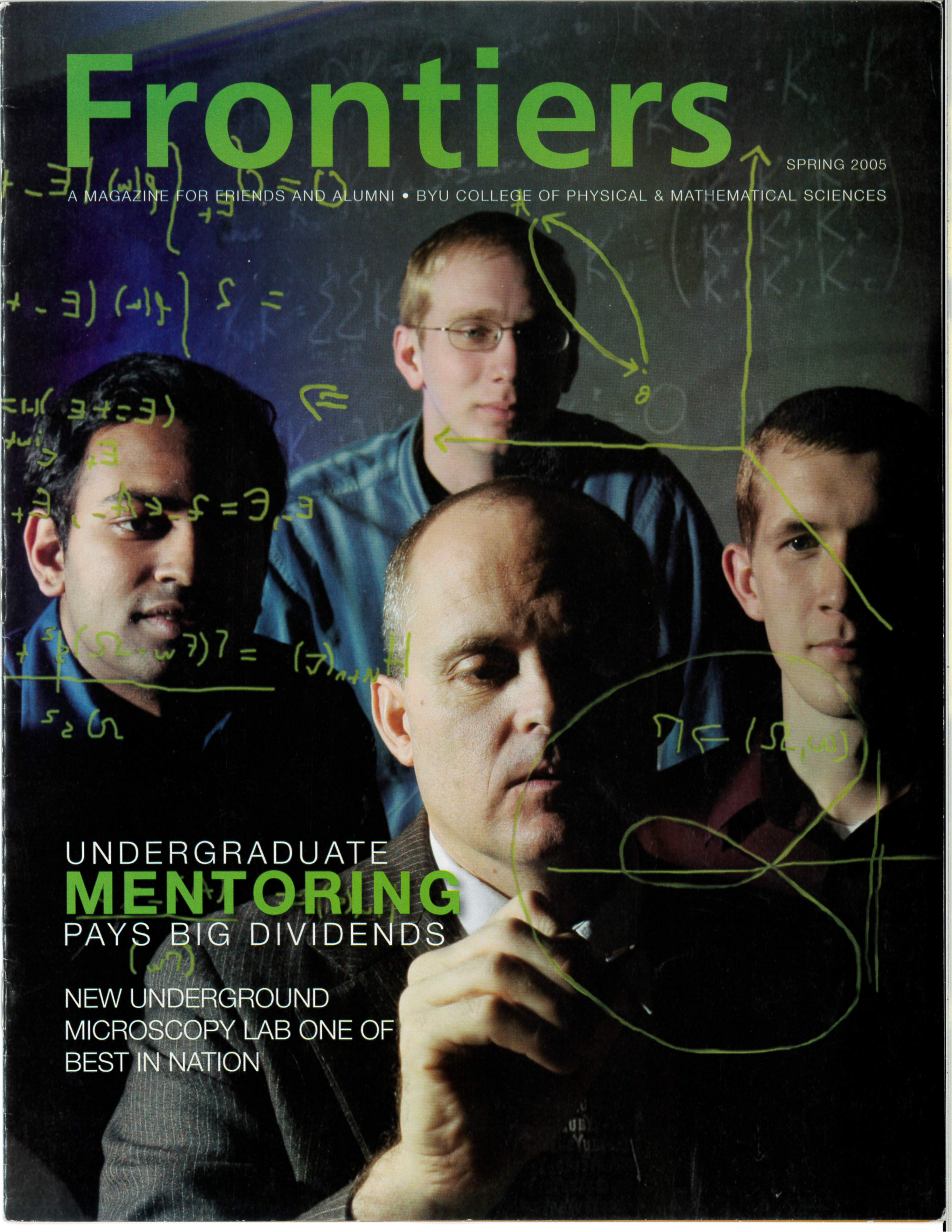
Frontiers

SPRING 2005

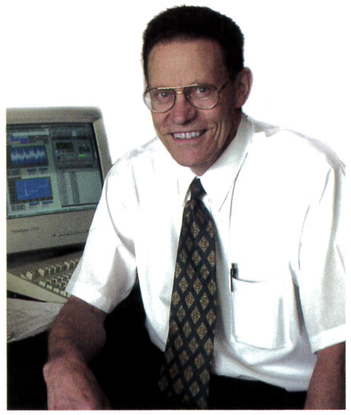
A MAGAZINE FOR FRIENDS AND ALUMNI • BYU COLLEGE OF PHYSICAL & MATHEMATICAL SCIENCES



UNDERGRADUATE MENTORING PAYS BIG DIVIDENDS

NEW UNDERGROUND MICROSCOPY LAB ONE OF BEST IN NATION

FOCUS ON Mentoring



Greetings! In this issue of *Frontiers* you will learn more of our college focus on student mentoring—the current buzz phrase used to describe what has occurred for decades in much of our college.

