Chemical Engineering

Winter 2006

Catalyst

UNIVERSITY OF WASHINGTON
COLLEGE of ENGINEERING
A Community of Innovators

In this issue

Finlayson Challenges Students with Real-World Problems

Helping to solve problems—from reducing pollution caused by catalytic converters to designing medical sensors tiny enough to slip into a slot on a cell phone—has been Bruce Finlayson's focus throughout his 38 years at the UW. His forte is developing and applying numerical methods for solving chemical engineering challenges. Despite retiring this fall, Finlayson continues to guide student research and teach his popular elective on computer methods for undergraduates.

Throughout his career, Finlayson has applied the latest research methods to challenges as diverse as computer recycling, swallowing, ferrofluids, and fuel cells. He also has been a pioneer in creating software and designing courses to help students focus on solving real-world problems.

Computers and books are both needed for good modeling, Prof. Finlayson explains to Nick Tapias, Thin Thin Swe, and Diana Chung.

More than 40 years ago, Finlayson was one of the first professors in the United States to introduce computer-aided design (CAD) tools. Early on, he witnessed how students' creativity flourishes when computer programs free them from the underlying calculations.

"My philosophy is that students can be good chemical engineers without understanding the

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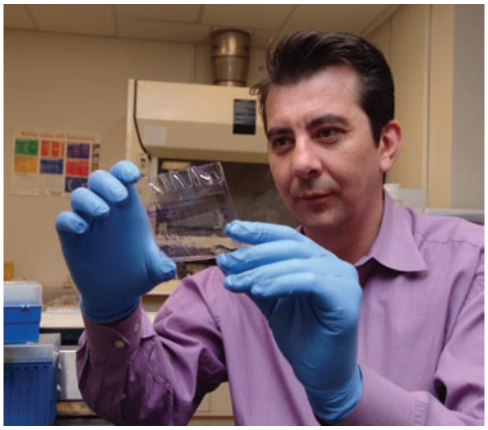

Professor François Baneyx

Endowment Opens Road Less Traveled for Baneyx

The ability to pursue research off the beaten path is a dream for many scientists. Being awarded the Charles W. H. Matthaei Professorship in Chemical Engineering opens the door to such explorations, says François Baneyx.

"What you propose on paper is rarely the way it works out, because you cannot predict the behavior of complex systems," he notes. "The most interesting outcomes have often come from paths that diverged from what was initially proposed."

The flexibility provided by endowments like the Matthaei Professorship are particularly valuable as agencies like the National Science Foundation move away from awarding traditional single-investigator grants. Discretionary money "allows us to collaborate across disciplines with other faculty, to go off on a wild chase and see if it pays off—and often it does," says Baneyx.

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Catalyst Gets a Makeover

We are moving into our second century with a new look and a new production schedule. This year, *Catalyst* becomes a biannual publication. Why the changes? We'd like to have more frequent communication with our alumni and friends, and we can report feedback in a more timely fashion and improve dialogue with our alumni. Each issue will include profiles of faculty, students, and alumni.

Two major events are celebrated in this issue—one honoring a great career and the other holding a promise for the future. Prof. Bruce Finlayson retired this fall after serving the department for 38 years. As many of you know, Bruce led the department as chair for nine years. He has been a great teacher, researcher, and mentor for both students and faculty. Fortunately, he won't be going very far away. He will continue his research, offering undergraduate research projects, and teach his popular Computer Methods in Chemical Engineering course to juniors. Recently, Bruce sent me an e-mail and noted, "It's surprising how fast one begins to relax upon retiring!" Well done, Bruce!

In July 2005, Prof. François Baneyx was named the holder of the Charles W. H. Matthaei Professorship in Chemical Engineering. This award recognizes François' strong commitment and success in research and teaching. The Matthaei Professorship, provided by a generous endowment from Chuck Matthaei (BS 1943), is a great honor for François and the department. The Matthaei Professorship will help François raise grant money for his students and allow him to take some risks in his research. You can read more about François and Chuck in the accompanying articles.

Call for 2007 Nominations!

The R. Wells Moulton Distinguished Alumnus/a Award is given annually to an alumnus or alumna of the UW Chemical Engineering program who achieves distinction in one or more areas of the chemical industry, other industry, academia, government service, or public or volunteer service. The 2006 honoree will be announced in May. Nominations may be submitted to dept@cheme.washington.edu.

