DEPARTMENT OF CHEMICAL AND
BIOLOGICAL ENGINEERING
UNIVERSITY OF COLORADO
AT BOULDER

ChBENews

SPRING 2010

Breaking New Ground

Planned biotechnology building will bolster interdisciplinary collaboration

This school year, CU-Boulder broke ground on the Jennie Smoly Caruthers Biotechnology Building, an interdisciplinary facility on East Campus that will provide greatly needed research and teaching space for the Department of Chemical and Biological Engineering and will have a significant impact on research collaborations in biotechnology. The department ranks in the top 10 public graduate programs in the U.S. and has built a reputation for groundbreaking research in a number of areas. On many campuses, departments can see their partnerships challenged by the physical distances between them. The Caruthers building will help break down these barriers through its layout and mission, promoting interdisciplinary ventures and unlocking countless possibilities for the department's researchers.

"The building brings together under one roof the brightest minds in the many disciplines of the biosciences to advance health and patient care in unprecedented ways," says CU-Boulder Chancellor Philip DiStefano. "This greatly complements the goal of our Flagship 2030 strategic plan of achieving seamless interdisciplinary research for the benefit of all citizens."

More than 60 faculty members and more than 500 researchers and support staff will be housed in the Caruthers building. A "main street" corridor will connect "research neighborhoods" made up of research labs, support spaces, and collaboration spaces.

Professor Kristi Anseth of chemical and biological engineering and Professor Leslie Leinwand of molecular and cellular biology will be among the first to benefit from their newfound proximity. Through tissue engineering, these two accomplished researchers will collaborate on an effort to develop replacement heart valves. Anseth, a Howard Hughes Medical Investigator, will also continue development of injectable, biodegradable scaffolds that regenerate cartilage in human joints. The team she leads has shown that these scaffolds can also be used to regenerate other tissues, such as skin, blood vessels, and bone.

The advantages of the Caruthers building will certainly be enjoyed off-campus as well. Colorado's biotech businesses generate more than $400 million in state taxes and support more than 36,000 workers, but the state's industry could be further strengthened by the new building when combined with CU's history of strong startups and the accomplishments of its faculty researchers.

"The research that will take place in the Caruthers Biotechnology Building at CU-Boulder will have a profound impact on Colorado's biotech economy," says Colorado Governor Bill Ritter. "This facility will continue to strengthen Colorado's business environment and elevate our bioscience ecosystem nationally and globally as we lead Colorado forward."

(Continued on p. 3)

A Moment to Remember

The official groundbreaking for the new Jennie Smoly Caruthers Biotechnology Building that is being built on the University of Colorado at Boulder's East Campus took place Sept. 9. Those in attendance included Colorado Governor Bill Ritter, CU President Bruce Benson, CU-Boulder Chancellor Philip DiStefano, and Professor Kristi Anseth of the chemical and biological engineering department. Jennie Smoly Caruthers, a longtime CU-Boulder research professor, died of cancer, and the building will be named in her honor.

YOUR SUPPORT IS VALUED AND APPRECIATED

Public and private assistance is still being sought for completion of the Caruthers building. If you would like to make a donation, please contact Ann Scott in Engineering Development at 303-735-2562, ann.scott@cufund.org.

this issue

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Message from the Chair

John Falconer

Growth is the big news in chemical and biological engineering at CU. This is an exciting and booming time in our department; enrollments have jumped, new faculty have been hired, and research activity has grown significantly.

We are excitedly following the construction of the Jennie Smoly Caruthers Biotechnology Building, which will eventually be the new home of the entire Chemical and Biological Engineering Department. The first phase will be completed in fall 2011. This new building should ease the growing pains we continue to experience as our undergraduate and graduate student numbers stretch our current capacity, and it will provide state-of-the-art teaching and laboratory space in close proximity to faculty and students in biochemistry and the Colorado Initiative in Molecular Biotechnology. Unfortunately, because of the economic downturn, the state of Colorado is not able to provide the funds it originally budgeted for the building. Thus construction of some parts of the building, which includes part of the Chemical and Biological Engineering Department space, may be delayed until funds are raised for their completion. You can learn more about the building and opportunities to support this effort on p. 1.

The department welcomed three outstanding new faculty in fall 2008. I invite you to read about the impressive work of Charles Musgrave , Arthi Jayaraman and Mark Stoykovich in the new faculty section of this newsletter and hope you will join me in welcoming them to the department. Our faculty continue to be recognized for their outstanding research and teaching, and the last two years have seen a number of faculty receive national and international recognition for their activities. We were excited to hear in 2009 that Distinguished Professor Kristi Anseth was elected to the National Academy of Engineering and to the National Institute of Medicine. Additional awards received by our faculty are highlighted in the awards feature on p. 12.

Research activity has increased dramatically in the department over the past couple years. For fiscal year ending June 30, 2009, the department received $14.8 million in new research grants, which is almost a 50 percent increase over the previous year. The increased funding fueled our graduate enrollment, which currently stands at 115 PhD students and 28 postdoctoral fellows. In addition, we have 10 BS/MS students who complete both degrees over five years.

As we continue to grow, we hope to stay connected to the alumni who have helped to make our department great. When you are in the Boulder area, please stop by and see how the department has changed, and keep us posted on your current endeavors and recent accomplishments. You can do so on our recently-updated alumni web page, www.colorado.edu/che/alumni/alumni.html, which also includes a link for making financial contributions. We appreciate the significant support that alumni have provided over the years and hope you will continue to contribute to the department. Private and corporate gifts are essential to the success of the department and to our ability to hire outstanding faculty and provide the best education possible to our students.

All the best,

John Falconer

Faculty Research:
Al Weimer's Hand in Biofuels

Synthetic gasoline produced by solar energy technology has finally been perfected. Sundrop Fuels, Inc. has proven this capability with a 60-foot tower supporting a solar array of nearly 3,000 mirrors that pulls in the sun's heat to generate synthetic gasoline. The tower is a first step toward commercialization of a process which can produce 100 million gallons of synthetic gasoline annually from biomass such as corn stalks and wood chips.

In its pursuit to use solar-fired reactors to produce synthetic gasoline (syngas), Sundrop recently purchased Copernican Energy, Inc., a company co-founded by CU chemical and biological engineering Professor Al Weimer, who also serves as executive director of the Colorado Center for Biorefining and Biofuels. This technology could revolutionize the biofuels industry because it removes one of the long-term cost hurdles of creating fuel from organic waste.

Gasification of organic material to make syngas by traditional gasifiers requires a large amount of biomass or a fossil fuel to reach temperatures above 1,000 degrees Celsius (1,832 degrees Fahrenheit) needed for the process. This new method uses the free energy from the sun to bring the reactors up to these high temperatures.

The process includes blasting organic materials, such as wood chips and straw, at very high temperatures gathered by the sunshine. The heat tears the material apart on a molecular level, adds the sun's heat energy in the thermo-chemical reaction, and creates syngas which can be formed into gasoline, diesel fuel, plastics, or chemicals. Sundrop's focus will be on gasoline or diesel because transportation fuels are a large, existing market where no new infrastructure is needed to use the fuel. The fuel is also cost-competitive, with unsubsidized production costs of under $2 per gallon.

"We're trailblazing an area, " Weimer says. "It's very unique and novel, and people don't think of it in terms of conventional fuel production. What we do is at the interface of a couple of technologies. You have concentrated solar thermal, using mirrors and towers to heat water to make steam to drive a turbine to make electricity. And on the other side you have people doing standard biomass conversion."