Student mentoring describes the close intellectual interactions of one or a few students with a faculty member as they learn together *outside* the classroom. Although limited mentoring can occur one-on-one in an instructional laboratory setting or occasionally in an inspiring classroom, such interaction is usually limited to at most a few minutes at a time, perhaps three times a week.

True mentoring is, of course, what occurs often in graduate programs where student-professor interaction is more intense. But for some time, BYU has successfully instilled mentoring at the undergraduate level. We have exceptionally well-prepared, industrious, and curious undergrads who want to know "why," rather than just "what."

After two or three years in the undergraduate curriculum, many of our majors are quite capable of serious involvement in the intellectual discovery or application processes. In these situations, they apply principles learned in the classroom and skills obtained in the instructional laboratory to problems that have not yet been addressed—by text books or even journals.

Sometimes the questioning of a bright undergraduate who has not been biased by what others have already conjectured or discovered leads to new and clear insights. An inquisitive student who asks even simple questions can lead the most sophisticated scholar to question his or her logic and rationale.

A student's questioning can lead faculty members to think about what they really know versus what they have only been told is true. Our undergraduate mentoring has prepared our students better for graduate school and has opened many academic and career doors in the process. An exciting example of this is the national ranking BYU has received in preparing Ph.D. candidates (see graph, page 9).

We invite each of you to reminisce about your earlier and current days of learning, questioning, discovery, and understanding. We hope the vignettes you read in the pages that follow will make you smile and remember this joy of discovery.

Earl Woolley

COVER

What happens when you gather a handful of sharp undergraduates and turn them loose on a problem in theoretical physics? The answer, under the mentorship of mathematics professor Scott Glasgow, is a lot of complex equations, and a brand new theory about an age-old problem in energy loss and recovery. Their project is about creating a complete physical picture, one that describes in real time where energy goes, what it does, and whether it's useful or not. It all adds up to a great undergraduate mentoring experience—similar to others contained in this issue.

Photography by Mark A. Philbrick

COLLEGE of PHYSICAL and MATHEMATICAL SCIENCES

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Mentored Projects Jumpstart Undergraduates

Unlike scholarships, mentorships require students to "work for their money." Unlike traditional college jobs, however, the research positions available in mentorships form an integral part of students' educational training. They give students experience in the laboratory and field settings, provide them with opportunities to work one-on-one under the tutelage of accomplished faculty, and they advance important scientific breakthroughs on myriad practical research projects that affect humanity—all while giving students the financial aid that many need to complete their education. Like dozens of others at BYU, the accomplishments documented on the next few pages are particularly unique because it is our undergraduate students who are getting these opportunities—an unheard-of phenomenon in higher education.

Howard Christensen

COLLEGE EXIT POLL

PROVIDES REAL WORLD EXPERIENCE

Ross Larsen, statistics department chair Dr. Howard Christensen, and Matthew Poulton map strategies that involved 900 students from eight universities who volunteered thousands of hours to predict the 2004 election results in Utah.

For 22 years, BYU students have conducted the only state-wide collegiate election exit poll in the nation.

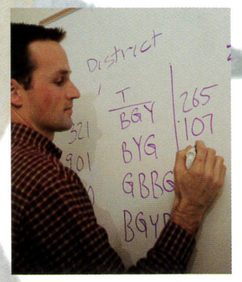
The exit poll predicts the outcome of races before official election results are in, but Dr. Howard Christensen believes that students are the real beneficiaries.

"It gives them a real world experience," said Christensen. Predictions are made on the very day the exit poll is conducted, with actual results known within 24 hours."

The collegiate exit poll concept originated in 1982 with David Magleby, BYU political science professor and current dean of the College of Family, Home, and Social Sciences. He asked Christensen to design the sample, select polling places, and tabulate results. The exit poll became a practical tool for a public opinion and voting behavior class taught last fall by political science professors Kelly Patterson and Quin Monson, and sampling classes taught by Christensen and professors Dan Williams and Lynne Nielsen.

"My mentoring experience had high-pressure situations requiring quick decisions. One of my jobs was to coordinate all exit poll committees and help resolve their troubles. Working with many different academic disciplines has been educational, as each has its own style to accomplish the same task."

Clint Stevenson
AFTON, WYOMING



"Creating the sample design let me use my statistical knowledge in a team environment. The election day deadline showed me how much energy is required for success. I learned that great achievements come only through working as a team."