Eric M. Stuve, Chair

New in this issue is a feature article, "Energy and the Future of Fuels," about the impact of diminishing oil production and how fuel cells can mitigate that effect and improve energy efficiency. We'll have feature articles on other topics in future issues.

You can find all the details, statistics, and fundraising successes in the two inserts. The *Year in Review* summarizes department productivity with facts and figures on students, degrees, research, education, and personnel changes. The *Report to Contributors* features our endowments, annual fundraising, and donor acknowledgments. Please take a moment to look through the inserts; they're our record of performance and our thanks to our many supporters.

I'd like to close this message with a request. Our celebration of the Matthaei Professorship was a great milestone, and we'd like to see more of those in the future. If you are considering an endowment or bequest, please contact me and we can discuss ways in which your support can make a significant impact in ChemE. Our most pressing needs are for faculty support in the forms of professorships and endowed chairs. A professorship or endowed chair conveys prestige and recognition both to the donor and recipient. Funds from the endowment help support a distinguished research program and give faculty a big competitive boost in getting more research grants funded. In turn that means more educational opportunities for graduate students and a stronger UW presence in research that can transform peoples' lives.

We hope you enjoy the new *Catalyst*. If you have suggestions for improving *Catalyst*, or just want to share a story about yourself, please send us a letter or an e-mail. We'd love to hear from you! •

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For more faculty and alumni news, visit our Website: depts.washington.edu/chemeng

Finlayson *(from page 1)*

details of the numerical analysis," said Finlayson, who is the Rehnberg Professor of Chemical Engineering.

Today, he uses the finite element program FEMLAB™ for computational fluid dynamics (CFD) to simulate the flows of gases and liquids. Rather than expressing models as differential equations, computer programs like FEMLAB visualize the models with contours and colors. The visual display lets researchers quickly see, for example, how the viscosity of liquids affects their diffusion in a mixing chamber or how heat transfer varies depending on the thickness of portions of a jet nose cone.

Not many years ago, such work required researchers to develop a deep understanding of numerical science, write their own computer programs to create models, and then laboriously reprogram to reflect any changes in variables. With today's graphical user interfaces (GUIs), the focus has shifted to coming up with solutions and evaluating them.

"Instead of teaching a small fraction of the class numerical methods," he says, "I now teach all the class to use the computer wisely. It gives them a chance to be creative without getting enmeshed in the details."

Examples of problems his students have tackled include reducing pollution from catalytic converters, designing mixing chambers optimized for the viscosity of different fluids, and filtering out sludge at the Renton sewage treatment plant.

Because of the growing importance of microreactors, his current research with undergrad students focuses on small laminar flows, dispersion, and mixing. In addition, he regularly helps graduate students in other departments develop models of their thesis subjects.

"My philosophy is that students can be good chemical engineers without understanding the details of the numerical analysis"

Finlayson describes his approach and teaching methods in his newly published *Introduction to Chemical Engineering Computing*, which is the first recipient of the department's $20,000 Richford Textbook Challenge.

For his leadership in chemical engineering education, Finlayson received the 2005 Dow Lectureship Award from the Chemical Engineering Division of the American Society for Engineering Education. Finlayson's many honors include the prestigious Walker Award from the American Institute of Chemical Engineers, induction into the National Academy of Engineering, and serving as president of the American Institute of Chemical Engineers in 2000. •

Moving Up

Mary Lidstrom became the UW vice provost for research on November 15th. Mary is professor of chemical engineering and of microbiology and holds the Frank Jungers Chair of Engineering. She was formerly associate dean for new initiatives in the College of Engineering.

Mary's own stellar research program and her long experience in leading interdisciplinary research, as well as her leadership in educational innovation, position her well to lead the UW's Office of Research.

Dan Schwartz took over as acting associate dean for new initiatives, succeeding Mary Lidstrom. Dan is the Boeing-Sutter Professor of Chemical Engineering and adjunct professor of materials science and engineering.

