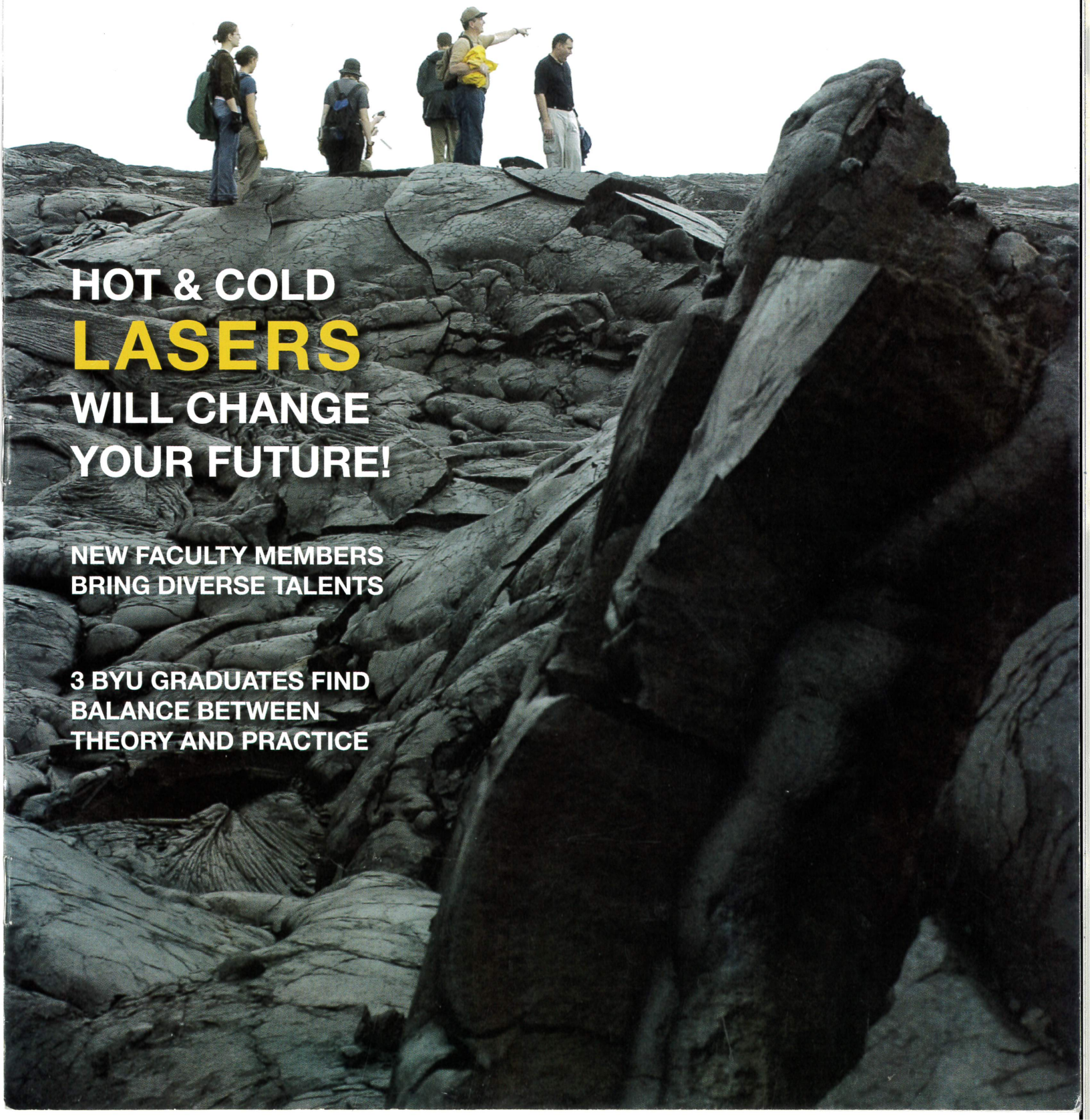
Frontiers

FALL 2004

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

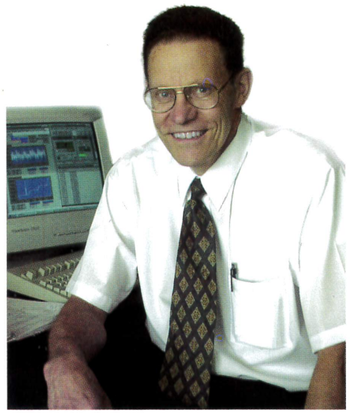


HOT & COLD LASERS WILL CHANGE YOUR FUTURE!

NEW FACULTY MEMBERS BRING DIVERSE TALENTS

3 BYU GRADUATES FIND BALANCE BETWEEN THEORY AND PRACTICE

Breaking **Barriers**



As we initiate our college magazine, *Frontiers,* it's hard to know whether the inaugural greeting should celebrate the past, attempt to forecast the future, or focus on the current state of the college. Perhaps it would be best to first address the question, "Why a magazine for the College of Physical and Mathematical Sciences?"

Chances are that when you graduated from BYU, you identified closely with your major department but were only vaguely aware that your department was part of a college within the university. That recognition may have dawned on you at your college convocation, where you saw students from several other departments, as well as from your own, march across the stage to receive a diploma.

The College of Physical and Mathematical Sciences is one of eleven colleges that make up BYU, but it is more diverse than most. We consist of seven departments: Chemistry and Biochemistry, Computer Science, Geology, Mathematics, Mathematics Education, Physics and Astronomy, and Statistics. We also house the West Mountain and Orson Pratt Observatories, the Earth Science Museum, and share responsibility for the BYU Cancer Research Center.

In the past, boundaries between departments—even within the same college—have acted as barriers to student and faculty communication. That's not true anymore. Today we have mathematicians working with physicists, physicists working with geologists, geologists working with chemists, chemists working with statisticians, and so on across the former barriers. And it isn't just the faculty. Students, too, are involved in much interdisciplinary work as they participate in mentored research with faculty members.

In this first issue, we have included each department in some significant way—articles about new faculty members, alumni doing exciting things, or research groups. We can't promise such universal coverage in every semiannual issue, but it seems appropriate to start that way.

We hope you enjoy becoming reacquainted with your college through *Frontiers.* Our hope is that this magazine will provide one way for us all to stay in touch a bit better.