Matthew Poulton
SANDY, UTAH

A third department–communications–produces election night coverage on KBYU-TV.

"The graduate class is taught only during an election year," said Christensen. "It consists of students who learn first-hand how textbook principles transfer to an actual exit poll. These students become committee team leaders. I meet with them one-on-one each week to mentor them in their work. They also meet weekly with their undergraduate committees to coordinate assignments. The process starts in August before the semester begins."

The undergraduate course in survey sampling is taught every semester. During an election year, students learn to create questionnaires, estimate voter turnout, design complex samples, coordinate with county officials, train pollsters, gather and analyze data, write reports, and discuss predictions on live television on election day. "This is no small task," said Christensen. "We recruit and train 900 student volunteers from eight campuses from Logan to St. George, ask them to attend training sessions, and provide them with materials to help survey about 9,000 voters."

"I worked with county clerks, supervised a committee of eight of my peers, and compiled the final report written by eight committees. This experience improved my ability to manage diverse types of people and will help me on future projects."

Kim Mah
LEBANON, OREGON

Faculty and students use exit poll data to better understand the voting behavior of Utah voters. ■

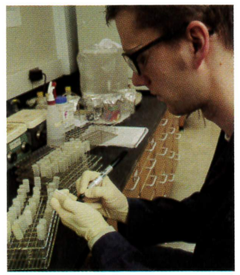
Paul Savage

NEW ANTIBIOTICS

CREATED TO TREAT DRUG-RESISTANT BACTERIA

For decades, antibiotics have been successful in controlling harmful bacteria. But overuse has caused bacteria to build resistance, making it increasingly difficult to treat disease and infection.

"If you take bacteria cultures in a hospital, you'd find most of them are resistant to prevalent antibiotics," said Paul Savage, professor of biochemistry at BYU. "It's easy to understand the problem when you realize there are up to one hundred trillion bacteria on the body. That's ten times the number of cells in the human body. These cells can divide every 20 minutes, so it's easy to see how they can become resistant. It only takes one organism to mutate. In contrast, there are only a limited number of new classes of antibiotics such as penicillin and tetracycline, and only two new classes have been discovered in the past 35 years."



"Mentoring has shown me that hard work, persistence, creativity, and rethinking, rethinking, rethinking are all essential to good research. This experience, resulting publication, and confidence in my research abilities has opened many doors by setting me apart from undergraduates at other universities."

Thomas Orsak
KIRBYVILLE, TEXAS

Savage is quick to point out, however, that organisms have lived in the presence of bacteria for eons. Plants and animals have survived, but only because they produce their own antibiotics.

The new class of antibiotics Savage and his researchers have created kill bacteria with the same mechanism of action as natural antibiotics and are easier to produce commercially. Testing has shown that they are extremely effective because bacteria do not easily become resistant to them.

"The key to our discovery", said Savage, "is the idea that endogenous antibiotics could be mimicked with small molecules by observing the kind of structures that these endogenous antibiotics form."

Research at BYU has focused on developing mimicking molecules for eight years. The new compounds are so promising that BYU licensed Denver-based Osmotics Corp. to exclusively develop this new class of antibiotics for treating bacterial infections such as staphylococcus, pneumonia, and salmonella.

Dr. Savage has mentored about 50 undergraduate, twelve graduate, and five postdoctoral students. Starting with a semester induction phase, his students learn advanced lab techniques under direct supervision. In the semi-independent work phase, students work on active research with graduate students, post-docs, and professors. After six months to a year, top students work at the graduate student level.

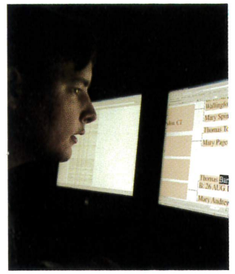
"I could do more mentoring and more research with funding earmarked for undergraduates," said Savage. "But funding agencies expect performance. Because undergrads have a learning curve, it's difficult to get back the same kind of return as with graduate students. But we're finding that these fast-track undergrads soon perform as well as graduate students because of our mentoring philosophy." ■

Because of an increase in drug-resistant bacteria and escalating costs of antibiotic therapy, Sara Salt and Dr. Paul Savage work to develop new antibiotics.

"There's no fix-all handbook in a lab. When we encounter problems, we search scientific literature for solutions. Dr. Savage's lab has given me opportunities to actively evaluate and solve problems. While I learn something new every day, the most important thing I've learned is to have confidence in my work."

Sara Salt
KATY, TEXAS

Tom Sederberg
NEW SOFTWARE
HELPS TRACK ANCESTORS



"I've gained practical experience in system administration, customer relations, and web programming, and a taste for what it's like to run a company. I've developed a greater appreciation for family history, and am now developing a new version of Relationship Finder."

