 students enrolled in *Science One* this year, chosen from 212 applicants. This year, students entering the Faculty of Science were also given a new Coordinated Science Option, and 101 students are enrolled in this program. CSO students take all of their core classes together, and are guided in their studies by a team of professors.

Many *Science One* students from last year spent their summers working in various labs at the UBC campus, putting the year of interdisciplinary learning to good use in research at the forefront of science. According to Jülyet Benbasat, Director of *Science One*, "The students surprised themselves, as well as their advisors, with their enthusiasm, knowledge, level of participation, and competence."

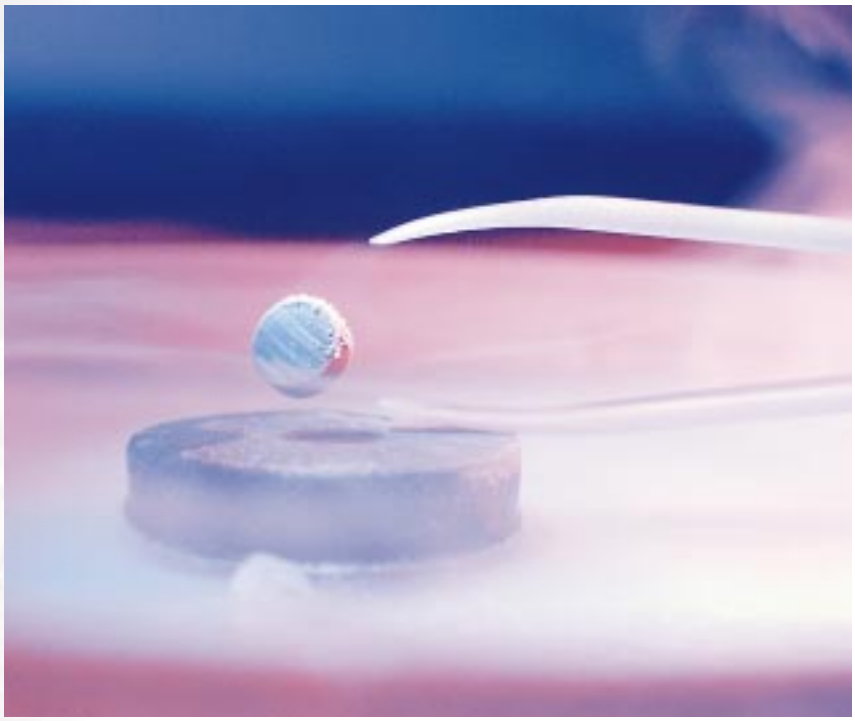
## Scholarship Winners Grateful to Alumni

Alumni, faculty and friends of the Faculty of Science raised over $80,000 for an endowment to create four $1,500 plus one $1,000 scholarships for undergraduate science students this year.

The endowment, called the Dean's Scholarship Fund, was raised in just the past three years. Dean of Science, Barry McBride, said he wants to thank the alumni for their support – it's making a big difference.

However, the Faculty has not yet reached its goal for the fund. At this time, we can only fund five students. In the future, we're hoping to be able to fund the top 30 students."

Scholarships are important because they provide access to science education for young adults, and rewards for their accomplishments. They also enable the Faculty to attract and recognize students who have demonstrated an aptitude for science.



***Searching for Beauty; cont'd. from pg. 1***

a complicated chemical composition, and exhibit rather mysterious behavior," said Affleck. "For example, at higher temperatures, they don't behave like normal metals. If you change their chemical composition slightly, they become insulators, (the very opposite of conductors)."

"The nature of these materials is a real mystery. The questions are still basically open," said Affleck. That is part of their attraction. That, and, for Affleck, the beauty and elegance of the mathematics required to conduct theoretical research in this field.