Earl Woolley

COVER

BYU geology students and faculty mentors look for active lava flows issuing from Kilauea volcano (the most active volcano on earth) on the big island of Hawaii. On this day the hot lava was concealed beneath hardened crust and flowing to the ocean in a lava tube just a few feet beneath where they are standing. Active flows were eventually found a few miles from this location and samples were taken to help understand where sulfur resides in the lava and how quickly it escapes to the atmosphere. *Photography by Mark A. Philbrick*

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theory & **Practice**

The BYU College of Physical and Mathematical Sciences does an excellent job of preparing students for real-world careers, and for the inevitable changes in career paths that follow. These graduates in computer science, math education, and chemistry share their career stories and what they've found in practicing their educational theories.

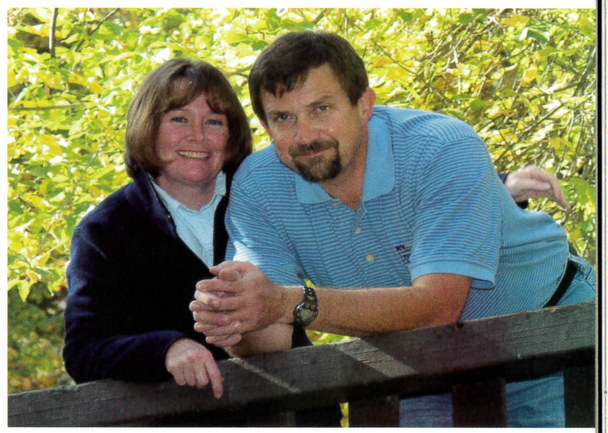
MIKE AND KIM BARTHOLOMEW

Dynamic duo uses their computer science skills in the game room and the classroom.

Mike and Kim Bartholomew's marriage is not all they share. They also share a love of computer science, having both graduated from BYU's Department of Computer Science.

Mike received his B.S. in 1981 and went to work for a government subcontractor conducting long-term failure trend analysis for missile defense systems. After his contract ended, Mike worked as a simulation project engineer for Evans & Sutherland, a world leader in 3-D vehicle motion and flight simulation. As personal computers became more powerful, he steered his career in a different direction.

"In the late 1980s, it became apparent that home computing would become capable of rendering real-time 3D images," said Mike. "So in the mid-90s, I co-founded a computer game studio called SingleTrac." Apparently Mike and the development teams at SingleTrac did good work because GT Interactive, a world-wide video game publisher, acquired SingleTrac in 1998. Not long after, a small group of employees left SingleTrac and started a new game studio called Incognito. Mike joined Incognito in 2000 where he opened, staffed, and managed an Incognito game studio and produced additional game titles. Sony recently acquired Incognito, but Mike still works for them and continues to actively develop game titles. "The PlayStation® technology continues to evolve," said Mike. "I'm now working on online-enabled titles for the network-capable PlayStation® family."



While Mike was launching his career in the video game industry, his wife Kim was following in her husband's footsteps and graduating from BYU with her own computer science degree. "I thought I'd have a wonderful tutor at home," she said. "While he did provide moral support, he expected me to make it on my own. Looking back, I think it was the right thing."

After earning her degree, Kim began teaching at Utah Valley State College (UVSC) while still working on her master's thesis. She now teaches in the Computer Information Technology for Education (CITE) department there. CITE offers programs in IT, network administration, and business education. The primary focus is using technology to meet business needs.

Along with their common bonds of love for each other and computer science, the Bartholomews share a common learning philosophy. "BYU encourages people to learn how to learn," said Mike. "Whether people go into government or the private sector, it's their ability to adapt and learn that will make them successful." Kim echoed his sentiments.

"BYU encourages people to learn how to learn. Whether a person goes into the government or private sector, it's their ability to adapt and learn that will make them successful." —Mike Bartholomew

"At BYU, I learned how to find answers to questions I didn't know," said Kim. "I learned that it was okay to experiment and try different things. I also received a good background in technical writing from the English department. Many students in computer science don't realize how much of their professional life will be spent in writing."

The Bartholomews suggested, however, that there are always real world challenges that a formal education doesn't cover. "I learned how real businesses work compared to how they should work," said Mike. "Both the university and the corporation focus on near-term deadlines, but industry sacrifices the academic 'right way' to do it to just get the product on the shelf. This frequently leads down an entirely different path in product development."

Kim has noticed similar trends in her educational career. "It's interesting to see how industry affects education and how education affects industry. When I

finished my bachelor's degree, object-oriented programming was still in its infancy. Graduates coming out of CS programs were pushing this new object-oriented paradigm onto deadline-plagued coworkers who were used to having the code visible. The result was often a lack of productivity because no one understood the other person's code. War stories that come into my classroom from industry speakers and working students stress the need to choose the correct tool for the problem at hand."

Both Kim and Mike emphasized the need for continuing education and adaptation for both students and young professionals. "Get excited about what you are doing," said Mike. "Focus on the fundamentals. Learn how to learn. Be adaptive. The foundation of your knowledge is very important, but the end result will likely be far different than what you thought." Mike has especially noticed this trend when he has hired other programmers. "I look closely at their resumes and their curricula," he said, "but then want to see how they have adapted and resolved conflicts along the way."

"There's a need to get beyond the theoretical," said Kim. "Demand real-world projects from your teachers, not just toy problems that won't scale up. If you can, find a part-time job in your career field while going to school, and build your resume." She said that an estimated 50-to-60 percent of Computer Science/ IT students at UVSC work in their field already, and such jobs often lead into full-time employment upon graduation.

SCOTT HENDRICKSON

Talented teacher transforms learning

Often the most rewarding result of a good education is the desire and ability to educate others. That's exactly what Scott Hendrickson has done with his education from BYU for the past 25 years. Raised in rural Gunnison, Utah, Hendrickson earned a bachelor's degree in 1979, followed by a master's degree in 1984. Both were in math education.

"Like that available from most universities around the country, my program was fairly traditional," said Hendrickson. "But in the past few years, BYU has attracted several top math educators. I've taught workshops and served on committees with professors from BYU. Their contribution to the math education community is much more powerful today than when I attended. The university is making a concentrated effort to focus on math education as a separate entity from applied mathematics. It is conducting a great deal of research on how we learn mathematics in school."

Hendrickson began teaching in 1979 and earned his master's degree attending evening and summer classes. He currently teaches at Lone Peak High School in Highland, Utah. From 1994 through 2003, however, he was the mathematics specialist for Alpine School District, which serves much of Utah County. "I taught half-day and did my district job the other half. For the district, I visited schools, did teacher in-service, conducted workshops, and worked with parents to help them understand changes being made in mathematics curriculum and instruction. I also worked with a consortium of seven other Wasatch front school districts—as well as serving as president of the Utah Council of Teachers of Mathematics—to provide conferences for math educators throughout the state."