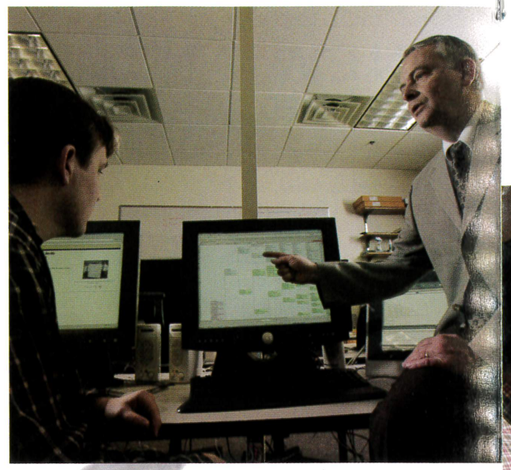
Brian Sanderson
PALM SPRINGS, CALIFORNIA

Student researchers under the direction of Dr. Tom Sederberg have developed three new genealogy software programs at Digital Roots. Digital Roots [digitalroots.org] is a non-profit research laboratory at BYU dedicated to simplifying family history through the creation of powerful and intuitive software tools.

One new program identifies family relationships within a given group of people such as a neighborhood, an LDS ward, or stake. Called Relationship Finder, the software can also determine relationships to kings, queens, apostles, or prophets. "I've used this software for several years in classes I teach," said Sederberg. "In a class of 70 students, I'll always find second or third cousins. It's a great tool to spark interest in genealogy."

"Another project we've completed is called One-Page Genealogy," said Sederberg. "It gives us the ability to print a giant pedigree chart on a three-by-four foot piece of paper that fits nicely on a wall. Programs like PAF print dozens of pieces of paper that would need to be glued together to produce such a chart. Our software also creates a pedigree in pdf format, viewable with Adobe Acrobat Reader."

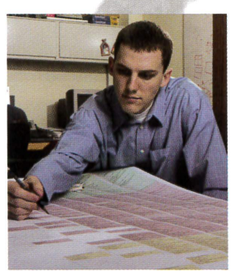
A third, nearly-completed software program promises to make it easier for several people working on one family line to share their work. Dr. Merge connects two genealogy databases and creates a third that indicates where the family paths cross. "It's a user-assisted merging program that provides some intelligence to merge as much as it can from two different Gedcom files," said Sederberg. "It uses probability logic to automatically perform the merge. The user is prompted to resolve ambiguities." Under Sederberg's mentorship, students have been working on this project for over two years.



Under the guidance of Dr. Tom Sederberg, computer technology is providing genealogists with new root-tracing tools. Mentored research lets students spend more time in the lab and less time at outside work.

"We recruit top students from our classes to work on mentored projects," said Sederberg. "They get paid an hourly wage for research. This lets them spend more time in the lab and less time at outside work."

Depending on funding, Sederberg's associate Dr. William Barrett wants to complete a handwriting recognition program. The new software would speed up microfilm searches by finding a particular name using an algorithm to detect similar patterns in other names. "If we get enough money," said Sederberg, "we'd like to keep one or two dozen undergraduate and graduate students working on this and other new tools." ■



"I've had the opportunity to develop a real product for real customers. We've received suggestions from users worldwide and work to implement them. Being able to work on a project with such a broad scope is an experience I didn't expect to have as a student."

Joshua Jenny
VALLEJO, CALIFORNIA

"Programming actual consumer software has presented me with opportunities only confronted in the 'real world'. I've become much more familiar with C++ and had the chance to learn techniques that are learned in a lab, not in the classroom."

Britton Quist
PORTLAND, OREGON

Ron Harris
QUAKES PREDICTED
BY SATELLITE TECHNOLOGY & HISTORY

Hendro Nugroho, Laura Wald, and Nova Roosmawati benefit from research led by Dr. Ron Harris that points to more earthquakes in the Sumatra region as well as in other areas of the world—like Utah. "It's not a matter of if, but when," he says.

Research by BYU geology professor Ron Harris pointed to the high probability of the Sumatra earthquake that occurred late last year. Armed with 17 years of data and teamed with students from Indonesia and BYU, he published a paper in 1997 that predicted a quake with a magnitude of 8.0 or greater—one that could produce huge tsunamis. He's also forecast a similar-sized quake on the eastern side of Indonesia in the Timor region.

Harris and his students are going back to Southeast Asia in June. He'll advocate planting a net of palm trees on the beach to absorb energy from incoming tsunami waves and act as a safety net when the water rushes back to the ocean. "Most people died as they were pulled back to the ocean," Harris said. "The trees can give people something to grab onto."