# Molecular Architecture

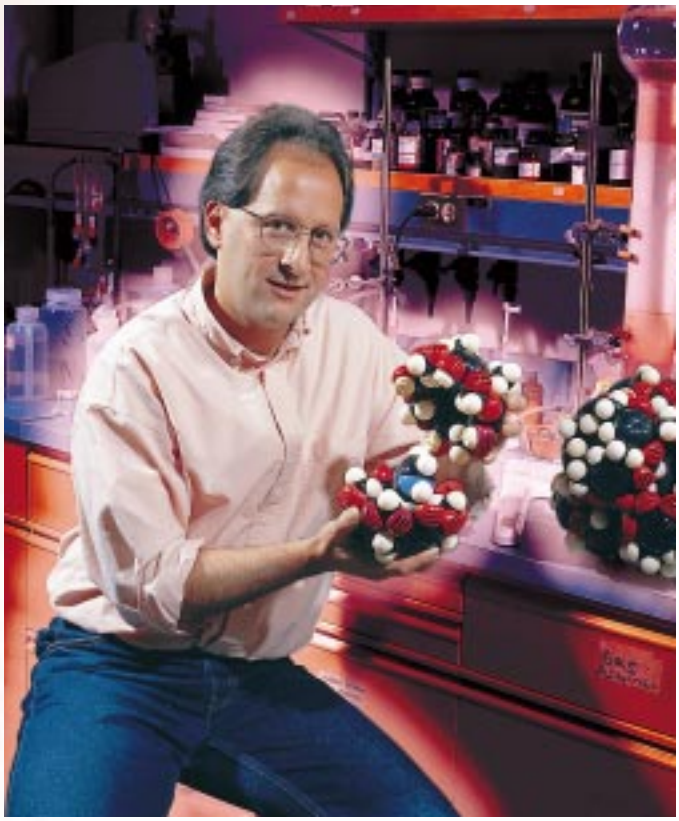
*John Sherman's research tends towards the philosophical, since much of his studies into organic chemistry are of situations that would never occur in the natural world. He has been able to make molecules do some things never done before in the lab or outside of it.*

JOHN SHERMAN IS AN ORGANIC CHEMIST WHO IS CARRYING ON THE WORK OF 1987 Nobel prize winner Donald Cram, who pioneered the study of carceplexes, complex molecules-within-molecules. Cram, who supervised Sherman's doctoral studies, "has asked me to carry the torch," said Sherman.

The knowledge acquired in the process may lead to innovative applications such as drug-delivery systems, pollution clean-up, sensors and switches. However, Sherman is not concerned with applications, but more with the research and discovery process itself. As an organic chemist, he focuses on designing new kinds of molecular structures, building them, and then studying them. "To a large extent, we create our own problems," said Sherman. "We're molecular architects."

He and Cram were the first to discover they could take two rigid, bowl-shaped molecules and trap a smaller one inside. The bonds linking the two bowls together can be permanent, or 'covalent', or they can close and open again under certain conditions.

For his Ph.D. at UCLA, Sherman studied the properties of a molecule trapped within a molecule, and asked what phase the 'guest' molecule was in: solid, liquid or gas. This is another philosophical question, according to Cram. Overall, the carceplex is solid, but inside, the small, trapped molecule is not in any of the three states, but somewhere between liquid and gas, according to Sherman.



***Sherman's work on developing carceplexes, molecules-within-molecules, may well prove to have significant practical applications even though his immediate focus is on the research and discovery process itself.***

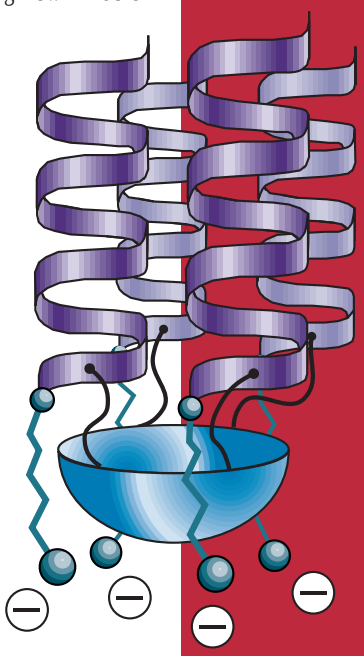
One thing Sherman is working on is making even bigger carceplexes, with four or more rigid-bowl-shaped molecules serving as a container. That way, much larger molecule could be encapsulated. "We might even be able to trap a few molecules and have interactions inside," said Sherman.