"I promised myself 25 years ago that when I stopped learning, it would be time to quit. But I'm still learning… and teaching!"

— Scott Hendrickson

While Hendrickson's teaching career was influenced by his service in the district office, it was his excellent teaching that earned him the prestigious Utah Teacher of the Year award in 1994 and the Presidential Award for Excellence in Mathematics and Science Teaching Award in 2003. Presented by President Bush, the latter award is given annually to two outstanding teachers—one from math and the other from science—for each state. Nominated by peers, parents, or students, the applicants must go through an arduous application process that includes a videotaped lesson and analysis and samples of student work following the lesson. The application is reviewed by peers from the nominating state. Three finalists in each discipline are then sent to the National Science Foundation for final selection.

"I've always wanted to be a good teacher," said Hendrickson. "I promised myself 25 years ago that when I stopped learning, it would be time to quit teaching. But I'm still learning ... and teaching!"

As part of that continued learning, Hendrickson believes he's experienced three paradigm shifts in his teaching career: inexperienced to traditional, traditional to technological, and finally, technological to transformational. "As a traditional teacher, kids would find things clear in class, but muddy when they got home," said Hendrickson. "In the technical phase, both teachers and students would rely more on manipulatives and graphing calculators. But in the transformational phase, I teach for understanding."

During the past decade, Hendrickson became more aware of how kids question things around them. "Math should not just be something memorized," he said. "So I moved away from formula memorization toward understanding and application. I use metaphors and models, and ask, 'how did you get there?' 'How did others get there?' 'Can different strategies be connected?' These techniques foster more discussion—and better learning."

There are many ways to learn teaching skills. One of them is to become associated with master teachers like Hendrickson. A former colleague of Hendrickson's has returned to BYU to get a master's degree, but visits Hendrickson's class weekly. He felt he wasn't successful at generating mathematical dialog with his students and wanted to discover how to create that environment in his classroom. Hendrickson's colleague became so engaged in his quest that he proposed the topic of "classroom discourse" for his master's thesis.

Speaking of his students, Hendrickson concluded, "We can say things that shut down their mathematical thinking, and we can ask questions that stimulate their thinking." It's Hendrickson's lifelong goal to pursue the latter.

"BYU prepared me for . . . experiences, in which I have blended analytical skills with business experience to build my professional career path." —Doug Later

DOUG LATER

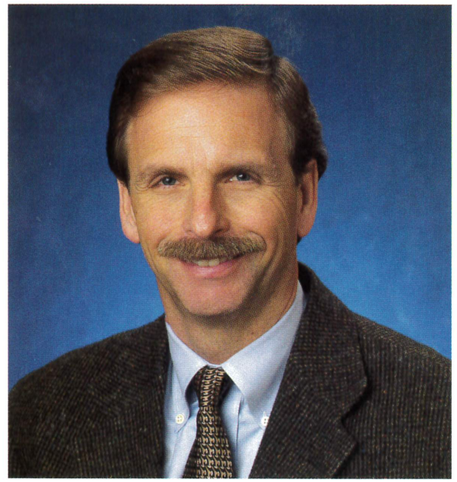
Varied career takes chemist from the lab to the executive suite

Not all chemistry graduates work *in* the laboratory. While he did spend several years in either a research or analytical capacity, Doug Later has migrated to the front office. He wouldn't be there without his hands-on laboratory experience, however. Raised in the Pacific Northwest and Alaska, Later graduated in 1978 from BYU with a BS in chemistry, followed by a Ph.D. in analytical chemistry in 1982.

"One can never anticipate everything that will happen in life," said Later. "I went to work for the largest research firm in the country and thought I was headed down a pure R and D career path. But in 1985, a new start-up high tech company presented a great opportunity that I couldn't resist."

Later was one of six co-founders of the new company Lee Scientific. "I was vice president of Research and Development," said Later, "but I also had responsibilities in engineering, manufacturing, and operations. I've always had the entrepreneurial spirit and enjoy this environment, as well as the larger business setting. Start-ups require a huge time sacrifice, but the paybacks are a sense of accomplishment and satisfaction."

Four years later, the company merged with Dionex, "As the two companies consolidated, other opportunities became more interesting," said Later. "So I joined a partner from the eastern United States and in 1989 we started an analytical environmental testing laboratory called Mountain States Analytical where I served as the president and laboratory director. Nine



years later I became the vice president and chief technology officer for Mining Service International (MSI), a chemical manufacturing company located in Salt Lake City, but with operations worldwide."

"I had worked in smaller companies for 13 or 14 years," said Later, "and felt I was ready to step up to bigger opportunities in a larger company that was more global. I was recruited by MSI for a year before joining, so it was not a quick decision."

Most recently, Later rejoined Dionex's market development department in 2002. "I've done three or four different things than I had anticipated," said Later, "but each contributed to my knowledge and experience. I'm not adverse to change—I like to do new and interesting things."

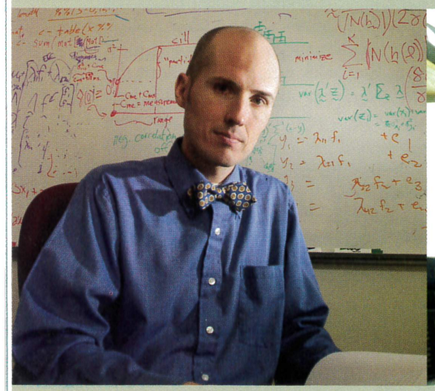
Today, Later is director of corporate marketing for Dionex corporation in Sunnyvale, California, with 1,000 employees and manufacturing facilities, technical centers, and sales offices throughout the world. Dionex products are used extensively in environmental, pharmaceutical, biotechnological, food and beverage, chemical, power generation, semiconductor, and other industries.

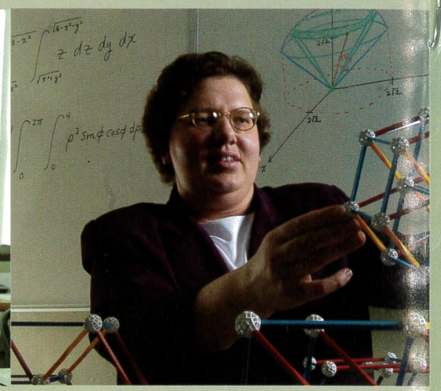
As the head of marketing for a large, worldwide corporation, Later feels BYU gave him an excellent foundation for his career. "BYU prepared me for a variety of experiences, in which I have blended analytical skills with business experience to build my professional career path," said Later. "In a company such as Dionex, where we manufacture, market, and sell a dozen different kinds of chromatographic instruments, my technical and analytical experience is tasked on a daily basis in my involvement with technical marketing and market development. Our market is spread across six major market segments from environmental to life sciences, and draws on a culmination of my background as a trained scientist and businessman. It's a far different set of circumstances and requirements than normally found with an MBA-type of marketing director."