"Each fault zone in the world has an earthquake cycle," said Harris. "The rate and direction of plate motion determine cycle length. A compressional fault like that under Sumatra moves faster, stores more energy, and is more powerful than an extensional fault—the kind found in Utah."

"Most faults can only hold so much stress before they rupture," said Harris. "The Sumatra fault will rupture about every 100 years. In Utah where the plate motion is slower, we can expect a major quake every 350 years. But no major earthquake has occurred in Utah for more than 500 years."

Harris warns Utahns that they're overdue for a magnitude 7.0 strike. "It may happen tomorrow or 50 years from now, but it's going to happen," he said. He fears Utah suffers from a lack of preparation similar to Indonesia's. He urges residents to secure hot water heaters and retrofit homes to prevent things from tipping over.

"Some people question whether the Wasatch is active or not," said Harris. "So we set up a GPS (global positioning satellite) network in the early 1990s. Repeated measurements show westward movement of the valley away from the mountains."

Harris mentors students in seismology by teaching them to use these high resolution GPS receivers, which must be set up meticulously and measurements checked several times to ensure accuracy. He also teaches them how to process data, take out atmospheric distortions, and connect their data with a global computer database. ■

"As I worked with Dr. Harris, I gained greater insight into the responsibilities and opportunities that I'd have as a scientist. With his mentorship, I learned much more than ever possible in a classroom. I now have the ability to solve a wider range of geological problems that come my way in my future career."

Laura C. Wald
CARSON CITY, NEVADA

"My BYU experience let me participate in a professional geologic community to develop as a scholar and a future university professor. Dr. Harris helped me think like a true geologist, recognize critical data, pay attention to detail, manage time wisely, and be disciplined."

Nova Roosmawati
YOGYAKARTA, INDONESIA

He came from Mississippi. She came from Virginia. They met and married their sophomore year at BYU. Both graduated in 2002 and went to Pennsylvania State University—an event made possible by their undergraduate mentoring experience at BYU.

BRENT & MELISSA CLAYTON

Melissa Greco came to BYU in the fall of 1998. She arrived with an art portfolio, prepared to major in sculpture. But halfway through her calculus final, she decided that math was fun and sculpture was going to be a hobby.

Brent Clayton came to BYU in the fall of 1996. His dad was a rocket scientist, and for years Brent had planned on a science degree at BYU. The fact that there were only two LDS girls in his high school also had something to do with it.

Melissa and Brent attended the same ward and met through friends. Within a year they were married in the Jordan River, Utah temple.

By the end of her junior year, Melissa started working closely with mathematics professor Scott Glasgow. "Although a straight-A student, I was intimidated by the idea of graduate school and doing math research. But when Dr. Glasgow approached me about doing research for him in the area of electromagnetic energy transfer, I was very interested. After working with him, I not only realized that I was capable of doing research, but I got really excited about it."

"I became co-author on two publications and one preprint—which is really neat for an undergrad," said Melissa. "I attended two math conferences generally reserved for graduate students and faculty, and a presentation that I helped prepare for the undergraduate research conference at BYU won a top award."

Increasing the funding for mentored research is one of the best things the college can do to prepare undergrads for graduate school.

Simultaneously, husband Brent was being mentored by Earl Woolley in the Department of Chemistry and Biochemistry. "I actually had concurrent experiences," said Brent. "I worked with organic chemistry professor Dr. Steve Fleming to study photochemical degradation of tear gas. I also took a class in analytical chemistry which led to a research position in Dr. Woolley's thermodynamics lab and a published paper. At Penn State I learned that it's rare to do chemistry research as an undergrad, yet I had the opportunity for two years."

Graduate School

"My decision to go to graduate school definitely was a result of my research at BYU," said Melissa. "And I firmly believe that it gave me the confidence to apply, helped me get great reference letters, and resulted in a great fellowship at Penn State. They asked me to do a Ph.D. program instead of a master's and offered me their highest fellowship with all tuition paid, a high stipend, and minimal teaching so that my emphasis could be on research."

Once at Penn State, Melissa quickly realized that she was one of the few entering grad students who had experienced undergrad research. "I was automatically a step ahead of most other students," said Melissa. "I was able to start research two years before most other students have the opportunity."

"When I came to grad school," said Brent, "my professor put me right in the lab. He didn't need to orient me because of my BYU experience. It put me about a year ahead of everyone else."