So far, he has been able to make a carceplex with four molecules enclosing a guest. He has also been able to covalently link two carceplexes together, a feat no other researcher has achieved before. Sherman said there was some serendipity involved in this discovery.

"It was a pleasant surprise. The same thing happened when we made the very first carceplex. We were actually setting out do something else." Many of the greatest original scientific discoveries come about in this 'accidental' fashion. However, these novel discoveries are never made unless researchers are pushing the frontiers of scientific knowledge in the first place.

## A New Twist

In addition to his ground-breaking work on carceplexes, Sherman is also developing his own proteins. These 'de novo proteins' are not found in the natural world, but they may be able to teach us a lot about how proteins parts interact.



Natural proteins, says Sherman, are way too complex to create, modify and study. He has created a four-helix protein, a common motif in nature, but has chosen his own peptide sequence, and made it much simpler than what one would find in the natural world. Sherman's main interest in this line of research is to develop a better understanding of how protein parts fold together.

# Interdisciplinary Approach to Bacterial Diseases

*In Brett Finlay's lab in the UBC Biological Sciences Building, he and about 15 researchers are conducting some of the world's leading research into bacterial diseases. Finlay's unique, interdisciplinary approach is leading to new knowledge about how bacteria cause disease. This basic research could lead to new ways to treat diseases such as* Salmonella, *and* Escherichia coli (E. coli), *which kills over one million children each year.*

THE MAIN REASON Brett Finlay is at the forefront of bacterial diseases research is that he was among the first to merge the fields of cell biology and microbiology, drawing relevant information and techniques from both. "It's fun to be in at the ground floor of the fusion of these two fields," said Finlay.

He started working in this emerging area while doing post-doctoral research in the laboratory of Stanley Falkow at Stanford University, and has not looked back since.

Finlay is a professor in three areas: the Biotechnology Laboratory, Biochemistry and Molecular Biology, and Microbiology and Immunology. The graduate students he supervises are almost evenly divided between microbiology and biochemistry, and he encourages them to move out of the comfort zone, to expand their repertoire. "You can no longer get by with just one skill set – the technology is changing so fast," said Finlay.

He uses this interdisciplinary approach to define, at a molecular level, the interactions that occur between pathogenic bacteria and host cells. The laboratory focuses on two diarrheal pathogens: *Salmonella typhimurium*, which enters into mammalian cells, and *Escherichia coli* (EPEC), which is an adherent pathogen.

***Brett Finlay's work has earned him international recognition. He is part of the Canadian Bacterial Diseases Center of Excellence, a Howard Hughes Medical Institute International Research Scholar, a Killam Research Prize winner and a Medical Research Council (MRC) Scientist award winner.***

EPEC is a leading cause of infantile diarrhea in developing countries, and claims more than one million lives each year. EPEC adheres to intestinal epithelial cells, and rearranges the host cell microvilli, causing the formation of a pedestal in the host cell. The exact mechanism by which EPEC causes diarrhea is still unknown, but understanding this mystery could lead to new forms of prevention and/or treatment.

Another major focus of Finlay's work is with *Salmonella*, which continues to cause health problems in both developed and developing countries. Intestinal epithelial cells do not usually take up bacteria, but they will take up *Salmonella*. Finlay and his team are working to identify the bacterial and host components involved in the life inside the cell. Again, a greater understanding may lead to new insights into how bacteria manifest disease, and to new therapeutic interventions.

"We're a problem-driven lab," said Finlay. "We'll use whatever technique we need to find an answer. This approach is more difficult, and riskier, but the pay-offs make it worthwhile."