Later also felt BYU prepared him to serve others professionally, in the community, and in religion. "BYU gives young people a very strong education," said Later, "so they can go out and get an advanced degree from top graduate schools or join the workforce at major companies. The university also reinforces the core values students learned in their homes."

Based on his own successful experience, Later's advice to undergraduates is direct: "Finish your education and get an advanced degree. Doing so will open up the best opportunities for an individual. It's a great way to provide financial stability and support a family in life." ■

new ideas from new teachers





Discovering Unidentified Pollution Sources

Imagine being handed a fruit smoothie and asked to figure out its ingredients—in their exact amounts. Sound difficult? The scenario is not too far from what scientists do to determine the makeup of pollution in the air we breathe. But thanks to statistics professor **William Christensen**, that job—which ultimately influences public policy and affects pollution-related health problems—has just become easier.

In two papers recently published by *Atmospheric Environment* and a forthcoming manuscript in *Communications in Statistics*, Christensen's methods more accurately identify which pollution sources contribute most to air pollution. One statistical approach, which he calls a simple modification of the "weighted least squares" method, attempts to unravel the contribution of individual pollution sources to total air pollution. It lets scientists say with greater accuracy which sources—like automobile exhaust, industrial emissions, and wood smoke—are contributing to air pollution, especially in situations where pollutant's "fingerprints" aren't well defined.

Christensen came to BYU in 2002 from Southern Methodist University in Dallas, Texas. He earned his Ph.D. in statistics from Iowa State University in 1999.

"It wasn't until the early 1970s that we

see "Improve the Air..." next page>>>

Changing Attitudes of Science Teachers

When geology professor **Barry Bickmore** came to BYU, he didn't expect to help write children's books, but that is exactly what he is doing thanks to a National Science Foundation grant aimed to help elementary school teachers teach science.

"A lot of elementary teachers don't like science," said Bickmore. "Their negative attitude is passed on to their students—even if just in subtle ways." Bickmore believes that the problem is due at least in part to the fact that schools don't have enough time to teach all the mandated subjects, and science is often the subject cut.

Bickmore's primary research field is mineral surface chemistry and his Ph.D. (Virginia Tech) and post-doctoral work (University of Colorado) are in mineral dissolution kinetics. But when he came to BYU in 2001 and taught a physical science class, he saw many students that were resistant to learning much about science—probably a result of poor learning in the early grades. He wanted to change that resistant attitude, and developed an idea for the "Earth Science Storybook Project."

"For their final class project, I asked students to create a storybook that taught an earth science principle," said Bickmore. "Through graduate student mentoring, students learned how to teach scientific

see "Teach Science..." next page>>>

Improving Engineering Mathematics

Most engineering and physics students know they need math in their chosen careers, but math classes offered at BYU didn't always connect with real life until **Denise Halverson**, a math professor specializing in topology, began coordinating a program to change that.

"When I was first assigned as the math coordinator, there were some problems with the engineering math program," said Halverson. "Relations between the engineering college and the mathematics department were poor, students didn't like the program, and instructors didn't like teaching the courses. Not surprisingly, student learning was inadequate."

BYU mathematics professors traditionally teach math and math education majors. But Halverson has helped redesign a curriculum for undergraduates across campus in the engineering college. The new courses help convey the mathematical knowledge they'll need for their career field.

Halverson, who received her Ph.D. in Mathematics from the University of Tennessee in Knoxville in 1999, helped organize several meetings to identify and discuss problems. Eventually, two new courses were created to replace older courses. Goals of the new program include:

see "Work Together..." next page>>>

"Improve the Air We Breathe" continued...

William Christensen

were able to go directly to the source of pollution, like a car's exhaust pipe, and say, 'That's the fingerprint, or chemical makeup, for car exhaust,' and then be able to disentangle the car pollution from the rest of the junk out there," said Christensen.

There is a limitation, however. "Getting a single, definitive fingerprint of car exhaust is extremely difficult," said Christensen. "There are hundreds of types of cars—each with a slightly different proportion of pollutants coming out of its tailpipe. Most expel different types of pollution when first started than when they've been running for hours. Time of year, grade of fuel, and location of vehicle also have an impact."

Christensen's approach appears to have significant advantages over other methods when there are one or more unidentified pollution sources affecting the air quality.

"A proposed statistical approach lets scientists say with greater accuracy which pollutants are contributing to total air pollution." – *William Christensen*

The standard tool for estimating the amounts of pollution sources has been the effective variance solution, used by the Environmental Protection Agency (E.P.A.). It assumes that pollution fingerprints are accurate. But the approach Christensen recommends works dramatically better when the fingerprints are poorly estimated, which is more in line with reality. He was joined on the study by Richard F. Gunst of Southern Methodist University.

In ongoing research funded by the E.P.A., Christensen and colleague Shane Reese, also of the BYU Department of Statistics, will develop approaches for pollution source apportionment which require even less information about fingerprints.

Christensen also applies his methods to teaching. "I wish to instill in students a curiosity," he said. "I want them to develop a desire to explore new areas. Learning to ask the right questions is the most important step in solving challenging problems. Getting students involved in research helps them gain ownership for their own education." ■

"Teach Science With Story Books" continued...

Barry Bickmore

principles and make a convincing presentation. Each book was illustrated by other students from the visual arts department as a part of their storybook illustration class."

Bickmore said the storybook idea just hit him one day, but since he was heavily involved in his own research, he recruited geology education master's student Mary Lusk. She took the idea, wrote a proposal to the NSF for $60,000, and got funded on her first try. "We also got a mentoring grant from BYU for $18,000. The funding is used to pay graduate students to administer the program, and to pay art students for their illustrations," said Bickmore.

The storybook project continued for two years. This fall, the team took some time off to complete other projects. The storybook project seems to be a success: early measures of achievement and attitude show significant improvement. Elementary students exposed to the storybooks appeared to do better on tests—not because their projects forced them to study more, but because their attitudes toward science improved.

The value of the project goes far beyond locally-printed storybooks. "Illustrated projects will be on the Web so teachers can download and use them in their classrooms," said Bickmore. "We're simply taking teachers' established interest in teaching children and adding science."