Melissa subsequently left Penn State in 2004 with a master's degree in mathematics and a nine-month old baby. "I couldn't have finished my master's in two years if I hadn't started research immediately," she recalls. "I strongly feel that my research at BYU prepared me for that. I will always be grateful for that experience—it gave me confidence in my abilities, and my advanced degree will open more opportunities for me down the road. I am now a stay-at-home mom with my 18 month old son Will, while Brent finishes his doctorate in organic chemistry."

Brent will graduate in 2007 and either work for a pharmaceutical company or teach at a university. He's already taught four semesters at Penn State.

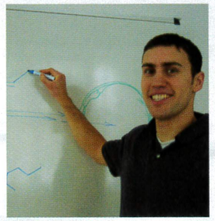
"We are so grateful for those whose donations made our undergraduate research experience possible," said Melissa. "They are truly making a difference in the lives of many students. Increasing the funding for undergrad research is by far one of the best things the college can do to prepare undergrads for graduate school. It certainly changed my life." ■

CLASS NOTES

From Aids research to black hole theories about the universe, mentored students at BYU's College of Physical and Mathematical Sciences push the limits of research.

RESEARCH AIDS CANCER STUDY

[Biochemistry] Dr. Heidi Vollmer-Snarr mentored **Matthew Sparks** (Sumner, WA) to create startup materials for the total synthesis of a pyridine bis-retinoid compound, which has cytotoxic properties to destroy cancer cells.



The first intermediate compound in the total synthesis process is 3-tributylstannanyl-prop-2-3n-1-ol. It's purified by passing the reaction mixture through a silica gel column to separate out the desired isomer from byproducts.

Purification for a single reaction is difficult and takes approximately six hours and only yields 3 to 5 grams of material. Sparks has performed this process eight times, and presented a poster detailing its potential impact in the treatment of cancer.

SENSOR DETECTS TOXIC METAL

[Chemistry] **Paul Reeve** (Gales Ferry, CT) has been developing a portable sensor for the detection of cadmium, a toxic metal, in water. The sensor is based on a compound called a chemosensor that is weakly fluorescent in the absence of cadmium, but strongly fluorescent in its presence. Under the mentorship of Dr. Paul Farnsworth, Reeve is designing instruments that will use either ultraviolet light emitting diodes or a small ultraviolet laser to excite the fluorescence from the chemosensor. His goal is to produce an inexpensive field sensor to detect heavy metal pollution in water supplies.

TEACHING WITH TECHNOLOGY

[Math Education] Under the guidance of Dr. Keith Leatham, **Kourtney Peters** (West Chester, PA) has developed a survey to gather information from university professors regarding the technology preparation their future high school math teachers receive.

Since there are no textbooks and few other resources available, the data collected from this survey has two primary purposes: 1) to create an online resource for mathematics educators from which they can get activities, rich mathematical problems, and references for preservice teachers on teaching and learning mathematics with technology, and 2) to prepare to adapt these materials for use in professional development programs with inservice mathematics teachers. Two of Peters' fellow undergraduates, Hillary Stone and Josh White, have now conducted the survey and are analyzing the data.

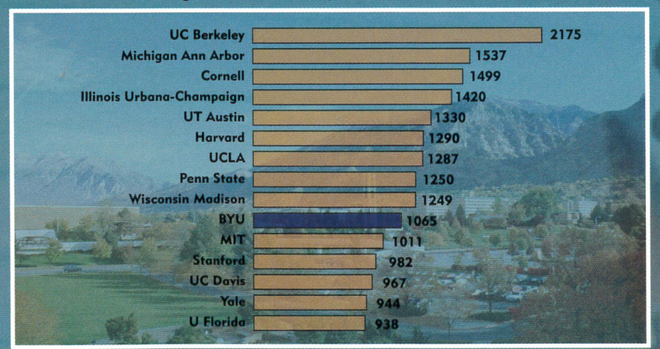
WOUND HEALING STIMULATED

[Mathematics] **Matthew Tolman** (Salem, UT) is studying the interaction between collagen and fibroblasts to understand chronic wounds. His mentor, Dr. John Dallon, chose a reaction-diffusion model and is attempting to apply this model to wound healing. As a wound heals, the skin moves in, filling the gap (a traveling wave). Dr. Dallon constructed a one-dimensional model inside a hyperbaric chamber to eliminate

BYU Ranks High as Ph.D. Incubator

In good company with Harvard, UCLA, and Penn State and ahead of MIT, Stanford, and Yale, BYU ranked tenth in the number of undergraduates that go on to earn a Ph.D. BYU credits much of this success to mentoring opportunities created by individual and corporate donors.