> "We're trailblazing an area. It's very unique and novel, and people don't think of it in terms of conventional fuel production.
> — Al Weimer"

Sundrop's next step is to raise money to build a demonstration, commercial-scale gasifier and refinery, with construction starting this year. A full-scale commerical plant, capable of producing 100 million gallons of fuel annually, is planned for completion in 2015.

Cover Story
New Building

Cont'd from p. 1

In addition, the educational activities that transpire within the building will benefit CU-Boulder undergraduates as well as Colorado K-12 teachers and students.

CU-Boulder currently offers funding for undergraduate researchers and outreach programs and workshops for Colorado K-12 schools, programs that will continue to expand through the Caruthers building.

The first phase of the building, designed by HDR Architects in association with Robert A.M. Stern Architects, will cover 257,000 square feet, and is scheduled for completion in fall 2011. You can watch the building's progress via webcam at http://cimb.colorado.edu/building-construction/

Faculty Research: Kristi Anseth—Body Architect

CU Distinguished Professor Kristi Anseth, of the Department of Chemical and Biological Engineering, was featured in the November 2008 issue of *Popular Science* as one of the magazine's annual "Brilliant 10." She was cited for her innovative design and use of hydrogels that induce rapid healing in human tissue.

"The Brilliant 10 are the brightest researchers of 2008, making the breakthroughs of tomorrow," says Mark Jannot, editor-in-chief of *Popular Science*. "PopSci is paying homage to these young scientists, who explore the world with an altogether original eye."

Anseth, a Howard Hughes Medical Investigator, is leading a team of researchers that is developing custom, degradable hydrogels that can be injected or implanted into the body, along with the cell cultures they contain, to repair human tissues affected by injury or disease.

Hydrogels are composed of networks of synthetic or natural hydrophilic polymer chains; the delicious dessert Jell-O® is a familiar example of a hydrogel. Containing over 90 percent water, hydrogels are very similar in elasticity and strength to natural tissue, and so are prime candidates for in vitro cell culture and the study of cell and tissue physiology.

The three-dimensional structure of hydrogels also contributes to their potential as tunable cellular microenvironments. Research in the tissue engineering field has previously shown that cells cultured in traditional two-dimensional environments exhibit aberrant behaviors, and that cells behave more naturally when cultured in three dimensions. In vitro cell culture and observation are essential to our understanding and interpretation of biological phenomena, and hydrogels allow for a unique insight into these processes.

Anseth is a pioneer in the tissue engineering field, designing novel hydrogels for use inside the body, and tailoring them to different types of tissues, such as heart valves, bones and cartilage, pancreatic tissue, and neurons. Today's treatments for healing cartilage involve injecting a solution of cells and nutrients and hoping that they stick to the right area. Anseth wants to use synthetic materials to provide not only a physical support for cells in applications like this, but also use the material to deliver biochemical and mechanical cues for directing cell behavior.

Current cell-based treatments for healing tissue also have been less effective because most of the cells that make up body tissue are adherent – they need to be attached to the extra-cellular matrix (ECM) in order to live. In fact, cell interaction with the ECM can also affect gene expression directly.

Hydrogels not only mimic the three-dimensional structural environment that adherent cells rely on, but can also be engineered to provide the signaling and binding characteristics of the native ECM. This allows injected cells to create their own ECM, as they would in vivo; ideally, the cells will create their own matrix as the hydrogel degrades, so the new tissue is all that remains.

Synthetic hydrogels have proven most conducive to the work of the Anseth team, largely because hydrogels created from natural sources (like the bovine collagen used to make gelatin) are purified from living organisms and are a non-homogenous mixture of many different materials. Some of the components in these mixtures can be bioactive, making it difficult to isolate which signals are promoting cellular function. Synthetic hydrogels can be made from homogenous reagents, containing only the desired biological cues, such as short chains of amino acids (peptides), and allow for more controlled studies.

With her customized hydrogels, Anseth is bridging the gap between materials engineering and molecular biology to develop cyto-compatible chemistries to make medically viable materials. In time, the technology may be used to repair damaged tissues such as defective heart valves, broken bones, and diseased neurons. One technique, extracting healthy knee cartilage from a patient, blending it with a hydrogel, and injecting it back into the knee, has been licensed by two companies who have already begun human trials.

The body has an incredible capacity for natural healing processes. Anseth and her team contend that you just have to find a way to turn them on.

To read the *Popular Science* article, visit: http://www.popsci.com/scitech/article/2008-10/body-builder

Eco Challenge:

Halliburton Foundation Awards $35,000 to ChBE Student Teams

In spring 2009, the Halliburton Foundation handed out $35,000 in awards to University of Colorado at Boulder chemical engineering students participating in the college's first annual Environmental Footprint Reduction Challenge. Students were asked to develop technologies for reducing the environmental footprint of oil and gas activities in Colorado.

The first-place team was awarded $20,000 for "Air Pollution Control for Natural Gas Processing." Comprised of chemical engineering students Ben Chittick, Julie Korak, and Robert Parker, as well as environmental engineering student Kelly Colwell, the winning team designed a vapor recovery unit to capture volatile organic compound (VOC) emissions from natural gas processing and incorporate them back into the sales line. Currently, VOC emissions from gas well site condensate tanks are incinerated. The team's system was designed to recover 80 percent of the VOC vapors.

The second-place team was awarded $10,000 for "Semi-mobile Operation that Transforms Oil/Gas Well Produced Water into Usable Water Source for Well Construction and Completion." Chemical engineering students Kevin Hoth, Vien Ngyuyen, David Robertson, and David Tzou used existing mechanical vapor compression (MVC) technology to design a semi-mobile water treatment plant that can be used to clean up water produced from oil wells. Their design allows for cleaning of up to 1,000 gallons of water per minute at a cost of less than $2 per barrel of oil.

The third-place team was awarded $5,000 for "Green Technology (Mobile Operation) that Transforms Oil/Gas Well Produced Water into Usable Water Source for Well Construction and Completion." Chemical engineering students Thomas Randle, Kevin Reinberger, Jamie St. Pierre, and Ashlyn Tung used existing ion exchange column technology to design a mobile system that can remove detrimental dissolved ions from water obtained during well construction. This cleaned water can then be used in the well construction process without the equipment damage caused by dissolved ions and without the need to use local potable water. The system allows for cleaning of up to 150 gallons of water per minute at a cost of $2-3 per barrel of oil.

A new group of students currently is working on projects for the 2010 Eco Challenge.

The Halliburton Foundation has a tradition of funding initiatives that enhance the quality of educational programs in those academic subjects most often sought after by Halliburton recruiters, such as engineering and the sciences. CU-Boulder was given funding for this project because of demonstrated excellence in preparation of students with advanced technological skills for the oil and gas services industry, programs that expose K-12 students to career opportunities within the oil and gas industry, and programs that assist in the professional development of teachers and faculty in understanding the business of the oil and gas industry.

Faculty Research:

Dan Schwartz—Liquid Crystals for DNA Detection

Liquid crystal. The term itself sounds almost paradoxical, but in fact liquid crystals are quite common in nature and ubiquitous in modern technology, despite remaining in relative scientific obscurity for almost 80 years after their discovery in 1888.

Liquid crystals are substances that occupy a phase of matter somewhere between a liquid and a solid crystal. This phase is often found in the natural world – in some proteins and cell membranes. Liquid crystals also play key roles in the functionality of computers, televisions, clocks, watches, calculators, gaming devices, and telephones, to name a few.