"Students involved in the storybook project appeared to do better on tests because their attitudes toward science improved." – *Barry Bickmore*

The work is far from complete. More testing in local schools is needed, and methods need to be aligned with state education standards. "We're still trying to determine the best and lowest cost method to implement this program permanently," said Bickmore, "and publish recommendations so others can replicate our model."

Like any good teacher, Bickmore has a personal aspiration that extends beyond standing in front of a classroom. "I just want to do the things that will make the best possible impact on society," he said. ■

"Work Together to Advance Curriculum" continued...

Denise Halverson

- Teaching students mathematical foundations necessary for studying engineering
- Helping students appreciate the value of mathematics in their engineering programs
- Providing students with a positive engineering math experience
- Working together to meet the needs of the engineering programs

"We gathered a lot of input and then I worked closely with Jordan Cox, the asso-

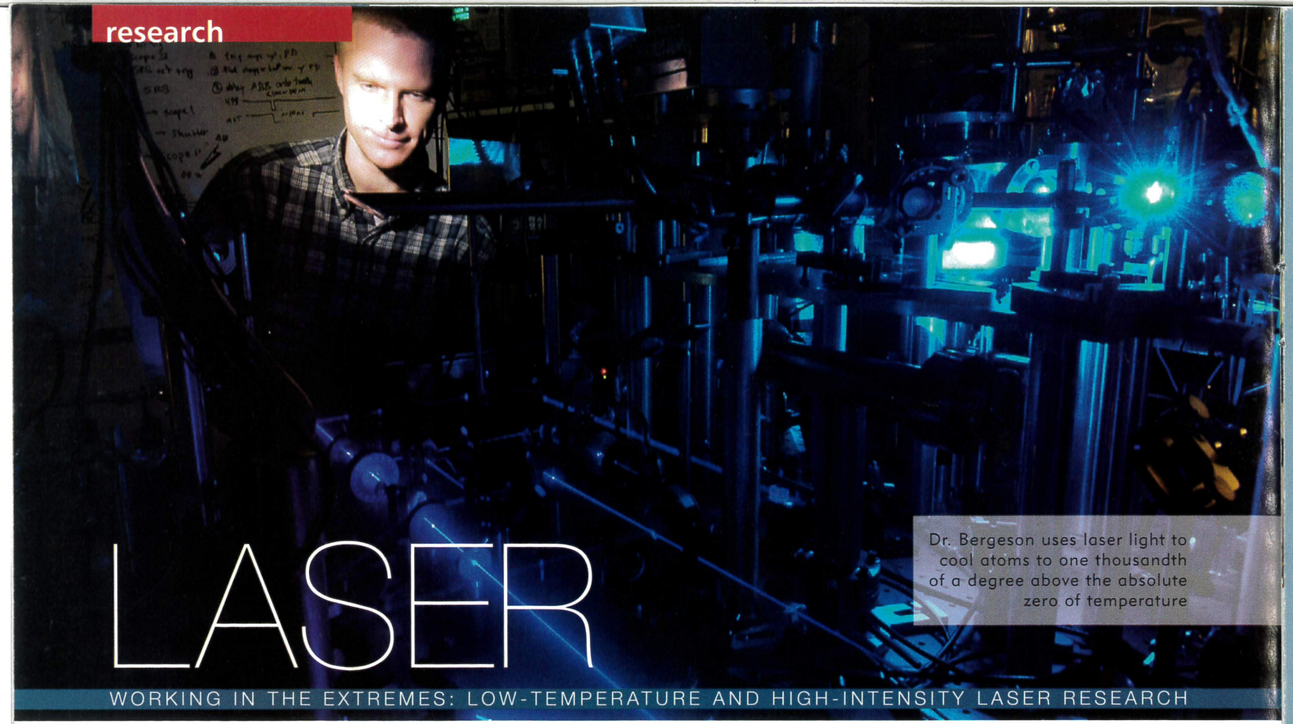
"Redefining a math curriculum for engineering and physics students has prepared them to understand practical math applications." – *Denise Halverson*

ciate dean for undergraduate studies in the engineering college, to write outcome statements that detail the learning expectations for both courses," said Halverson. "I organized the first group of Math 302 and Math 303 instructors to create lesson outlines for both courses."

One of the most positive aspects of the new engineering math program is the teaching group that it created. "The instructors work very closely together," said Halverson. "We discuss the course policies, make common midterms and share teaching ideas. Engineering professors make presentations four times a semester to give students opportunities to see research in their fields, why math is important, and how it applies. This also gives math instructors an opportunity to interact with faculty outside the math department, and thereby gain a better understanding of the application of mathematics in engineering and the sciences."

"It's been a tremendous amount of work," said Halverson, "but very rewarding. Students are better prepared to understand and use practical math applications in their area of study, and their test scores have continued to improve since the course was introduced in 2002."

Halverson has enlarged her research interests as a result of her involvement with engineering. "There is a need for mathematicians to better communicate with people outside their profession," she said. "I'd like to help play that role." ■



Dr. Bergeson uses laser light to cool atoms to one thousandth of a degree above the absolute zero of temperature

LASER

WORKING IN THE EXTREMES: LOW-TEMPERATURE AND HIGH-INTENSITY LASER RESEARCH

To most of us, lasers are the stuff of new-fangled eye surgery, psychedelic shows at the local planetarium, high-tech rifle scopes, and the always-annoying pointers that teens pull out at the movie theater. To Scott Bergeson and Justin Peatross, however, they are critical components of helping us understand our world at the atomic level.

A career in particle physics is not exactly a popular life path. Even Peatross admits, "I had no idea someone could do just science for a living." During their youth, however, Bergeson and Peatross were perennial science enthusiasts. Although it's unlikely their childhood daydreams were filled with visions of blasting calcium atoms with lasers to create ultracold plasma or shooting lasers at noble gas jets to create extreme ultraviolet radiation, they both grew up loving physics.

"I can't remember a time that I wasn't interested in physics," says Bergeson, a physics professor and researcher at Brigham Young University.

"It wasn't until college that I even had an idea that someone could become a physicist," says Peatross, also a BYU physics professor and researcher. "I was an engineering major because I thought that was the only career that really got to use physics. I had no idea that people could do just physics and nothing else. When I figured that out, I changed majors that very day."

Today, both Bergeson and Peatross are physicists. They both teach at BYU, and they both are conducting cutting-edge research using laser and optics technology. The only difference is the temperature.

DR. SCOTT BERGESON: ULTRA-COLD PLASMAS, LASER COOLING, AND TRAPPING

Bergeson's research has focused on studying the properties of a special type of matter, called plasma, at ultra-cold temperatures.