Source: The Chronicle of Higher Education 1/7/05 p. A24.



oxygen as a variable. A proof guaranteed a traveling wave when the production and chemotactic terms met certain restrictive conditions. Tolman attempted to verify the proof by stopping the traveling wave. Using C++ and Matlab, he was able to simulate the healing process while varying those conditions with numerical experiments. In the end, he wasn't able to stop the traveling wave (a chronic wound), but its progression was severely inhibited.

BLACK HOLES THEORY EVOLVES

[Physics & Astronomy] A current astronomical theory states that every galaxy contains a black hole, detectable by short, intense fluctuations in brightness at the galactic center. But it's difficult to detect the small amplitude of these fluctuations at the far reaches of the universe.

With Dr. J. Ward Moody, **Carolee Blackham Fairbanks** (Penn Valley, CA) believes the problem can be resolved with a new digital image processing technique. If all galaxies have a black hole at their centers, it may mean that they need a gravitation "seed" to form around. That in turn restrains the possible ways in which galaxies can be created, change, and die. Fairbanks' second motivation is to find locations where black hole behavior can be better studied to help build a better model of how the universe works.

AUTOIMMUNE REMEDY FOUND

[Biochemistry] BYU scientists are part of a multinational effort that may have unlocked some secrets of illnesses like lupus, multiple sclerosis, rheumatoid arthritis, and even cancer. Dr. Paul Savage and graduate students **Ning Yin**, (Kunming, P.R. China) **Randy Goff**, (Norwalk, CA) and **Ying Gao** (Jinzhou, P.R. China) made significant contributions to research conducted at BYU and other universities to find the missing antigen that activates natural killer T cells.

Randy Goff

T cells determine whether to unleash responses in the body, such as inflammation. Savage and his colleagues are the first to identify a specific antigen. Because people with autoimmune diseases may lack sufficient antigens, they may be helped by the development of synthetic keys to switch the response on and off.

Many researchers from all over the world have sought this antigen, but teaming organic chemists with immunologists made the discovery possible. ■

Come with Us to Visit Middle Earth

"Trip of a lifetime" planned for New Zealand journey in February 2006.

Photo courtesy Adventure Films

The BYU College of Physical and Mathematical Sciences invites you to mingle with Hobbits, Elves, and Orcs, or at least where they were filmed in the recent "Lord of the Rings" series. Although you probably won't encounter the creatures of Middle Earth, those who travel to New Zealand will be sure to see some amazing geologic scenery worthy of a fantasy land.

Tour leader Tom Morris is a professor and associate chair of the Department of Geology at BYU. He has an extensive background in shoreline, glacial, wind blown, and river systems, and plate tectonics. The dynamic interplay of these systems in New Zealand created the spectacular landscapes made famous by the "Lord of the Rings" films. Throughout the expedition, Dr. Morris will use his knowledge and prior New Zealand experience to paint a picture of how the landscapes were formed.

Planned for February 11–26, 2006, the trip will tour both the north and the south islands. Highlights include:

- A tour of the Waitangi Treaty House in Paihia—the birthplace of the New Zealand nation
- An evening at Tamaki Maori Village in Rotorua to experience Maori lifestyle and traditions
- A visit to Tongariro National Park, which encircles three active volcanoes
- A drive through the Southern Alps
- A trip to explore Milford Sound in Fiordland World Heritage Park

Other activities include a powerboat trip into Bay of Islands through the Hole-in-the-Rock, a tour of Cape Reinga, a whale watching expedition along the coast of Kaikoura, a helicopter landing on Franz Josef glacier, and a scenic flight over Mt. Cook National Park.

Visit [cpms.byu.edu] and click Travel for this and other travel opportunities.

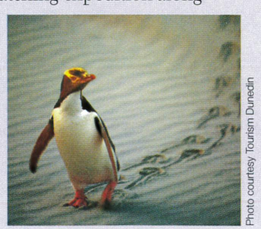
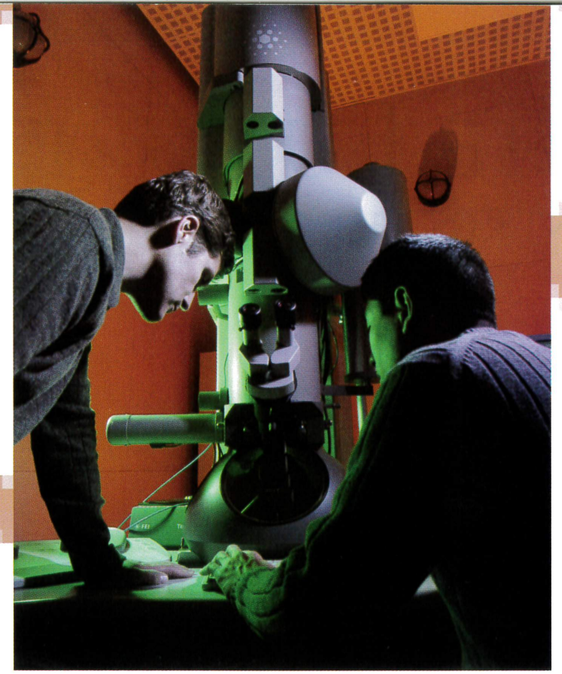


Photo courtesy Tourism Dunedin



RARE & POWERFUL MICROSCOPES UNLOCK NANOSECRETS

New facility that houses two rare transmission electron microscopes can't be seen on the BYU map because it is buried several feet under the sidewalks and grass adjacent to the physical sciences building.