Professor Daniel K. Schwartz of the ChBE department is preparing to make liquid crystals even more relevant to modern technology, particularly in the area of DNA detection. Schwartz has found a new method that could create an inexpensive, portable alternative to current DNA detectors through the use of liquid crystals.

DNA detection is now performed using microarrays — a solid surface like glass or silicon, covered with up to tens of thousands of microscopic spots of DNA oligonucleotides, or probes. Each probe contains a specific sequence of single-stranded DNA.

To detect DNA in a given sample, the DNA contained on the microarray is hybridized by applying chemically labeled complimentary strands. While this method has significantly advanced the pace of discovery in the field, bulky and expensive lasers are needed to excite the labeling compound and expensive microscopes are needed to see which probes receive a complimentary strand.

Schwartz's discovery may lead to the technology that changes that.

A feature of liquid crystals, discovered by Austrian botanical physiologist Friedrich Reinitzer, is that they possess the optical property of birefringence, or the ability to decompose light into two rays and rotate its polarization direction as it passes through. Also, the orientation of the liquid crystal is very sensitive to the physical and chemical properties of the surface it is interacting with, and is directly related to the appearance of contrasting colors and textures.

Schwartz and his team have used this functionality to their advantage to identify the presence of both single- or complementary-stranded DNA along a liquid crystal/aqueous interface, obtaining results visible with a very basic light microscope. The results displayed in this article are attributed to Schwartz and Dr. Andrew D. Price.

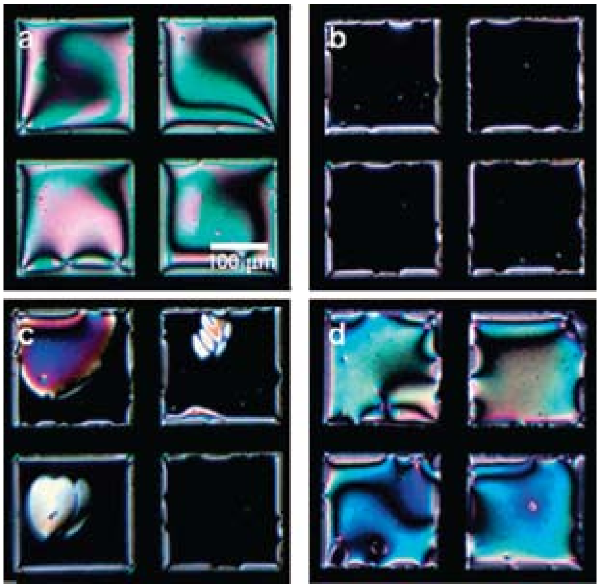
Because of the crystals' ability to rotate the polarization of light, when a thin layer of liquid crystals is viewed on a polarized light microscope, a beautiful pattern of greens and pinks emerges (figure 1a). The crystals in this figure are aligning themselves at an angle which is tilted slightly up from the surface of the slide. This angle allows for the polarized light to be rotated so that it can pass through the second polarizer in the microscope and be visualized.

When a glass slide is coated with a self-assembled monolayer, liquid crystals added to that glass slide will interact with the surface and naturally align themselves homeotropically, or perpendicularly, to the surface. This angle of orientation causes the polarized light to pass through without being rotated, preventing light from passing through the second polarizer, and thus preventing any visible results when viewed from above (figure 1b).

Schwartz's team discovered that adding single-stranded DNA (ssDNA) to the surfactant/liquid crystal interface will cause the liquid crystals to once again tilt, this time at an intermediate angle from the surface. The polarized light is rotated in the same manner as figure 1a, and again colorful results are viewable (figure 1c). Over time, as the interactions take place, more birefringent areas appear (figure 1d). The different colors are relevant and result from the angle of orientation of the liquid crystal.

Even more significant, when the ssDNA is hybridized by adding complimentary strands, the liquid crystals return to their homeotropic

Figure 1.



alignment and once again prevent light from passing all the way through the polarizers. The results are dark areas on the slides (figure 2) that increase in size as the concentration of DNA increases.

Just to be sure the homeotropic areas were in fact the cause of DNA hybridization, a slide with fluorescently labeled DNA was viewed using fluorescence microscopy. The brighter areas (figure 3b) correspond to greater concentrations of labeled DNA, suggesting that the dark homeotropic areas viewed in polarized light (figure 3a) are indeed attributable to dsDNA interactions with liquid crystals.

Current microarray technology can detect differences of even one base pair in complementary strands, and this is often used as a control, so it was important for Schwartz and his team to demonstrate that liquid crystals have the same sensitivity. In fact, they do. A mismatch of even one base pair produces much smaller homeotropic regions than those seen in figure 2.

"The relevance of a one-base-pair mismatch is that it relates to the degree of precision with which this technology can identify DNA sequence," says Schwartz. "If two closely related bacteria had similar DNA sequences in a certain gene, one might need to distinguish a single base difference in order to make a correct diagnosis. Similarly, some genetic defects which cause genetic disease in humans are related to a single changed base."

Schwartz's discovery of the ability of liquid crystals to orient themselves and refract light in a particular manner in response to both ssDNA and dsDNA has the potential to radically change the face of current DNA detection. The technology could become label-less, inexpensive, and portable, making it ideal for field-based or point-of-care testing.

"In principle, a device based on this technology could be very similar in size and cost to a digital wristwatch with an LCD display – compact, inexpensive, and battery powered. These properties make it well suited to point-of-use applications."

The next step for Schwartz's team will be to work on ways to engineer a liquid crystal microarray. We could be looking at a future of home-based DNA testing and identification.

Read the article in *Chemistry World*:

http://www.rsc.org/chemistryworld/News/2008/June/26060801.asp

Figure 2.

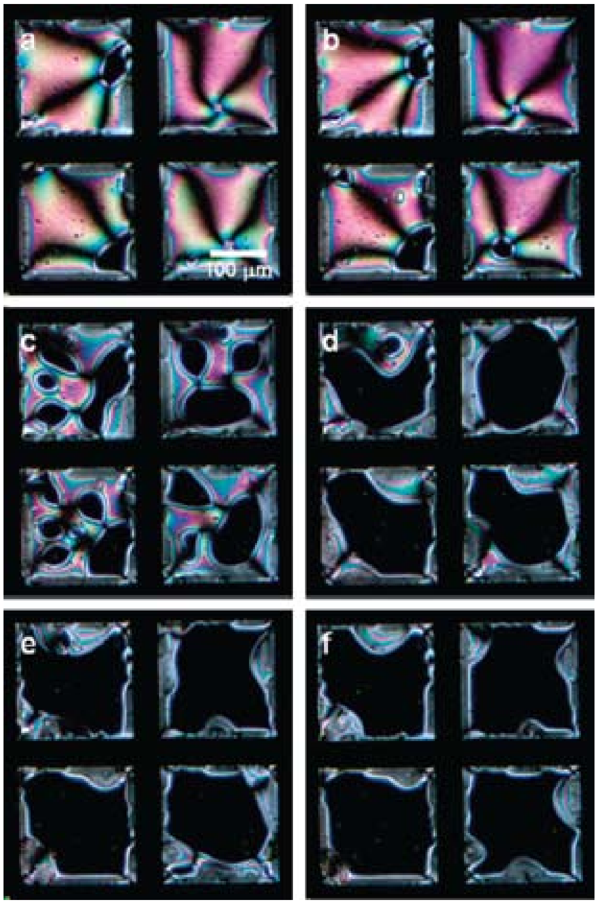
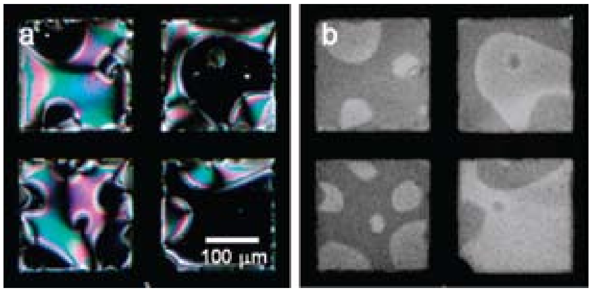


Figure 3.