"Plasmas are forms of matter in which a significant amount of the atoms have been ionized, meaning there are a lot of free electrons and ions," says Bergeson. "Most of the universe is made up of plasma, and usually it is quite hot."

Bergeson's lab, however, has been creating very cold plasma by using lasers—one laser to trap the particles in the experiment and cool them to temperatures of 1 microKelvin (less than -459° Fahrenheit) and another laser to ionize the atoms to make the plasma.

Being able to create cold plasma makes it much easier to study ions and atoms because the electrons can be controlled. Ultra-cold plasma has more potential electrical energy and less kinetic energy, which means the atoms are not moving around as much, and thus easier to diagnose. Plasma in this state is called "strongly coupled."

Some of Bergeson's research studies plasma in a Rydberg state, which is when the matter is almost—but not quite—ionized; the outer electrons are still attached to the atom, even though they are comparatively far from the nucleus.

"No one has been able to study Rydberg systems before," says Bergeson. "Learning about them will help us understand the predictive qualities of metallic gases, which will have applications for people studying high-temperature gas super-giant stars."

The most recent step in Bergeson's research has been to optically image the plasma. By "taking pictures" of ultra-cooled calcium atoms, Bergeson has been able to answer additional questions about plasma, such as why plasma expands much faster than expected. When the plasma's expansion is controlled, its overall lifetime is extended.

Although Bergeson terms his research "nerd science," it is breaking new barriers in the current understanding of basic physics. He writes in *Physics World*: "In addition to being fascinating in themselves, these exotic and unexplored states of matter may also help us to understand the surface of neutron stars and the centers of planets such as Jupiter."

DR. JUSTIN PEATROSS: LASER HIGH-ORDER HARMONIC GENERATION

On the other end of the laser spectrum, Peatross studies radiation generated from atoms when they are struck by intense laser light. His lab has created laser pulses with extremely short duration—25 femtoseconds, or 25 millionths of a billionth of a second. Because the bursts of laser energy are concentrated, the intensity is very high.

"By concentrating the amplified laser energy into such a brief duration, we can achieve intensities beyond a million trillion watts per square centimeter," says Peatross. "That's equivalent to taking all of the sunlight striking the Earth and concentrating it onto the head of a pin."

Even though the intensity and temperature of the laser are extremely high, Peatross says the total energy is quite modest because each burst is incredibly short.

Peatross uses this laser to hit jets of noble gases such as argon, neon, or helium. When the laser beam hits a jet of one of these gases, the atoms' electrons are violently pulled and disassociated from their nuclei. This creates radiation in the extreme ultraviolet energy range.

"The accelerating electrons radiate high-order harmonics of the laser wavelength, which emerge in a directional laser-like beam. The harmonics are extremely short in duration—even shorter than the laser pulse," says Peatross.

The harmonic radiation from the atoms is the focus of Peatross' recent research.

"Our question is, 'Can we make this light [radiation] source brighter?'" says Peatross. "The main problem is that the atoms often work against each other. The trick is to get billions of atoms to cooperate by producing this harmonic light in phase; if they are out of phase, the energy just cancels out."

"Rather than trying to straighten them all up, we've decided to kill all the ones that are out of phase," says Peatross. "This is called quasi phase matching." Peatross compares this process to two opposing armies. If allowed to fight, they may destroy each other except for a small remainder on the winning side. If you wipe out one army before they fight, however, then an entire army can be preserved intact.

Peatross' experiments use an additional laser beam to achieve quasi phase matching. By placing another laser opposite from or perpendicular to the original laser, he's been able to remove many of the out-of-phase atoms. This makes the extreme ultraviolet radiation even brighter.

Although Peatross' experiments are "basic research," the results of his findings may have practical applications.

"The wavelength range of the high harmonics is increasingly important to the semiconductor industry because shorter wavelengths are needed to make smaller features on computer chips," says Peatross.

Peatross' work will probably not translate directly to chip lithographic imprinting technology, but it may be important in testing the optical properties of new materials that could be used in the process.

"No one has been able to study Rydberg systems before," says Bergeson. "Learning about them will help us understand the predictive qualities of metallic gases, and this will have applications for people studying high-temperature gas super-giant stars."

A TEACHING TRADITION

After pursuing their undergraduate degrees at BYU, both Bergeson and Peatross have returned to Provo so they can work and teach at BYU.

"I've always wanted to teach," says Bergeson. "Although I received several offers to work in government labs, I turned them down to teach here."

Bergeson's and Peatross' love for science has not only led them to successful careers in unlocking the secrets of basic science, they are also well-liked and devoted teachers.

"It's rewarding to watch students grow," says Bergeson. "Undergraduate opportunities at BYU are top-notch." Peatross agrees. He has 10 undergrads working in his lab—more than any other in the department.

"I really enjoy working with students," says Peatross. "The university provides opportunities for funding so they can make a little money working on their research and not have to be a janitor somewhere at 2 a.m."

"Undergraduates here are doing the things that graduate students normally do," says Peatross. "It's great to watch the younger ones learn from the advice and experience of the older ones."

LIFE LESSONS

Lessons in the lab have also translated to lessons in life for Bergeson and Peatross.

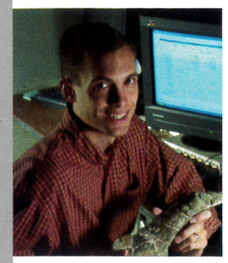
"My research has taught me respect for nature," says Bergeson. "Learning is much more subtle than you might expect. The answers you get are not just X-Y-Z, and so you learn about being really patient on a project and working hard. You really have to put your soul into the subject."

"I've learned that research takes time," says Peatross. "When I first got here, I was eager to accomplish milestones and to build my lab. Over the years, I've had disappointments, but I learned that you have to stick with it. When you do, you'll get lucky breaks, and you'll never know where they are going to come from." ■

Dr. Peatross working with experimental equipment used to generate high-order harmonics

CLASS **NOTES**

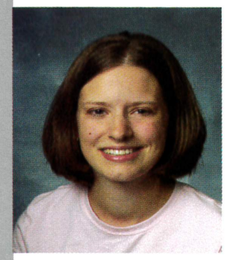
DEMISE OF THE DINOSAURS



Brent Greenhalgh used a geology time machine to solve a 120 million-year-old mystery. He looked at more than 3,000 dinosaur bones and found that they were bitten, gnawed, trampled, and crushed by other dinosaurs, then left to the elements and transported in a debris flow to the edge of a lake where dinosaurs pushed them into the mud. There, the bones were partially eaten by insect larvae.