## Biotechnology Laboratory

Brett Finlay is a member of the Biotechnology Laboratory, a highly interdisciplinary group, with researchers in various fields scattered throughout the UBC campus. The Lab includes many distinguished present and past members including the 1993 Nobel Prize in Chemistry winner, Michael Smith.

- Biochemistry
- Botany
- Chemical Engineering
- Electrical Engineering
- Forest Sciences
- Medical Genetics
- Medicine
- Microbiology & Immunology
- Neuroscience
- Plant Sciences
- Zoology

The members of the Biotech Lab represent a broad range of disciplines and are very well supported, with an average of $300,000 each in research grants annually.

According to Finlay, links have been made throughout many disciplines at UBC. "We are constantly shifting barriers. The joy of the Biotech Lab is that its members can go where they need to find required expertise. It's really interspersed throughout the whole university. There is a lot of talk about the need for interdisciplinary boundaries to be broken down — this is a working example of how it can be done."

# Goldberg Pioneers On-Line Education

*Computer Science instructor Murray Goldberg is experimenting with education delivery methods of the future. Last September, he offered a Computer Science course to 70 students — some via the worldwide web only, some via lecture only, and some via a combination of the two. He is incorporating the responses into a new version of the course, and into the development of a software package to develop on-line courses.*

GIVEN A CHOICE, STUDENTS PREFER TO TAKE courses on-line rather than using a traditional lecture format. This is one of the conclusions Murray Goldberg drew after surveying the first class he offered a worldwide web-based course to.

Goldberg admits it was a small sample that may not be representative of the student population at large. However, of the students he surveyed, those who took the combined on-line and lecture course were most satisfied, followed by those who took the course on-line only. Least satisfied were those attending the course via the traditional lecture format.

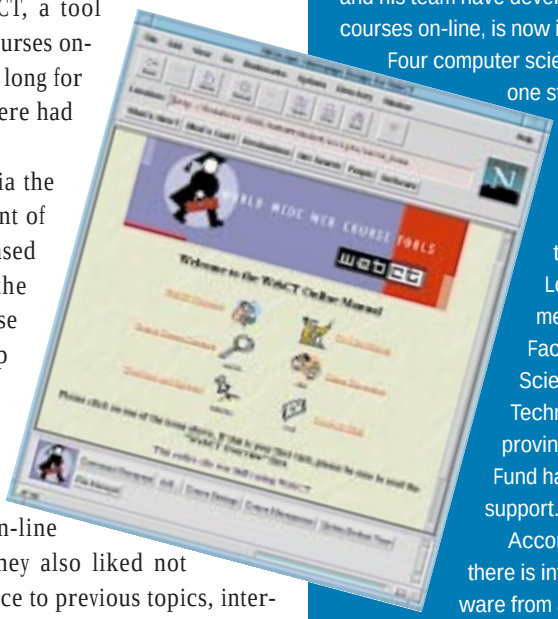
This unique course offering included a bulletin board, interactive exercises, assignments, quizzes, course notes, chat facility, searchable glossary, and more. It took over a year to develop. Afterward, Goldberg developed Web-CT, a tool which enables others to put their own courses on-line in a fraction of the time. "It took so long for us to develop the course, we thought there had to be a better way," said Goldberg.

For instructors, offering a course via the web seems to be about the same amount of work as offering a traditional lecture-based course. However, said Goldberg, if the number of students enrolled in the course increases, the workload does not go up proportionally because questions asked via the course bulletin board need only be answered once by the instructor.