Faculty Research:

Two ChBE Projects Receive 'Proof of Concept' Funding to Propel Commercialization of Research

In January 2009, a partnership between the CU Technology Transfer Office (TTO) and the CU-Boulder Energy Initiative, which has since evolved into the Renewable and Sustainable Energy Institute (RASEI), selected four projects for grant funding. These awards, known as "proof-of-concept" (POC) grants, are designed to fill a funding gap between basic research funding and industrial commercialization of technology, and will help move CU-Boulder renewable energy and clean-tech inventions towards commercial readiness. Two of the four projects on campus are in the Department of Chemical and Biological Engineering.

Bifunctional Catalysts

CU-Boulder Professor Will Medlin of the ChBE department was selected for POC funding for "Bifunctional Catalysts" that enable the efficient production of fuels and chemicals from renewable biomass feedstocks.

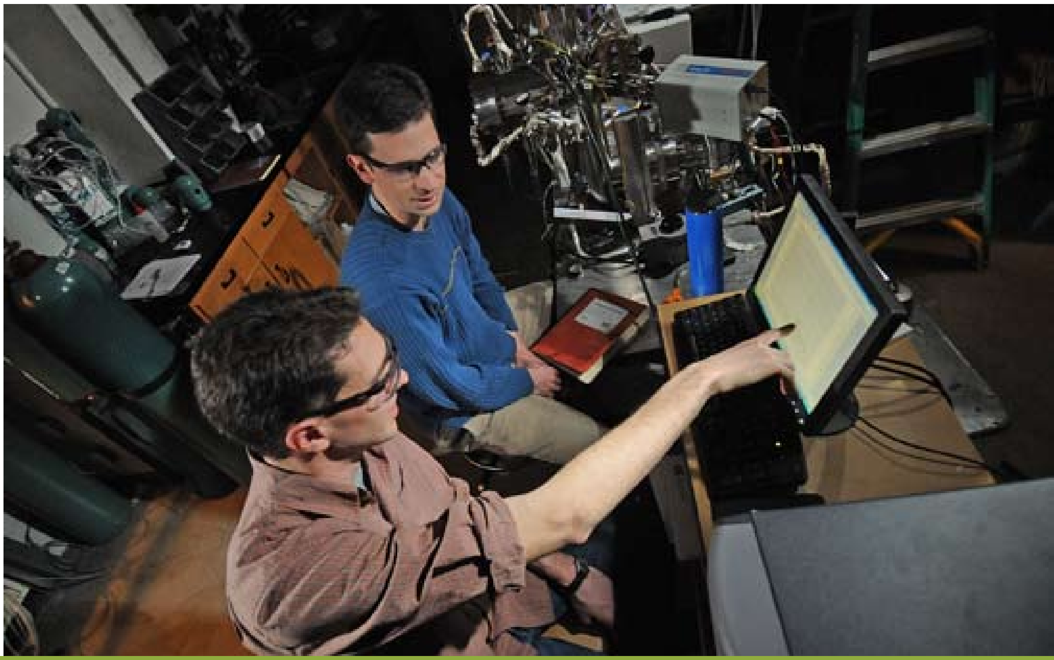
Intermediates produced from deconstruction of biomass using common technologies are not optimal fuels and need to undergo catalyst-mediated upgrading reactions to improve their fit into the fuels infrastructure. In contrast to hydrocarbons like petroleum, biomass molecules contain many oxygen-containing functional groups that react with conventional catalysts, making the production of fuels less efficient. If the reactions of positions on the individual molecule could be controlled, better fuels and more valuable chemicals could be produced.

Medlin, his group, and collaborator John Monnier at the University of South Carolina designed and synthesized an unusual synthetic catalyst by coating supported platinum catalysts with silver using a process called electroless deposition. This "bifunctional" catalyst uses the silver to "hold" the part of the molecule for which a reaction is not desired, while allowing the platinum to catalyze the reaction of the other function as normal.

The molecule epoxybutene was chosen as the reactant because it is a useful probe molecule for a large number of molecules that can be derived from biomass for conversion into sugar. In fact, Medlin says that it may have been more difficult to optimize catalyst design for epoxybutene because of its extremely high reactivity, but their success in using it also leads the team to believe that they can extend the concept to other biomass derivatives.

The POC grant is aimed at determining how "extendable" a concept is. Medlin and his group will continue to test this catalyst design on other molecules more directly suitable as biofuels, derived from wood chips, grasses, algae, or anything else that can be turned into sugar. The team will also search for other ways in which the bifunctional catalyst might be industrially promising.

Prof. Will Medlin and PhD student Steve Marshall discuss the results of a temperature programmed desorption (TPD) experiment. The Medlin group uses TPD and other spectroscopic techniques to understand the reactions of biomass-derived intermediates on catalyst surfaces.



Professors Rich Noble and Doug Gin collaborate with ION Engineering to efficiently remove CO2 from fossil fuel power plants such as the Valmont Power Plant in Boulder, pictured above.

Carbon Capture and Sequestration

Boulder-based ION Engineering (ion-engineering.com) was selected for POC funding, and secured an exclusive option agreement with CU-Boulder, for efficient and economical capture of CO2 and other contaminants from natural gas wells and coal-fired power plant emissions. The technology was developed by PhD alumni Jason Bara and Dean Camper, professors Richard Noble and Douglas Gin, all of the ChBE department. Bara and Camper co-founded ION based on their research at CU-Boulder, and are now working there exclusively.

ION is working in two large markets, natural gas sweetening and carbon capture. ION's solvents and processes show vastly improved efficiencies and throughput relative to the current aqueous amine technologies used in natural gas processing. ION also makes a significant impact in reducing the cost of CO2 capture from power plants and other industrial sources to economically acceptable levels. The captured CO2 can be sequestered or re-used in a number of ways, but ION's primary focus is on capturing CO2 as cheaply and efficiently as possible.

ION uses a combination of conventional amines and ionic liquids (ILs) – stable, non-volatile and tunable solvents. They are the first clean-tech company to successfully integrate IL-based solutions with capture carbon and gas processing applications. Their process is faster, cleaner, and cheaper, because ION's solvents improve throughput while using less energy than conventional aqueous amine solvents. ION's technology also eliminates many of the problems associated with aqueous amines (corrosion, solvent losses, etc.). ION's technology can be adapted to a wide range of processing conditions (such as pressure) by the use of different solvent formulations.

ION Engineering was recently named among the Giubg Greeb Top 100 Private Companies, and was prominently featured in a July 2009 article appearing in *Chemical & Engineering News*. ION has already constructed a continuously operating demonstration unit, and will be scaling the technology for industrial use with help from the POC grant.