His research explores the electrochemical science and engineering that underpins wide-ranging technologies from fuel cells to biomimetic materials. Dan's research and teaching is highly collaborative, involving faculty from electrical, mechanical, materials science, and civil engineering as well as microbiology, chemistry, and physics. His group is also a regular user of shared research instrumentation on campus. Dan brings to the job his extremely valuable experience in building major interdisciplinary initiatives in both research and education. •

Energy and the Future of Fuels

"Are We Running Out of Oil? That's the Wrong Question," Prof. Bruce Finlayson told a gathering of local alums. The occasion was an alumni forum on "Energy and the Future of Fuels," held at Benson Hall on March 23, 2005. The forum continued discussions begun during last year's centennial celebration. Finlayson expanded on a book written by K. S. Deffeyes, *Hubbert's Peak: The Impending World Oil Shortage* (Princeton University Press, 2003).

"It is the peak, rather than the time the reserves will last, that will cause the real problems."

While oil reserves have always had a finite lifetime, that lifetime has eluded prediction because the amount of available reserves increases as the price of oil increases. If people are willing to pay more for oil, then more oil can be extracted. Some sophisticated modeling by Hubbert shows that reserves can reasonably be expected to last for 50 years or more, but that oil production will peak in the near future, if it has not done so already. It is the peak, rather than the time the reserves will last, that will cause the real problems. The estimate of the peak time ranges from 2000 to 2020.

With increasing demand for oil production, a peak in production means that an oil shortage occurs immediately once the peak has past. Any shortage, no matter how small, will cause oil prices to increase, possibly dramatically. This happens because of an unusually inelastic demand for oil. The most recent energy consumption figures from the U.S. Department of Energy, Annual Energy Review (2003) show why oil holds a special relationship in energy demand.

The United States derives over 86% of its energy from fossil fuels: oil, natural gas, and coal. Oil provides about half of fossil fuel energy, and natural gas and coal each split the remaining half. The remaining U.S. energy needs are divided about equally between nuclear power and renewables, which includes hydroelectric, solar, ethanol, wood, wind, biogas, and biodiesel.

Now we ask the question, "How flexible is our energy system?" That is, how easily can other sources of energy offset a decline in one source? Three of the four main energy use sectors—industrial, commercial, and residential—have good energy flexibility, since they take their energy from all available sources. The fourth sector—transportation—has very little energy flexibility. Oil supplies 95% of the energy needed for transportation, and transportation uses 66% of all oil-supplied energy. This unusually tight link makes oil an inelastic commodity; oil prices rapidly escalate under any threat of diminished supply.

To ease the dependence of transportation on oil, we seek an intermediate fuel that can be produced from a variety of energy sources and a technology for using that fuel in transportation. Hydrogen and fuel cells combine to make one

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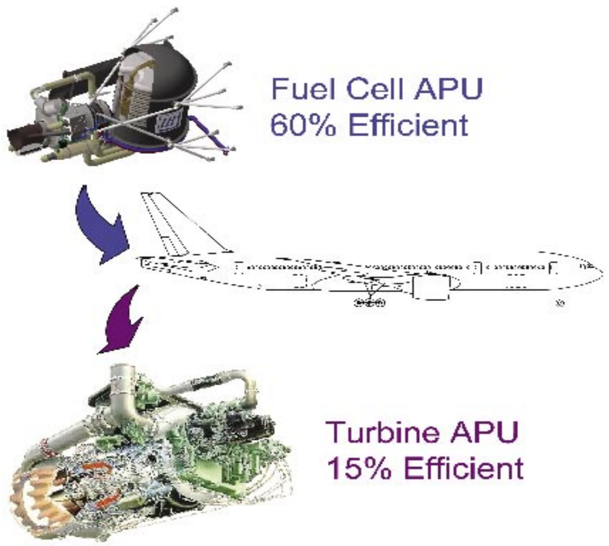
Student Biodiesel Project

Senior design students, co-taught by Profs. Schwartz and Finlayson, designed a facility to make biodiesel from raw materials grown in Washington state for vehicles in King County.

The students found that if Eastern Washington farmers grew rapeseed (canola oil) on half the land in seven counties now being used to grow wheat, they could supply only 18% of the state's diesel market. Fortunately, the rapeseed could be grown between wheat crops, so income to the farmer would be increased. The process is fairly simple, but the equipment to crush the seeds costs as much as the chemical plant. Diesel prices need to be higher to make it economical.

Students looked at the societal impact of their decisions through three debates: Resolved: The environmental and geopolitical benefits of biodiesel are great enough to warrant a $1 per gallon subsidy by the government. Each group debated one side and possibly not the side they believed in. Afterwards, they voted on the debate performance, and the total vote in the three debates was 31 affirmative, 25 negative, and 3 ties. However, when they voted their personal preference, the vote was 12 affirmative and 18 negative—interesting.

