# BioEngineering

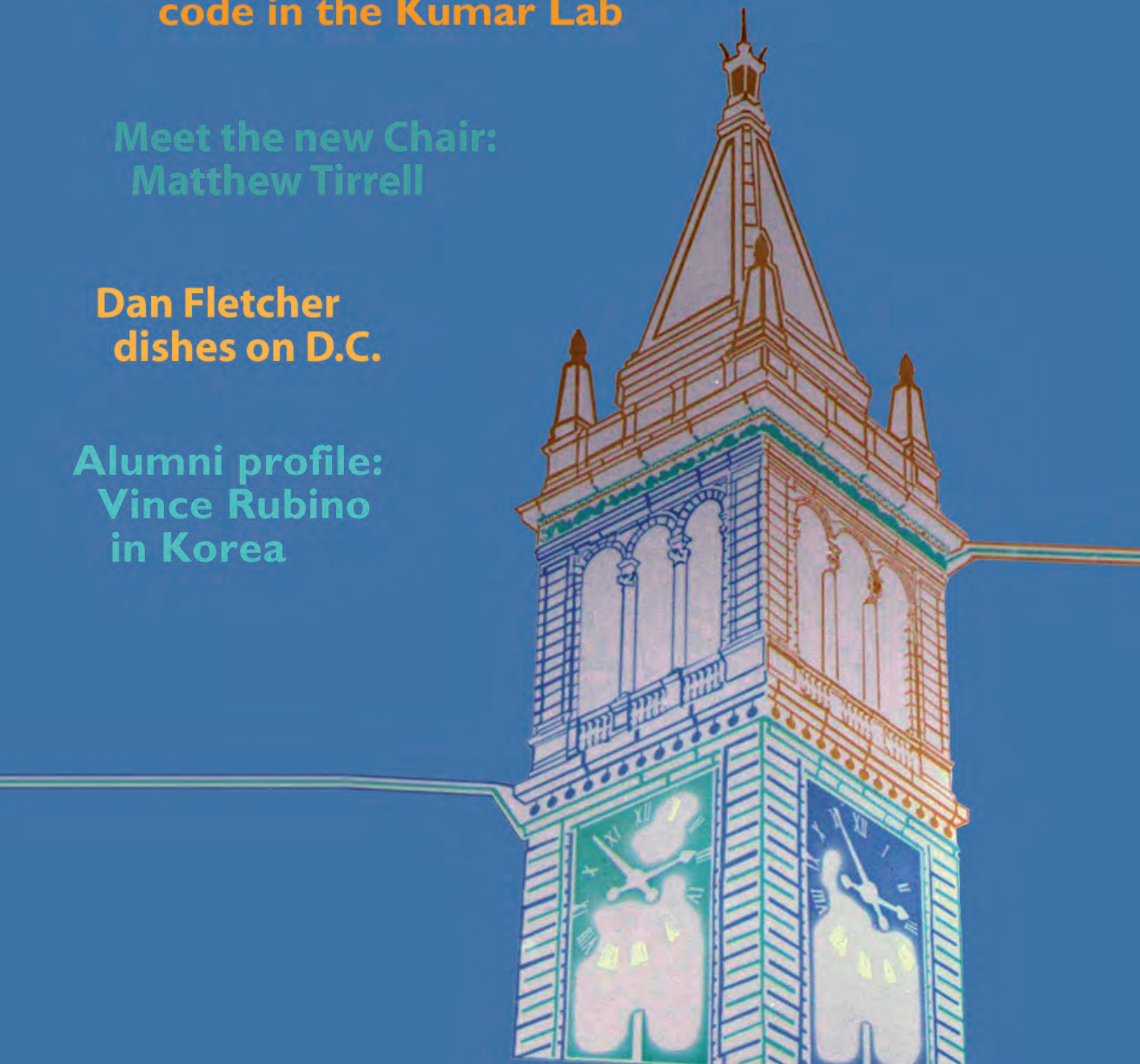
University of California, Berkeley
2008-2009

## Cracking the cell's mechanical code in the Kumar Lab

## Meet the new Chair: Matthew Tirrell

## Dan Fletcher dishes on D.C.

## Alumni profile: Vince Rubino in Korea



# *Bioengineering at Berkeley*

- Matthew Tirrell

Greetings!