Greenhalgh, a native of Pleasant Grove, Utah, has been involved in this taphonomic study of the Dalton Wells Quarry dinosaur fauna near Moab, Utah. As a graduate student, Greenhalgh is helping solve the mystery of what killed off the dinosaurs and what happened to their remains. He will graduate with a master's degree in geology in 2006.

MATH LITERACY FOR WOMEN

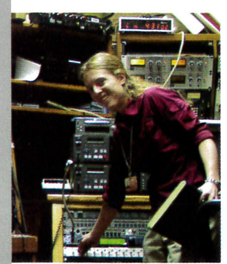


Janel Joy Williams is helping to increase math literacy in Mexican women through studies conducted during a student mentoring experience through BYU Study Abroad. During each visit Williams taught adults math and its importance in real-life situations. As a female math education major, Williams has always been interested in women's attitudes regarding mathematics.

She studied the reasons why a group of 37 adult women did or did not want to study mathematics and the usefulness of math in the lives of these women. She presented a mathematical situation similar to situations these rural women encountered in their lives, such as paying for their children's schooling by selling the goat cheese they made. Williams is in the process of translating, transcribing, and analyzing her data.

The Provo, Utah, native graduated with a bachelor's degree in math education in 2004 and is now living in South Bend, Indiana.

TABERNACLE ACOUSTICS

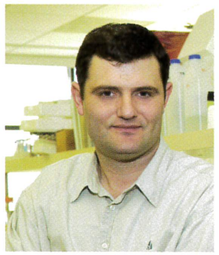


Sarah Rollins, a physics graduate student from West Valley, Utah, is helping to preserve the quality of one of The Church of Jesus Christ of Latter-day Saints' most notable historic landmarks. She has excelled in architectural acoustics and is currently involved in characterizing the acoustics in the historic Salt Lake Tabernacle.

Rollins' work delves into past designs as well as future renovations to help the Church maintain the acoustics of the Tabernacle. Her characterization includes on-site acoustical measurements and computer modeling. Computer models of the Tabernacle are used to study its acoustics in its current configuration as well as of different historical configurations. Rollins' work is available to acoustical consultants involved in the current restoration of the Tabernacle to test how proposed changes could affect acoustics in different parts of the building.

Rollins will graduate with a master's degree in physics in 2005 and plans to acquire a Ph.D. in acoustics or work in sound design or architectural acoustics consulting.

REGULATION OF THE G PROTEIN



In his relatively young life, Georgi Lukov was the the sixth person to join the Church in Plovdiv, Bulgaria, served as a branch president, earned an M.D. degree, then married and became the father of three children. In 2001, he became a full-time biochemistry graduate student in the Department of Chemistry and Biochemistry.

Under the guidance of Barry Willardson, he is investigating the cellular role of a phosducin-like protein (PhLP). Lukov and Willardson believe that their discoveries are fundamental for the understanding of a major signaling pathway and could lead to development of new therapies targeting signaling pathways coupled to G proteins.

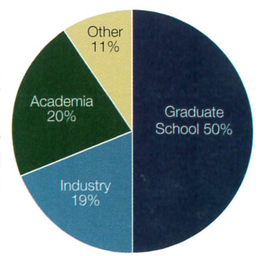
In his spare time, Lukov and his wife work as Church service missionaries, interpreting General Conference and other Church broadcasts to Bulgaria. Lukov will earn his Ph.D. in biochemistry in 2005, and plans to work in experimental medicine.

STARRY, STARRY NIGHTS

Renovations on the Eyring Science Center Planetarium began July 5, 2004. The old, 43-seat facility on the roof of the Eyring Science Center was demolished and is being replaced with a new, 120-seat structure. Renovations will include a complete redesign with a new dome, new seating, digitally controlled sound, and a new projector. The project is expected to be completed by the end of the year. When the planetarium is not being used for astronomy classes, it will be available as a large classroom. Star shows are also planned for the general public.

GRADUATE DESTINATIONS

A recent survey showed that 50 percent of the 2003 graduates from the BYU College of Physical and Mathematical Sciences went on to graduate school. Twenty percent picked up academic jobs, and another 19 percent were hired for jobs in industry.



INVESTING IN MENTORED FUTURES

A remarkable single mom helped put two children through BYU, and then saved enough money to become a significant contributor to their alma mater.

When Leslie Shepherd got married in 1967, she didn't know she would soon become the primary provider for her family. Shortly after Shepherd attended BYU for one year then served a mission to the Eastern States, she married. In the next six years she had three daughters and worked to help her husband go to graduate school in Wisconsin. Her husband's work for the navy moved them from coast to coast and halfway around the world. But her life took an abrupt turn in 1977 when she became a single mom with three young children.

"Two other companies wanted me to invest with them but I wanted to give back to BYU because my children received scholarships there. With the trust, I'm getting eight percent on my money." – Leslie Shepherd

Shepherd returned to her parents' home in Arizona. With no credit history and just $500 for a down payment, she bought her first house on contract from the seller. She took courses in real estate and personal finance and graduated from Arizona State University in 1981 with a degree in elementary education. But it was her real estate and finance training, coupled with property inherited from her parents, that paved the way for Shepherd and her three children for the next 20 years.

"I tried selling real estate for a living," said Shepherd, "but didn't have much success. I sold my first house to a lady in my ward who had never owned a home. Much to the dismay of my broker and the loan officer, I chipped in my commission to make the deal go through." An unscrupulous buyer defrauded the seller in the next house Shepherd brokered, and though she had no legal obligation, she paid the seller as much as she could to offset a portion of his losses.

While her career as a real estate agent was short-lived, Shepherd put her knowledge to work and started buying houses and rental units for her own portfolio, then reselling some of them for a profit. At one time, her portfolio included 14 properties in Utah and Arizona, including a home in Provo used by her daughters attending BYU.

This summer, Shepherd decided to give back to BYU a portion of what the university gave to her family. "Each of my daughters received a scholarship to BYU," said Shepherd, "and two graduated there—one with a bachelor's and one with a master's. Two went on to receive doctorates. I paid very little for their educations."

Shepherd selected a charitable remainder trust (see inset) as the vehicle to provide funds for mentoring students in the Department of Chemistry and Biochemistry in the College of Physical and Mathematical Sciences. "My oldest daughter was a premed student, the second has a doctorate in chemistry, and the youngest has a doctorate in electrical engineering. My uncle was also a professor of chemistry until he retired," said Shepherd.