Transmission electron microscopy (TEM) has been at BYU for a long time. But because of the increased need to understand fundamental phenomena at an ever smaller scale, the TEM facilities and equipment needed to be improved. Two years ago, a new underground facility was completed, two new microscopes were in place, and two Ph.D. electron microscopists joined the faculty.

"Research at the nanopartical or atomic level helps scientists understand how extremely small defects can affect the strength, brittleness, and electrical conductivity of a metal or ceramic," said Dr. Dana Griffen, associate dean for BYU's College of Physical and Mathematical Sciences. "TEM makes that research possible."

"'Nanotechnology' may be a buzz word for some," said Dr. Jeffrey Farrer, lab director for TEM, "but increased demand for greater technological advances in computers, medicine, and the environment decreases the dimensions in which we look for usable materials and devices. As those dimensions go down, so do those of the building blocks of these materials and devices. The defects, surface properties, and other nanoscale phenomenon therefore become more critical to the properties of the materials. Additional accessories on the microscopes also help determine the chemical compositions of the small areas we are imaging, which adds tremendous power to the scientific interpretations."

To house the sensitive new microscopes, a second underground lab was constructed adjacent to, but physically separate from, an existing lab that provides added room and better isolation.

"The facility is tops in the country," said Griffen. "The microscopes are insulated from vibrations and electromagnetic interference so effectively that the installation engineers at first thought their test equipment had malfunctioned. This level of 'quiet' is necessary, of course, to push the TEMs to the limits of their capabilities. When one is viewing features the size of a few atoms or less, even the smallest interference is obviously intolerable."

The electron microscopes in the TEM lab combine to give BYU capabilities that are virtually unique. The physical facility has been measured and remeasured since its completion and is still one of the best in the nation, rivaling anything built worldwide. ■

Completed in 2003, the underground lab is home to two TEMs, an AFM (atomic force microscopy) lab, a reverberation chamber for acoustic studies (insulated from the microscope labs), and spaces for specimen preparation and incidental work. AFM is another technique for looking at surfaces on the very small to atomic scale. TEM looks inside.

SHAPING THE FUTURE

MENTORING STUDENTS IN THE SCIENCES

"The most valuable part of my education, in terms of postgraduate opportunities, was participation in mentored learning experiences."

Every student who leaves the College of Physical and Mathematical Sciences with a mentored learning experience is better prepared to bless others and help our world solve its problems. Consider the following experience of physics major Brigham Frandsen, from La Canada, California:

"My academic experience at BYU—inspiring professors, stimulating classes, and challenging assignments—was excellent, but the most valuable part of my education, in terms of postgraduate opportunities, was participation in mentored learning experiences.

"Pursuing an independent research project with regular feedback from a faculty member adds tremendous value to lectures and exams. My Honors thesis on laser particle acceleration provided an opportunity to develop my own ideas, but with guidance from Dr. Scott Glasgow in mathematics, Dr. Justin Peatross in physics, and Dr. James McDonald in economics. The experience extended beyond my Honors thesis, and soon involved me in other aspects of the professors' research. Opportunities opened up to attend research conferences, and my thesis became the basis of a paper on which we collaborated.

"Largely as a result of my mentored learning program, I was offered stipends to pursue a Ph.D. at MIT, the University of Chicago, and Stanford, as well as a job offer from McKinsey & Company, a top management consulting firm. I served a mission in Hungary, so it has always been a dream to go back there to live and work. All these opportunities presented a welcome but very difficult choice, but MIT agreed to defer my fellowship while I work in Budapest for two years. So now I'm in Hungary with my wife Christine, whom I married just before we both graduated from BYU."

To help mentor more students like Brigham, I invite you to contact David Bonner at 1-800-525-8074 or david_bonner@byu.edu. Mentored learning experiences lead our undergraduates along paths toward new discoveries and positive contributions to society. Together, you, our faculty, and our students are pushing back the frontiers of science.

Earl M. Woolley, Dean