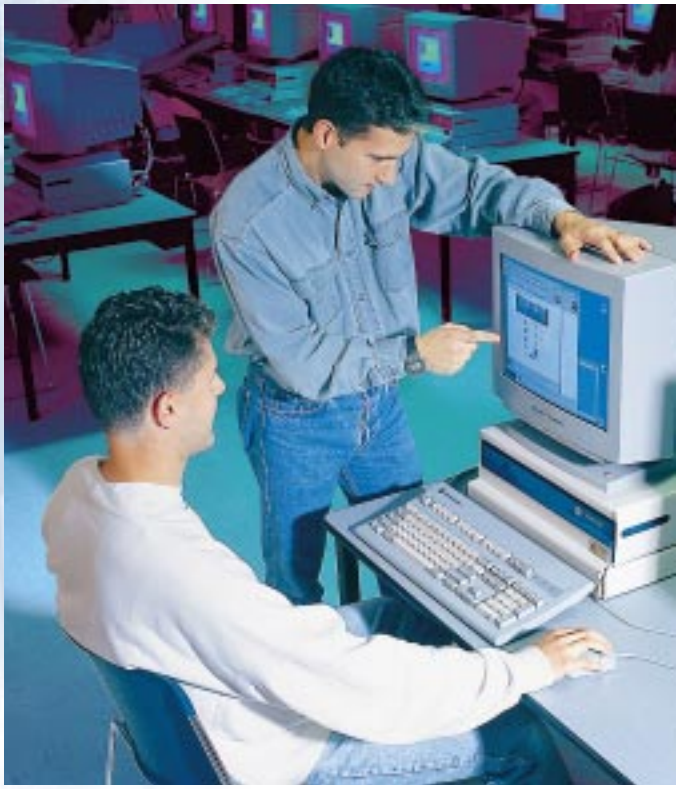
For the students surveyed, the main advantage to taking a course on-line was the ability to pace themselves. They also liked not having to attend classes, ease of reference to previous topics, interactive exercises, availability of the entire course at once, and the ability to learn anytime, anywhere. The disadvantages students cited included the fact that they need more self-motivation to complete the course, they don't get immediate answers to questions, and they miss the interaction with other students.

Goldberg plans to keep offering on-line courses, and to keep improving the software. "The goal of Web-CT and the course is not just to put notes up, but for it to be a real interactive experience," said Goldberg. He is keeping on top of the latest technologies to create more attractive and responsive interactive tools.

Although Goldberg sees room for improvement, he is already flooded with interest in his on-line course development software, and is receiving encouraging feedback from students taking his courses on-line. "The response was more positive than I expected," said Goldberg. "Almost all of the students said they would take an on-line course again."



*Murray Goldberg (standing) discusses Web-CT with Sasan Salari, the main implementer of the project.*



## Web-CT

Web-CT, the software Murray Goldberg and his team have developed for putting courses on-line, is now in beta testing.

Four computer science students and one staff member are working on the project. Most of the funding is being provided by the Teaching and Learning Enhancement Fund, and the Faculty of Science's Science Educational Technology Fund. The provincial Innovation Fund has also provided support.

According to Goldberg, there is interest in the software from all over the world. "Putting courses on the web has been a major hurdle for some people. Right now, it's only barely accessible, and you need to be a programmer to make the courses really interactive and exciting. I hope Web-CT will make it more accessible for people."

Goldberg said the software will be free for any UBC instructors who want to put their courses on-line. Others may soon be able to buy it. Goldberg already has a company interested in marketing the software commercially, and negotiations are under way via the Industry Liaison Office.

# New Ways to Look Inside the Earth

*Geological Sciences professor Rosemary Knight did not want to have to choose between her love for math, physics and chemistry. She chose the field of rock physics, where she can put all three disciplines to good use. Her work focuses on developing ways of using geophysical data to determine what is really happening with the rocks and fluids moving under the surface of the earth.*

IF A DOCTOR WANTS TO KNOW WHAT IS HAPPENING inside a person's body, it is rarely practical for him or her to cut the patient open to find out. There are other, less invasive means, such as ultrasound and x-rays, which provide images and data that can be interpreted to find out what's going on.