Guest speakers enlightened students about their professional responsibilities: Tapas Das (state Department of Ecology), Prof. Joyce Cooper (mechanical engineering, life cycle analysis), Jaimie Hennessy (CH2M Hill, BS ChE 1988), Prof. Gerry Philipsen (communications), and Ravi Mikkelsen (BS MSE 2005), who is starting a biodiesel company in Oregon. Nathan Miller, our computer systems analyst and owner of a biodiesel-fueled Volkswagen TDI, provided a consumer perspective. During the quarter this was a hot topic in Seattle (Senator Maria Cantwell was advocating for biodiesel), and four of our students were interviewed on the radio.



possible solution. Hydrogen can be produced by all major energy sources, and fuel cells use hydrogen more efficiently—and with substantially less environmental impact—than internal combustion engines can burn gasoline, diesel, or even hydrogen itself. This is the basis of "The Hydrogen Economy," the National Academy of Engineering's 2004 report.

Prof. Stu Adler introduced alumni to fuel cells and their operation. He presented a number of examples of fuel cells used for automobiles, portable power devices, and even airplanes. Nearly every major automobile manufacturer now has prototype vehicles running on hydrogen-powered, proton exchange membrane (PEM) fuel cells. The use of fuel cells in automobiles has a few major engineering hurdles remaining, such as the ability to withstand freezing (to –20°C), storing enough hydrogen on board for a 300-mile trip (currently, the best is about 200 miles), and providing sufficient lifetime (about 5,000 hours).

Boeing is studying the use of fuel cells as auxiliary power units (APUs) in airplanes. The APU is a small turbine located in the tail of the aircraft. Turbine APUs typically have an average fuel efficiency of around 15% and contribute to airplane nitrogen oxide (NOx) emissions. A solid oxide fuel cell (SOFC) APU running on jet fuel may one day generate electricity with over 60% efficiency and virtually no NOx emissions. In fact, the APU is more efficient than the main engine generators and can save fuel by generating electricity in flight. Also, water can be recovered from the fuel cell exhaust for graywater applications on board. This, in effect, makes the fuel cell APU a chemical plant that turns fuel into water. With improved engineering, the SOFC APU could become a reality in 10–15 years. For now, it's a very interesting application for Boeing and the UW. •

by Eric M. Stuve

Unit Ops: The French Connection

Ten UW seniors participated in an experiment in summer 2005. The students, supported in part by funding from Prof. Jim Seferis, took their final required chemical engineering course in Toulouse, France, with Prof. Larry Ricker as their instructor.

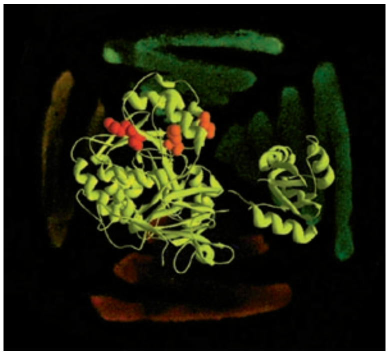
The students were able to use the excellent unit operations lab facilities in Toulouse, discovered by Prof. Ricker while he was there on sabbatical in 1994–95. As it turned out, the students found the intensive, three-week lab schedule to be more demanding than they had expected, but the facilities and the city made it worthwhile. In addition to French students, they worked with six juniors from the University of Colorado chemical engineering program. Several UW students commented that it was eye opening to work in teams with the Colorado students, who had similar but different educational preparation and ways of approaching problems.

French faculty members and students sat in on the last round of oral lab presentations. Several commented that they were impressed by the UW students' results-oriented, professional approach to lab work.

After successfully completing the course, the students dispersed in small groups to travel and relax before returning home. Prof. Ricker headed back to Seattle to consider, among other things, improvements for the next offering. •

Rebecca Weathersby, one of 10 UW chemical engineering seniors, in the unit operations lab at Toulouse, France.

Baneyx *(from page 1)*



Fireflies produce green light by making use of a protein called luciferase. This light-emitting enzyme holds great promise for sensing applications and medical imaging, although multicolored variants are desirable for monitoring multiple signals. Baneyx's PhD student Elyse Shapiro used random mutagenesis to isolate luciferase variants that produce light in the yellow-red region of the spectrum. The three-dimensional structure of the luciferase enzyme is superimposed.