Last year, Shepherd went to an investment seminar where they talked about charitable remainder trusts. "Two other companies wanted me to invest with them," she said, "but I wanted to give back to BYU because my children received scholarships there. With the trust, I'm getting eight percent on my money. Then, when I die, BYU receives the balance. If BYU earns more than they're paying me, the difference goes on the principle and my interest percentage earns me even more."

Shepherd found the process of creating the trust relatively simple. "It was very easy," she said. "David Bonner [of the LDS Foundation] came to my house and explained the process to me, then took care of all the details. The foundation attorney set up the paperwork to ensure I get all the tax advantages available, and this amounted to several thousand dollars."

"The CRT not only benefits BYU," said Shepherd, "but gives me several advantages. BYU also allowed me to determine how my funds would be used. I like the mentoring program because it pays the students to work in their major field instead of an unrelated job." ■

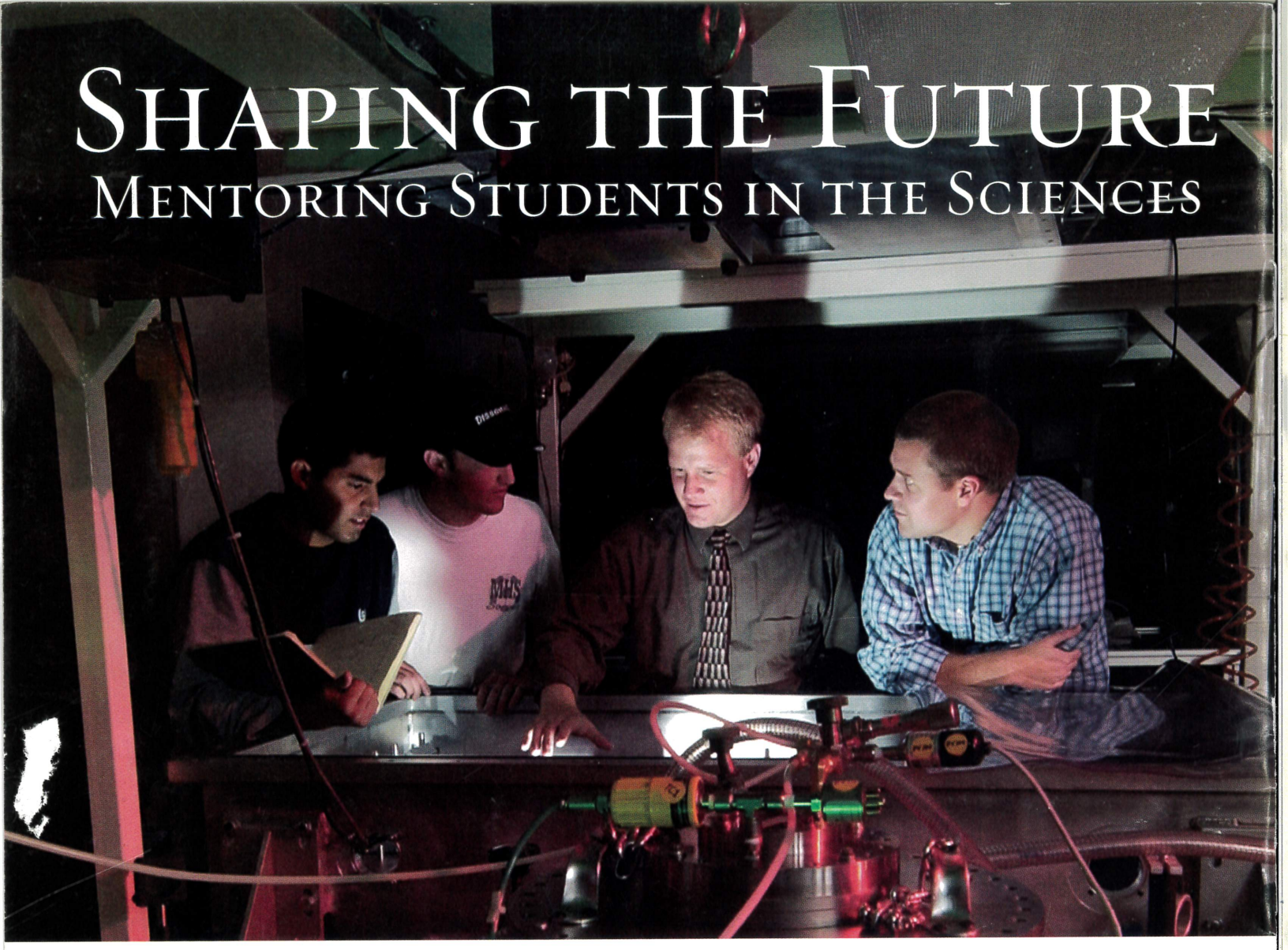
Charitable Remainder Trusts

Charitable Remainder Trusts (CRTs) are flexible instruments that can provide you an income for life, and then present a nice gift to your favorite charities upon your passing. Properly designed and implemented, CRTs provide asset diversification and significant tax advantages.

The LDS Foundation at BYU provides considerable expertise in planned gifting in strict confidence and at no charge. Working in harmony with you and your professional advisors, the Foundation can help you identify the potential benefits offered by CRTs and other planned giving vehicles. For assistance in creating an effective estate planning strategy, please contact David Bonner, 1-800-525-8074; david_bonner@byu.edu.

Shaping the Future

Mentoring Students in the Sciences



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. The college has current resources to support about 250 students with a one-semester mentored experience. Our goal is to provide a year-long mentored experience to every undergraduate who wishes to participate. To do that, we must triple our funding.

Students learn the real application of a discipline as they work closely with our faculty. They gain experience using modern instruments as they work with leaders in their chosen fields, which often leads to publication of their research in professional peer-reviewed journals. This builds student confidence as they become members of successful scientific teams.

I invite you to contact David Bonner at 1-800-525-8074 or david_bonner@byu.edu for more information on ways you can support mentoring in the College of Physical and Mathematical Sciences. His service is confidential and without obligation. I also invite you to view a complementary DVD, *Enhancing Undergraduate Education at BYU,* illustrating mentoring in action. Please send an email to frontiers@cpmsdo.byu.edu and include your name and mailing address to request your free copy of our DVD.

Mentored learning experiences lead our undergraduates along paths toward new discoveries that will have a positive impact on society. Together, you, our faculty, and our students are pushing back the frontiers of science.

Earl M. Woolley, Dean

BYU COLLEGE OF PHYSICAL AND MATHEMATICAL SCIENCES