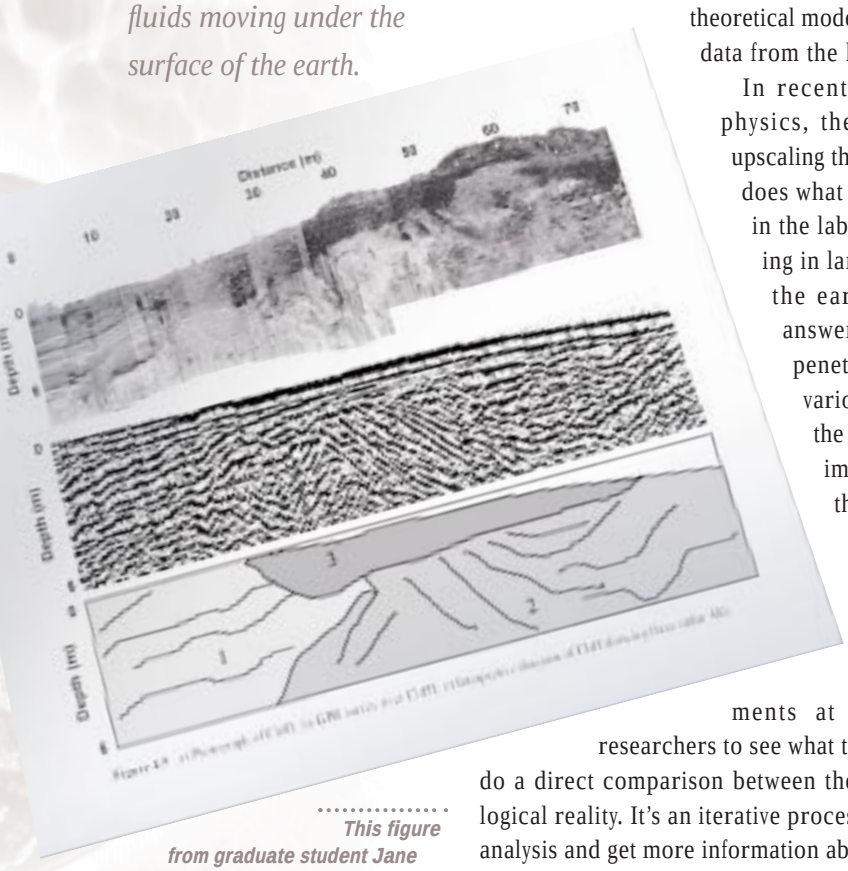
In the same way, it is not always practical to drill into the earth to find out what's happening below the surface. Instead, earth scientists obtain geophysical data, by sending seismic or electromagnetic waves into regions of the earth they can't directly sample. They end up with data that give the seismic or electrical properties of a part of the earth. Rosemary Knight's work focuses on turning these data into the information that earth scientists really want — the properties of the rocks and fluids in the subsurface.

Knight will take samples from the field into the lab, and look at how their geophysical properties change as the internal properties change. "I use theoretical modeling to interpret and refine the data from the lab," said Knight.

In recent years in the field of rock physics, there has been an interest in upscaling the information. The question is, does what we learn about small samples in the lab truly apply to what's happening in large areas under the surface of the earth? Knight is attempting to answer this question using ground penetrating radar, taking data from various field sites and determining the relationship between the radar images and known properties of the earth in that area.

One of the field areas is east of UBC near Abbotsford, where there are numerous exposed cliff faces. Conducting radar field experiments at these cliff faces enables researchers to see what they're imaging. "We're able to do a direct comparison between the geophysical image and geological reality. It's an iterative process," said Knight. "We collect a data set, take it back to the lab for analysis and get more information about what we're seeing. In the process, we're also generating ideas about new ways field data can be used."

Knight has received plenty of recognition for her work, which is fairly unique — there are a handful of rock physics labs across North America. She completed her Ph.D. and taught at one of the largest labs, at Stanford, before moving to UBC in 1987. An excellent communicator, she has won awards for her writing, teaching, and speaking. In 1994, she was named Distinguished Lecturer for the Canadian Geophysical Union. One person a year is selected for this award, which is given to people "who are not only outstanding scientists but outstanding communicators of science."