Faculty News: New Faces

Arthi Jayaraman

Dr. Arthi Jayaraman, pictured above right with three of her students, joined the faculty as an assistant professor in August 2008. She comes to Colorado from the University of Illinois at Urbana-Champaign, where she was a post doctoral research associate with Dr. Ken Schweizer in the Department of Materials Science and Engineering. In 2006 Jayaraman received her PhD in chemical engineering at North Carolina State University under the guidance of Dr. Carol K. Hall and Dr. Jan Genzer, where she received the Edward M. Schoenborn award for outstanding graduate research. She moved to the United States in 2000 after spending her formative years in India where she obtained her BS in chemical engineering from BITS Pilani.

Jayaraman's research focuses on the study of soft materials (polymers, colloids) and biological systems (DNA, protein) using theoretical and computational techniques. She applies computer simulations and polymer theory to obtain a molecular-level understanding of experimentally observed phenomena and uses this insight to predict unknown mesoscopic structures and dynamics in nanostructured materials and biological systems. Jayaraman recently received a $750,000 Department of Energy Early Career Research Award.

Jayaraman has made Boulder her home. She enjoys landscape photography and in her first year in Boulder has put her SLR to good use capturing the beautiful outdoors during her short hikes. In her free time she enjoys the restaurants and various ethnic cuisines that Boulder has to offer.

Charles Musgrave

Dr. Charles Musgrave joined the faculty as an associate professor in August 2008. He comes to the department from Stanford University, where he was on the chemical engineering faculty from 1996 to 2008. While at Stanford, he used quantum chemical methods to study semiconductor surface chemistry, including the organic functionalization of semiconductors, atomic layer deposition, and homogeneous transition metal catalysts. Musgrave earned his PhD in 1994 in materials science at Caltech under the guidance of Dr. William Goddard. He did his postdoctoral work in chemical engineering at MIT with Klavs Jensen, and spent a sabbatical at Harvard teaching undergraduate quantum chemistry. He earned his BS in materials science and engineering at UC Berkeley.

Musgrave's research uses quantum chemical methods to study atomic and molecular layer deposition, surface and interfacial phenomena related to photovoltaics and batteries, and homogeneous catalysis. Musgrave taught Introduction to Quantum Chemical Simulations and Chemical Engineering Kinetics last year, and Energy Fundamentals and Chemical Engineering Kinetics this year. He also serves on the Department Improvement Committee, and is currently co-chair of the Graduate Admissions Committee.

Musgrave and his wife Luanne have four children, all of whom are musically inclined. Additionally, all of the family participates in sports, and Charles, an avid cyclist, spends his free time racing mountain and road bikes.

Mark Stoykovich

Dr. Mark Stoykovich joined the faculty as an assistant professor in August 2008. He comes to the department from the University of Illinois at Urbana-Champaign, where he was a postdoctoral research associate in materials science and engineering from 2007 to 2008. While there, he developed an "electronic eye" camera with the shape, size, and optical simplicity of a human eye by developing processes for making electronics on three-dimensional surfaces. Stoykovich earned his PhD in 2007 in chemical and biological engineering at the University of Wisconsin-Madison, where he researched self-assembling polymers for lithographic applications in the microelectronics industry. He received his undergraduate degrees in chemical engineering and chemistry at MIT.

Stoykovich's research interests include block copolymers, polymer self-assembly, nanostructured materials, advanced lithography, and nanofabrication. He taught Senior Lab and Polymer Engineering this year.

Stoykovich and his wife enjoy golfing and other outdoor activities available in the Boulder area.

Wendy Young

Dr. Wendy Young joined the faculty in January 2009 as an instructor and department manager. She comes to the department from Intel, where she was a senior process engineer from 2002 to 2008, serving as a microprocessor developer specializing in lithography. Young earned her PhD in 2002 in chemical engineering from the University of Colorado at Boulder, under the advisement of Professor Rob Davis. She earned her BS degree in chemical engineering from Notre Dame.

Young is teaching Separations and will teach Creative Technology in the fall.

Young and her husband Darrin enjoy the Boulder area and playing in the outdoors with their two dogs. They welcomed their first child, daughter Meadow, on August 11.

Faculty Research: Musgrave—Quantum Simulations Shed Light on Solar Efficiency

Quantum mechanical simulations have become an invaluable tool within the chemical, material, and physical sciences, and their use has exploded over the last two decades. While their ability to describe the fundamental behavior of materials and processes at the molecular scale can be applied to a wide variety of problems, Associate Professor Charles Musgrave and his group use quantum simulations to understand and guide the development of new materials, including photo-active materials for solar cells and solar fuels, catalysts, advanced batteries, and ultra-capacitors and biomaterials.

The group's approach seeks to uncover the underlying principles that govern the system and then to exploit those principles to design superior materials. Unfortunately, performing these simulations using state-of-the-art theory requires enormous computational resources. For example, the latest Musgrave group computer has 512 processors and over 3 terabytes of RAM!

While the majority of scientists and engineers use more basic methods, Musgrave and his team differentiate themselves by tackling problems that are not only of critical importance to society, such as catalytically converting CO2 into fuels or making more efficient solar cells, but that also require more sophisticated approaches to solve. Part of the reasoning for this is that future scientists and engineers can learn from the ways newer methods were used and evolved before the community adopts them.

An example is Musgrave's work on singlet-fission for more efficient solar cells. One approach to making more efficient solar cells is to use materials that can efficiently use both lower-energy sunlight and high-energy sunlight to make electricity. Typically, solar cells waste any excess energy contained in light beyond the minimum required energy for the photovoltaic effect. However, if a process called singlet-fission can be used to convert the excited states to lower-energy states, solar cells can be made significantly more efficient. Ultimately, this work will lead to designing materials that exploit this effect where quantum simulations become an engineering tool similar not unlike molecular CAD.

Faculty News: Faculty Awards

Christopher Bowman received the 2009 American Institute of Chemical Engineers' **Charles M.A. Stine Award**, which recognizes an individual's outstanding contribution to the scientific, technological, educational or service areas of materials engineering and science. Bowman was also awarded the 2008 **CU-Boulder Residence Life Teaching Award**.

Stephanie Bryant received a **National Science Foundation CAREER Award for 2009-2014**, one of the most prestigious awards given to junior faculty, awarded to those who "exemplify the teacher-scholar role." This award will contribute to the development of injectable scaffolds containing stem cells that will regenerate the bone/cartilage interface. Bryant was also appointed as a CU-Boulder **Patten Faculty Fellow**.

David Clough received the 2008 **Robert L. Stearns Award** from the CU Alumni Association for his extraordinary teaching and service to the university over the last 35 years, including serving as the NCAA Faculty Athletic Representative.

John Falconer received the 2008 University of Colorado **Hazel Barnes Prize**, which the largest single faculty award given by the university, for his outstanding teaching and distinguished record in research and scholarship. Falconer also received the 2008 College of Engineering and Applied Science's **Max S. Peters Faculty Service Award** for professional and civic service to the university.

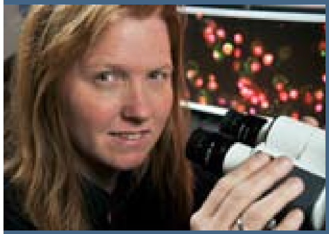
Douglas Gin received the 2008 College of Engineering and Applied Science's **Faculty Research Award**, recognizing his outstanding contributions to the advancement of knowledge through the research he has conducted in polymers and nanomaterials since arriving at CU in 2001.