One example of fruitful collaboration is his work with Professor Daniel Schwartz, combining protein engineering and electrochemistry. Together, they are exploring how to make proteins bind to inorganic compounds to create new materials with valuable magnetic, structural, or photonic properties. Already, they have succeeded in mimicking the biomineralization process at the nanoscale—using proteins to synthesize inorganic nanoparticles and organize them into a predictable structure (which is how marine mollusks make their shells).

Nanostructured materials—made of particles measuring less than one-millionth of a millimeter—hold great promise for electronic, photonic, and chemical applications. Baneyx considers these materials essential to constructing the devices of tomorrow including nanocircuits, designer dielectrics (electrical insulators), and highly sensitive biosensors.

"The sky's the limit when you bring different types of skills into these collaborations," says Baneyx, who is acting director of the Center for Nanotechnology and site director of the UW node of the National Nanotechnology Infrastructure Network, funded by the NSF.

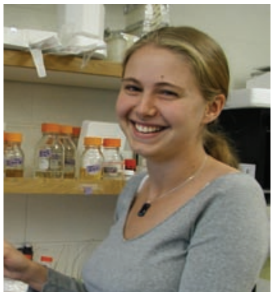
Another area of interest for Baneyx is protein folding. His research focuses on foldases and "molecular chaperones," which help other proteins fold into the precise structure that they require to function correctly—whether it's building bone, fighting off infection, or switching on vital chemical reactions in the body.

Baneyx notes that while great progress has been made in using recombinant DNA technology to make proteins with therapeutic or commercial interest (such as insulin and antibodies), challenges stand in the way of mass production. His research focuses on understanding how molecular chaperones and other folding modulators work and how to direct the process. A long-term goal is to reduce the costs of producing large amounts of recombinant proteins and to understand the role of folding modulators in neurodegenerative diseases such as Parkinson's and Alzheimer's.

In related work, his research team is investigating how *E. coli* bacteria respond to stressors such as cold and heat. The team is exploiting stress responses to help identify new antimicrobial agents. Such compounds are urgently needed to replace current antibiotics, which are losing their effectiveness against resistant bacterial strains.

Baneyx joined the Department of Chemical Engineering in 1992 and also serves on the Bioengineering faculty. •

Putting Bacteria to Work



Alex Holland, PhD student

Imagine neutralizing toxic waste with bacteria. Graduate student Alex Holland, with others under the guidance of Prof. Mary Lidstrom, is working to make that vision a reality. By adapting chemical engineering methodology, Alex has gained an understanding of the metabolism of bacteria and is learning how to manipulate it. The metabolically altered bacteria will aid in reclaiming our environment for future generations. One of the first applications is expected to be at the Hanford nuclear waste site in Eastern Washington.

Alex says, "The growing availability of genome sequences provides a rough blueprint for cellular function ... I am working to engineer the phosphate metabolism of the radiation-resistant bacterium *Deinococcus radiodurans* for radioactive waste cleanup."

A fifth-year doctoral student, Alex is an interdisciplinary NSF IGERT (Integrative Graduate Education and Research Traineeship) fellow. As part of this National Science Foundation program, Alex is participating in a multinational collaboration on challenges to the environment. The year-long team project focuses on land use at the Washington-British Columbia border and will conclude with a six-month exchange at a Chinese university. •

Matthaei Endows Chemical Engineering Professorship

Chuck Matthaei in the lab with Prof. Baneyx.

"The book on protein chemistry is a lot bigger than it was during my student days," says Charles "Chuck" Matthaei (BS ChE 1943), chairman of Roman Meal Bread Company in Tacoma. He is delighted that the first holder of the Charles W. H. Matthaei Endowed Professorship in Chemical Engineering is Professor François Baneyx, who is adding new chapters to the protein book of knowledge. (See related story on page 1.)

Matthaei established an endowed professorship because innovative research holds tremendous potential for benefiting people and society in areas such as health, protecting the environment, and energy efficiency. "The technology today is just out of this world," he says. Benefiting people has been Matthaei's driving goal for nearly 60 years as he built the family company into a nationwide pioneer in producing and marketing healthful, whole-grain breads. He maintained close contact with the department over the years and sought advice from faculty experts in cellulose technology for evaluating the many potential sources of fiber suitable for bread production.