*This figure from graduate student Jane Rea's Ph.D. thesis shows (from top) a composite photograph, a GPR survey, and an interpretive diagram of a cliff. (See Bits & Bytes on page 8 for more news on Jane Rea.)*

## Applications of rock physics

Rosemary Knight's work has applications both in the oil industry and in addressing environmental (groundwater and contaminant transport) problems. "A strong interest of mine, as an applied scientist, is in taking the results of my research, and the research of others, to the community of people who can use it," says Knight. To this end, she spends a considerable amount of her time communicating the results of her research to end users.

Knight performs a significant part of her research through funding from the oil industry and government agencies. For example her work has been, or is being funded by Imperial Oil, Shell Canada, Mobil Research, Petro-Canada, U.S. Environmental Protection Agency, U.S. Air Force, and the Geological Survey of Canada. The U.S. Department of Energy recently awarded Knight a three-year research grant of almost US $500,000.

In environmental applications, Knight uses ground penetrating radar to look at groundwater flow and contaminants in the near surface. "You can't drill at these sites, or it could make the problem worse," said Knight. She uses different data collection methods, but similar techniques in research relation to applications in the oil industry. "The common denominator is that I focus on fluids, how they're moving underground, and how we can use geophysical imaging."

## UBC professors elected to Royal Society of Canada

Two UBC professors, Anthony Sinclair and F.J.R. (Max) Taylor were elected this year to the Royal Society of Canada. Sinclair is a Zoology professor whose research has focused on the regulation of animal populations and the functioning of ecosystems in tropical African regions and the Canadian arctic and sub-arctic. Taylor is a botanist who focuses on the study of marine phytoplankton.

## Chemists Honoured

Two Chemistry Department members recently won major awards. Brian James was given the E.W.R. Steacie Award for 1997. Colin Fyfe recently won the Alexander von Humboldt Research Award for scientific cooperation between Canada and Germany.

## Science Teaching Awards Announced

Professor Michael Gerry of the Department of Chemistry was one of the 1995/96 recipients of a Faculty of Science Teaching Award. Microbiology Professor George Spiegelman and Mathematics Professor David Austin were also recognized this year for teaching excellence.

## Killam Award Winners

Martin Barlow of the Department of Mathematics was one of this year's winners of a Killam Faculty Research Fellowship. Last year, he was awarded the Izaak Walton Killam Memorial Faculty Research Fellowship. Physics Professor William Unruh was also a Killam Prize winner this year, and Dolph Schluter of the Department of Zoology picked up a Killam Faculty Research Fellowship.

## Student Wins Don Gray Award

Jane Rea, a student in the Department of Earth and Ocean Sciences, won the Don Gray award at the recent annual meeting of the Canadian Geophysical Union in Banff, Alberta. Her winning presentation was entitled, "Determining Hydrological Length Scales for Ground Penetrating Radar Data." She is supervised by Rosemary Knight (featured in this issue).

## Geophysicist Honoured

Douglas Oldenburg was recently named to the Canadian Society of Exploration Geophysicists. Oldenburg's main area of research is using the inverse theory from mathematics to process geophysical data into useful information about the earth's structure.

## New Faculty Members Welcomed

Among the many new faces on campus this fall are two new members of the Faculty of Science. Lori Kennedy is a new assistant professor in the Department of Earth and Ocean Sciences, and Robert Orr is a new professor in the Department of Physics and holds the Warren Chair of Subatomic Physics.

Kennedy recently completed her Ph.D. in geology at Texas A&M, and will specialize in teaching courses on structural geology. Her research focuses on the evolution of continent-scale fault zone, and on determining what controls the onset of earthquakes.

Robert Orr was a professor of Physics at University of Toronto for the past 14 years. His research interest is in the connection between the known forces and the weak and strong nuclear forces. He believes this is the most important question in particle physics.

## Did you know…

The Faculty of Science has registered it's highest enrollment ever of 5,100 students. This represents an 8% increase over last year.

The trend sees no abatement with first-year enrollment up 19% to 1,485 from 1,250 last year.

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