Christine Hrenya received the 2008 **Provost's Faculty Achievement Award**, which honors a paper or series of papers that have had a large impact on the community. She was recognized for identifying a new mechanism that describes the tendency for solid particles of different sizes to segregate, which has applications in a wide variety of industries.

Arthi Jayaraman was one of 69 scientists across the nation selected to receive an **Early Career Award** from the **U.S. Department of Energy**. The award, worth $750,000 over five years, is funded by the Office of Basic Energy Sciences. Jayaraman investigates nanoscale phenomena that govern the physical properties of materials and is seeking to improve the efficiency of organic photovoltaic devices.

Will Medlin received the 2009 **Boulder Faculty Assembly Teaching Excellence Award** for his use of "Just in Time Teaching," an active learning technique in which student feedback directs the content of each course session. He also received the 2009 **Charles A. Hutchinson Memorial Teaching Award** from the College of Engineering and Applied Science, and the 2008 **Provost's Faculty Achievement Award** for contributing to the molecular-level understanding of a catalyst that has the potential to eliminate production of waste compounds in certain petroleum and biomass processing reactions. In 2008, Medlin was also awarded a **ConocoPhillips Faculty Fellowship**.

Anseth Elected to National Academy of Engineering and Institute of Medicine



Kristi Anseth was elected to the **National Academy of Engineering**, one of the highest professional distinctions accorded an engineer, in February 2009. In October, she was also elected to the **National Academy of Sciences' Institute of Medicine**, one of most significant honors in the field of health and medicine.

The National Academy of Engineering recognized Anseth for "pioneering the rational design of biomaterials for tissue engineering, drug delivery, and bio-sensing applications." Her innovative use of ultraviolet light to make 3D polymer scaffolds when implanted into tissue facilitates healing. The scaffolds dissolve after tissue regeneration. Anseth also has designed materials to accelerate bone healing, grow cartilage tissue, and even help regenerate defective heart valves. The Institute of Medicine recognized Anseth for her outstanding professional achievement and commitment to advancing health and medicine.

Anseth also was the recipient of the 2009 American Institute of Chemical Engineers' Professional Progress Award, recognizing outstanding progress in and significant contribution to the field of chemical engineering, and became a Fellow of the Materials Research Society for sustained and distinguished contributions to the field of materials science.

Richard Noble received the 2010 **Robert L. Stearns Award** and the 2008 **Inventor of the Year Award** for the Boulder campus. He was recognized for research leading to commercialization in the areas of capture of carbon and other contaminants from gases, as well as the development of microfluidic devices.

Ted Randolph began 2008 as the **Honorary Lecturer** at the Bayer Lectureship in Biochemical Engineering at the University of California, Berkeley, where he spoke about novel purification processes for protein therapeutics. He was also named Fellow in the American Association of Pharmaceutical Sciences in 2008 for his scholarly and research contributions to the field. In 2009 Randolph was awarded the **John M. Praustniz Award** in Applied Chemical Thermodynamics and will deliver the award lecture at the May 2010 International Conference on Properties and Phase Equilibria for Product and Process Design in Suzhou, China. He also was named the **Distinguished Interdepartmental Inventor** by the CU Technology Transfer Office for research that generated improved methods for stabilizing vaccines during freeze drying and storage, techniques of significance in developing nations lacking proper medical storage facilities.

Daniel Schwartz received the 2009 College of Engineering and Applied Science **Faculty Research Award** and the 2008 **Boulder Faculty Assembly Award for Excellence in Research**. He was recognized for "pioneering contributions to understanding how molecules self-organize at interfaces and exploiting ted his knowledge in applications related to nanomaterials, biomaterials, biosensors, and protein stability."

Jeffrey Stansbury received the 2009 **Wilmer Souder Award** from the International Association of Dental Research. The award is intended to bestow the highest honor to scientists who contribute to outstanding advances in dental health through research of dental materials.

Mark Stoykovich had a paper listed in the 2008 **Essential Science Indicator Hot Papers**, which are selected by virtue of being cited among the top one-tenth of one percent (0.1%) in a current bimonthly period across 22 fields of science. The designated paper describes an approach for controlling the spontaneous self-assembly of polymer materials.

Alan Weimer was awarded the 2009 **Thomas Baron Award** from the American Institute of Chemical Engineers' Particle Technology Forum. He also was invited to give the **keynote address** at the **14th Biennial Solar PACES**, the premier global meeting for solar-thermal energy research in the world. Weimer was selected based on his research to split water using concentrated sunlight. His lab is the lead in the seven-nation project (International Partnership for a Hydrogen Economy; www.iphe.net) to split water using solar thermo-chemical cycles.

AIChE Celebrates Centennial, Honors CU Boulder Faculty

The American Institute of Chemical Engineers celebrated its 100th anniversary in 2008, highlighting two CU-Boulder faculty members as part of the centennial. In the Institute's "100 Chemical Engineers of the Modern Era," both Klaus Timmerhaus and Kristi Anseth, of the Department of Chemical and Biological Engineering, were named as significant contributors to the field whose research, achievements, and leadership will shape the future of the profession.

Timmerhaus was recognized for his achievements in cryogenic science and practice. He has held numerous posts as the Institute, including its presidency in 1976, and has won major awards in teaching and research, as well as in his professional pursuits, including being elected to the National Academy of Engineering in 1975. Timmerhaus was a faculty member at the University of Colorado for over 40 years. He served as chairman of both the Chemical Engineering and Aerospace Engineering Sciences departments, and also served as Associate Dean of the College of Engineering and Applied Science. Timmerhaus is the author of six textbooks and over 150 technical and nontechnical articles. His distinguished and prolific career not only launched a legacy of success and distinction in the department, but will also continue to inspire future generations of engineers.

Anseth was recognized for developing new materials to replace diseased or damaged body parts. She is the recipient of numerous national and university awards for research and teaching, including the NSF Alan T. Waterman Award and the AIChE Allan P. Colburn Award, and was recently elected to the National Academy of Engineering, becoming one of its youngest members. Anseth has been a faculty member at the University of Colorado since 1996. She is author on over 170 technical publications, has contributed to 80 proceedings and book chapters, holds 17 patents, has given over 300 lectures and presentations worldwide, and serves on the editorial board of six scientific journals. The unfolding of her career has been exciting to watch, and the department anxiously awaits the next phase.

"100 Chemical Engineers of the Modern Era"
Read the article at: http://www.aiche.org/uploadedFiles/About/Centennial/100moderneracheme.pdf

Wenyu Zhang:

Undergrad Gets Head Start on Publishing

Having a few published papers as an undergraduate is guaranteed to add extra oomph to any graduate school application. Wenyu Zhang, who graduated from the University of Colorado at Boulder in spring 2009 with a bachelor's degree in chemical engineering, has accomplished just that.

Zhang was second author on two papers he wrote in collaboration with graduate students in CU Professor Will Medlin's research group. One paper, published in the November 2008 issue of *Surface Science*, addressed the investigation of submonolayer SiOX species formed from oxidation of silane on Pt(111). The other, published in the December 2008 issue of Journal of Physical Chemistry, addressed the common decomposition pathways of 1-Epoxy-3-butene and 2-Butenal on Pd(111).

Zhang grew up in Singapore, but moved to Lafayette, Colorado, for his senior year of high school before coming to CU-Boulder. Initially uncertain of which direction to take at the university, he became interested in chemical engineering his sophomore year. Realizing that his interests had turned to energy, the department seemed like the right fit.