Descended from a lineage of German bakers dating back more than 300 years, Matthaei has passed day-to-day operations of Roman Meal to his son William but remains active in the business, in civic organizations in Tacoma, and with a group of World War II Navy veterans who saw battle in the Pacific on the *USS Missouri*. Chemical Engineering honored him with its Distinguished Alumnus Award in 2003.

Since his initial gift of $500,000 in 2001, Matthaei has contributed another $400,000. "I wanted to keep building the endowment," he says. The Campaign UW matching initiative boosted his recent support by $200,000, which elevated the total endowment to $1.1 million.

"It is a great honor to hold the Matthaei Professorship," Baneyx says. "In a time of tight resources, this support will allow graduate students to explore a new idea or approach that may contribute to our research goals." A faculty member since 1992, Baneyx also is an adjunct professor of bioengineering. He completed his BS degree in his native France and received his PhD from the University of Texas. He received the NSF CAREER Award ('95) and the Whitaker Young Investigator Award ('94). •

CAMPAIGN UW Update

- Thanks to the enthusiasm and commitment of alumni and friends, support for the University exceeded $1.6 billion by December 31, 2005. The campaign goal is $2 billion by 2008.
- The College of Engineering is on target with more than 75% raised toward our goal of $250 million for student scholarships, fellowships, professorships, capital projects, and programs.
- Chemical Engineering is benefiting from the generous support of alumni and friends who have created three new endowed fellowships and scholarships and the department's first endowed professorship. These Campaign UW endowments strengthen Chemical Engineering's education and research programs.

We invite you to help create futures in chemical engineering.
Contact Jan Labyak at 206.543.8779 or labyak@engr.washington.edu

Benefits Abound Through Planned Giving

Planned gifts offer creative and flexible strategies for meeting your charitable and financial goals. Such support yields immediate dividends: financial gains, personal satisfaction, and a sound investment in the UW. A planned gift could be as simple as naming Chemical Engineering in your will or establishing a charitable gifts annuity. Your gift will be a legacy that will create better futures for generations of students.

To learn how your vision and values can carry into the future, contact Jan Labyak at 206.543.8779 or by email at: labyak@engr.washington.edu.

Alumni News

Jim Jensen, BS '37, MS '39, a 1994 UW ChemE Distinguished Alumnus, received his Moulton Medal among a small gathering of family and friends last February.

Dilip Das, MS '71, is proud of daughter Alina, a graduate student at the New York University Law School. Alina was one of two recipients of the 2004 National ProBono Publico Award.

Larry Young, PhD '74, set us straight about the fancy cars and boating mentioned in last year's *Catalyst*. Larry says there is nothing fancy about a Model-T Ford or a Triumph, and they sold their boat 10 years ago. Larry and his wife, Sue, ran Reservoir Simulation Research Corp. from 1984–96, when they sold the company to a Norwegian firm. After a lengthy stay in Norway, they returned to Tulsa and retirement, where Larry enjoys working on cars and is a fan of vintage auto racing.

Todd Brix, BS '91, married Brenoc in 1998. They have two daughters, Camille (4) and Claire (2), and live in Woodinville. Todd works at Microsoft as director of product planning and platform strategy in the mobile and embedded devices division. Todd received an MBA with high distinction from Harvard and has also worked for Chevron and Intel.

Brian A. Knowlton, BS '93, earned a PhD in chemical engineering from UC Santa Barbara in 2000. He works for Toyon Research, a Department of Defense consulting firm. Brian is married and has a son.

Christophe Poulain, PhD '95, and his wife, Eva, and their two children, Michael and Viviane, have relocated to Issaquah. Christophe works at DEMO, near Pioneer Square in Seattle. Work phone: 206.219.3023.

Jennifer Loesche Durkin, BS '00, works at Alcoa, 4050 Mountain View Road, Ferndale, CA 98248. Jennifer.Drkh@alcoa.com.

Jake Koerner, BS '04. jakekoerner@gmail.com

Jessica Lembong, BS '04, has completed her first year of the PhD program in chemical engineering at Princeton.

Alumni Updates

We want to hear from you! Please use the reply envelope inside this issue to let us know what you've been doing or send e-mail to: dept@cheme.washington.edu.

Visit our alumni yearbook on the Web at: http://depts.washington.edu/chemeng/new/people/alumni.htm.

Scenes from Open House 2005

Website: depts.washington.edu/chemeng / ChemE Reception: 206.543.2250

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