Zhang became involved in Medlin's research during his first year after the professor came to his Introduction to Chemical Engineering course to do a project presentation. He began working in Medlin's lab the following summer, and continued working for the professor in various ways throughout the duration of his student career at CU. Zhang's main focus during his senior year was studying proton formation on a Pd(111) surface when dosed with hydrogen and water at low temperatures, which has applications for understanding the reactions on cathodes in fuel cells. He also worked on a project studying the reaction of SiH4 (silane) and oxygen on Pd(111) surface, which is relevant to fields such as heterogeneous catalysis and catalytic sensor technology.

Zhang says working for Medlin fueled his interest in research. He now plans to focus on fields that have applications in energy, a subject that has interested him for the past several years, as he continues his studies as a graduate student at Cornell University.

Industry Gifts Propel Labs Forward

Junior Chemical Engineering Lab Professor Robert Sani oversaw an upgrade of the experiments in the Chemical Engineering Junior Laboratory in the last few years. We have been fortunate to acquire a new fluid dynamics experiment thanks to ConocoPhillips and a new mass flow experiment thanks to Emerson. In the fluid dynamics experiment, students put to practice what they have learned in their Fluids course, with a practical experience of fluid flow through different components such as valves, elbows, venture meters, and orifice plates. The mass flow experiment has a Micro Motion® Coriolis flow meter that teaches students about the principles of mass flow measuring techniques.

Senior Chemical Engineering Lab A new fuel cell experiment was designed for our Senior Lab to give students first-hand experience with emerging alternative energy technology. The addition of a metal hydride storage container funded by ConocoPhillips made it possible to run the experiment in the teaching lab.

Samantha Davis:

ChBE Senior Wins Scholarship Award from Genentech

Samantha Davis, a senior in the ChBE department and graduate of Niwot High School, received a $2,500 scholarship award from Genentech, a company that uses human genetic information to develop medicines to treat patients with serious or life-threatening medical conditions.

The Genentech Process Research and Development Outstanding Student Award was founded to recognize outstanding students in disciplines related to chemical and biological engineering. It is given annually to one student from each of 13 universities nationwide.

Davis was chosen for the award based on an essay she wrote explaining what Genentech's motto ("Business for Life") means to her and how Genentech's products, research and business ethics impact people's lives and the future of the pharmaceutical industry. Although the award is not required to be put to any particular use, Davis says she will probably use the money to help pay for tuition and books.

Davis spent the last two summers interning for Shell. In 2008, she interned at Shell Denver, where she was exposed to the upstream oil sector – the search, recovery, and separation of crude oil. In 2009, she interned at Shell's Houston facility, working on conceptual control systems for distillation columns. She says that her chemical engineering Fluids course came in handy for that particular line of work.

Davis is also active in extra-curricular activities on campus, such as the American Indian Science and Engineering Society (AISES), where she currently holds the office of vice president. The local AISES chapter offers tutoring to high school students and is active in fundraising to support member students attendance at the national AISES conference, which includes a career fair and workshops on a variety of subjects. To learn more about AISES, visit www.aises.org/AboutUs.

Davis plans to graduate in May 2010 with a bachelor's degree in chemical engineering, bioengineering option.

Opportunity to Engage:

Graduate Students Host Annual Research Symposium

ChBE graduate students hosted the Student Annual Research Symposium in the fall semester at which they presented their research to students, faculty and industrial visitors. This symposium, called StARS,has been partly supported with funds from industry and student research is judged by faculty and industry representatives.

Alumni are encouraged to consider this opportunity to engage with students and reconnect with the department. We invite you to contact us if you would like be involved in the symposium next fall. Please visit the department website (www.colorado.edu/che) for a more complete description of current research and other activities in the department

Katie Rice:

Grad Student Receives ConocoPhillips Fellowship

Katie Rice, a third-year graduate student in the Department of Chemical and Biological Engineering, received a 2009 ConocoPhillips Technology Fellowship. These fellowships provide support to outstanding graduate students working in areas of energy research and development.

Rice's research focuses on different types of nanomaterials for applications in renewable energy, with the ultimate goal of being able to take advantage of the new properties available at the nanoscale to increase efficiency or lower the cost of current renewable energy technologies. One such application is in the replacement of silicon in solar panel manufacturing. Most of the silicon currently used to create solar cells has to be mined, purified, and grown into a single crystal before being sliced into ultra-thin wafers. A large part of the expense in solar energy comes from this process. If nanomaterials were used to replace the silicon used in the manufacture of solar cells, we may someday be able to simply spread a nanomaterial solution over a large area and allow it to dry, making materials cheaper and processing costs lower.

In addition to conducting research relevant to the ConocoPhillips Fellowship, Rice has been involved in graduate student recruiting, high school and grade school outreach, the planning of the annual Student Annual Research Symposium (StARS), as well as the organizing of the Graduate Assistantship in Areas of National Need (GAANN) retreat and its associated outreach.

Undergraduate Education:

Senior Biological Engineering Laboratory in Full Swing

Glowing bacteria, microbe growth within milk cartons, and biofuels from algae – these are a few of the exciting new additions made over the last year to the Biological Engineering Lab course. The senior-level lab class was first taught during the fall of 2008 as one of the final required courses of the new degree program in Chemical and Biological Engineering. Enrollment has continued to increase with up to 50 students anticipated for fall 2010. To accommodate this predicted increase in enrollment, the lab has been extremely fortunate to have received multiple sources of funding that have enabled the purchase of several state-of-the-art pieces of equipment over the last few years.

Two 5-liter fermentors, or bioreactors, enable the growth of yeast and E. coli bacteria under very controlled conditions of pH, temperature, and oxygen concentration and are comparable to bioreactors used in industry. A new plate reader allows the simultaneous reading of up to 96 samples and is paramount to many of the experiments that use the "student-friendly" green fluorescent protein as a therapeutic protein analog. Similarly, a new gel imaging system allows visualization of protein gels under normal and fluorescent conditions, and is a piece of equipment standard in many top research facilities

With the new high-tech equipment, Instructor Charlie Nuttelman says that students are exposed to both "old school" and "new school" methods simultaneously. For example, a new NanoDrop spectrophotometer, which only uses a single drop of sample, replaces the standard method of spectroscopy that uses an entire milliliter of sample and is very time-intensive. The old method is still practiced in some experiments, allowing students to develop a real appreciation for the faster, more efficient equipment that is currently available while learning and applying the traditional techniques that today's procedures were built upon. We are grateful to Shell for funding the purchase of this state-of-the-art equipment.

A future addition to the Biological Engineering Lab course may enable a new focus on bio-fuel production from algae. Many biological phenomena are vital to the production of bio-fuels on a large scale. Thus, Nuttelman is working to put together a photo-bioreactor, either by adapting one of the current 5-liter bioreactors to a photo-bioreactor or soliciting funds to purchase a state-of-the-art photo-bioreactor. Students could then help design and conduct initial experiments to enable the growth of lipid-producing algae with the intention of making biodiesel from algae.

Students use a NanoDrop Spectrophotometer to evaluate samples

ChBE DEAA Winners

Mohamed Al-Mady - 2010

Mike Wirth - 2010

Kenneth May - 2009

Ted Randolph - 2009

Kristi Anseth - 2008

Student Awards

April Kloxin (PhD '09) recently received the Western Association of Graduate Schools Innovation in Technology Award for her outstanding dissertation.

Janine Galvin (PhD '07) received the 2008 Best PhD Thesis in Particle Technology Award from the American Institute of Chemical Engineers for her thesis, "On the Hydrodynamic Description of Binary Mixtures of Rapid Granular Flows and Gas-Fluidized Beds."

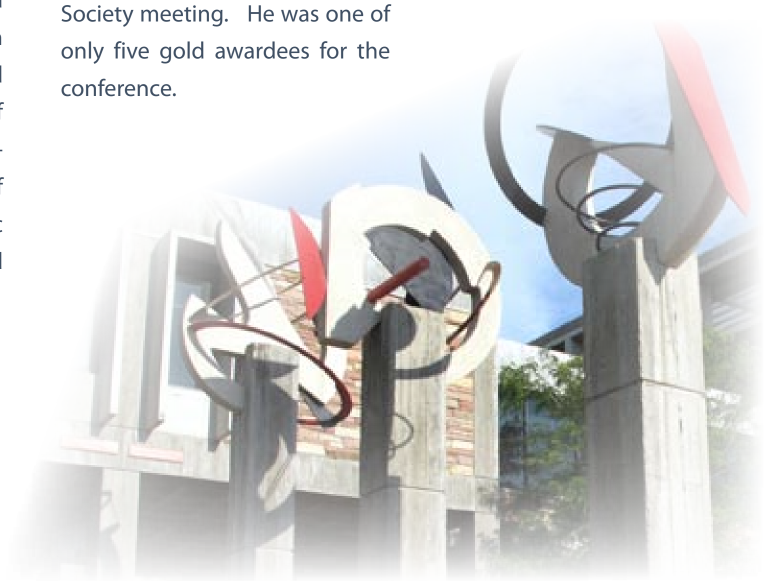
Luis Hakim (PhD '06) received the 2009 Best PhD Thesis in Particle Technology Award from American Institute of Chemical Engineers for his thesis on "Surface Modification of Nanoparticles Using Atomic Layer Deposition in Fluidized Bed Reactor."

David King (PhD '09) received the award for the outstanding PhD thesis in the College of Engineering and Applied Science for his work on optical properties of nanoscale coatings on particles fabricated by atomic layer deposition.

Cole de Forest (PhD candidate 2011) was selected to receive a Gold Student Award based on his presentation of bioorthogonal click chemistries for synthesizing and patterning a 3D cell niche at the Materials Research Society meeting. He was one of only five gold awardees for the conference.

Ryan Erickson (BS '08) received the Silver Medal from the College of Engineering and Applied Science at the May 2008 Engineering Recognition Ceremony. The Silver Medal is the highest award for a graduating senior.

Joshua Kats (BS '08) received the College Academic Achievement Award and the Outstanding Graduate award at the December 2008 graduation.



Distinguished Engineering Alumni Awards

The Distinguished Engineering Alumni Award recognizes graduates of the University of Colorado at Boulder College of Engineering and Applied Science who have demonstrated an exceptional impact to engineering through research and invention, education, government service, industry or private practice.

We are proud to announce that in the last three years, five chemical and biological engineering department alumni have been bestowed this honor. Along with faculty members **Ted Randolph (BS '83)** and **Kristi Anseth (PhD '94)**, **Kenneth May (MS '74)**, director of the Industrial Division at Abengoa Solar, was honored with the award in 2009.

This year, two more alumni were selected to receive the award: **Mike Wirth (BS '82)**, executive vice president of Chevron and **Mohamed Al-Mady (BS '73)**, vice chairman and CEO of Saudi Arabia Basic Industries Corp.

Alumni Updates

Ellen B. Deisler, BS '45, has three grown children and five grandchildren and is long retired. She and her husband are currently living in Austin, Texas.

Gerald Richardson, BS '50, has been retired for 15 years from the Hanford Nuclear Plant, where he helped develop separations processes for recovering plutonium and other byproducts of uranium fuel irradiation. He lives in Richland, Washington, and has been busy since retirement hybridizing irises and working on family genealogy.

Larry Irwin, BS '60, is happily retired in Bellingham, Washington, and proud to be a Buff!!

Charlie Czarniecki, BS '74, placed second in the Rocky Mountain Senior Games 20K bicycle road race in June behind CU dental school graduate Eric Van Zytveld. Czar is a retired Air Force colonel working at Schriever AFB in Colorado Springs as a space systems engineer on the Global Positioning System program.

Seth A. Darst, BS '82, is the Jack Fishman Professor and head of the Laboratory of Molecular Biophysics at Rockefeller University in New York City. He recently was elected to the National Academy of Sciences, one of the highest honors that can be accorded a U.S. scientist or engineer in recognition of distinguished and continuing achievements in original research.

Kathleen (Beyer) Devine, BS '85, is an adjunct professor at Monmouth University in New Jersey, teaching about environmental issues. She has three children, ages 16, 15, and 9. She also works at Sandy Hook, runs a nonprofit to restore a herring run in the Navesink estuary, and is an active scout leader and Water Watch committee member.

Jeff Sczechowski, BS '85, PhD '94, returned to Boulder in 2008 and is working for CU's College of Engineering as the coordinator for research opportunities. His job is to help faculty find new research opportunities with government agencies and industry. Following graduation in 1994, he was a professor of environmental engineering at Cal Poly, San Luis Obispo. He took a leave of absence from Cal Poly to work for STMicroelectronics Central R&D Division in Crolles, France (near Grenoble) from 1999 to 2002. He then continued to work for ST in the U.S. at the Engineering Research Center for Environmentally Benign Semiconductor Manufacturing at the University of Arizona. He and his wife live in North Boulder with their 4 children.

Joe Vranka, BS '85, is overseeing Montana's 14 Superfund projects in his new job with the U.S. Environmental Protection Agency. He was hired after 18 years with the Colorado Department of Public Health and Environment, where his jobs included Superfund work and management of radiation programs.

Christopher Kurtz, BS '95, joined Alexza Pharmaceuticals as vice president of global supply chain and sustainment engineering. The company is located in Mountain View, California.

Scott Holmes, BS '99, finished architectural graduate school at the University of Florida two years ago and now lives in Tampa. His thesis was published by WIT (London), and he is the author of a chapter in "Eco-Architecture II." His project is also currently on the cover of one of the best 3D modeling programs available and in some of their publications. Scott was also hired by the University of Florida, where he taught environmental technologies. He and his father started a new firm designing green schools, and are now working on their fifth. The first was the first LEED silver-certified K-12 school in Florida: http://www.fefpa.org/sc_images_09/Holmes_Hepner/Holmes_Hepner.htm.

Keith Rawlins, BS '01, formed his own law practice in April 2009. He specializes in intellectual property, i.e. patents, trademarks, copyrights, and trade secrets. Keith graduated from the University of Houston Law Center in 2007.

Margaret Tripodi, BS '07, is an associate engineer at Genentech in San Francisco.

Elizabeth McCartney, BS '08, is living in Muscat, Oman, working as a field engineer with Schlumberger, Oman Well Production Services in Fracturing. She recently was promoted and may be moving to another country.

WHERE ARE YOU NOW?

We want to know where you are and what you're up to! Send us an update at **www.colorado.edu/chbe/alumniupdate**.

Get updates on College of Engineering and Applied Science alumni news and events. Keep in the loop at **http://engineering.colorado.edu/alumni**.

Colorado
University of Colorado at Boulder

Department of Chemical and Biological Engineering
424 UCB ■ Boulder, CO 80309-0424
303.492.7471 ph
303-492-4341 fax
www.colorado.edu/che

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