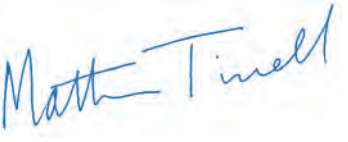
I'm pleased to be sending out my first official missive from Berkeley. As a new member and chair of the UC Berkeley Department of Bioengineering, I was prepared by my experience, and by the interview process, for the high quality and broad intellectual diversity of my departmental faculty colleagues. What I did not fully appreciate before my arrival is how superbly positioned Berkeley Bioengineering is to lead the field of bioengineering at a national and international level.

This positioning derives in part from the excellence of our departmental faculty, and the students they attract and teach, in regenerative medicine, quantitative, systems and computational biology, micro- and nano-technology, and the development of new instrumentation. It also derives from the growing centrality of bioengineering tools to a diverse array of major societal issues including medicine, public and global health, energy, nutrition and agriculture. Owing to both this centrality and their outstanding work, Berkeley Bioengineering students and faculty are important members and leaders in the Energy Biosciences Institute, several divisions of the Lawrence Berkeley National Laboratory, the Berkeley Stem Cell Center, the Helen Wills Neuroscience Institute, QB3, CITRIS and other major collaborative research organizations on campus and off.

Berkeley Bioengineering has a unique blend of *biomedical engineering* and *biological engineering*. This is leading in the first case to new approaches to therapeutic engineering – addressing matters from age-related chronic conditions to cost-effective health care by moving innovations to practice more rapidly and in volume – and in the second to new pharmaceuticals, chemicals, fuels and materials from synthetic biology, and to new quantitative biological measurements and predictive computational tools. The synergies among Berkeley Bioengineering, the superb broader Berkeley environment, and the technological surroundings of the Bay Area are enabling us to change the face and the impact of biology-based technologies in society.

This report highlights a selection of our recent accomplishments to give some concrete examples of our activities. Enjoy it and keep in touch.

Until next year,



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Chair - Matthew Tirrell
Editor & Design - Pamela Reynolds

On the cover:
Microfluidic art by Tanner Nevill, Ph.D. 2008 and Austin Day, B.S. 2008.
See back cover for more information.



## Who are we?

Berkeley Bioengineering is one of the premier departments of bioengineering research and education in the country. We are the newest department in the University of California, Berkeley's College of Engineering, which is consistently ranked among the top three schools of engineering in the world.

Only ten years old, the Department has grown by leaps and bounds, having recruited 18 new faculty since 1999. Bioengineering is now one of the largest and most in-demand majors among undergraduates.

Our doctoral program is administered jointly with the Department of Bioengineering and Therapeutic Sciences at UC San Francisco Medical School, and grants the Ph.D. from both campuses. Now 25 years old, the graduate program has tripled in size since the Berkeley Department of Bioengineering was founded.

### Undergraduate Program

Fall 2009 Enrollment.....441
Women.....35%
Applicants for Fall 2009.....1292

### Doctoral Program

Fall 2009 Enrollment.....173
Women.....35%
Applicants for Fall 2009.....485

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# Cracking the cell's mechanical

There are thousands of different types of cells in our bodies. Skin cells, organ cells, muscle cells, bone cells. Red blood cells, white blood cells, platelets, incredibly long nerve cells. Even cancer cells. These aren't created just once, when we are conceived. Our bodies manufacture new cells of every kind over and over throughout our lives - for growth, for repair and replacements, and unfortunately, for disease.

Photo by Catherine Ocampo

Kumar Lab members

But how do our existing cells know what sort of new cell to manufacture, or in the case of stem cells, to become? It's not just a simple matter of genetic instructions, researchers are finding out. The physical environment - inputs like shear and stretching forces and the stiffness of the extra-cellular matrix (ECM) - have a great deal of influence on how the cell behaves and changes, and Assistant Professor Sanjay Kumar's lab is at the cutting edge of understanding what those signals are and how cells interpret them.

"Our lab is generally interested in how cells receive and process information encoded in mechanical forces and other physical signals from outside the cell," said Kumar. "We're interested in this problem because it appears that these kinds of forces can affect very fundamental properties of cells and tissues, including the rate at which cells divide, and for stem cells, how they differentiate. In the case of diseases like cancer, this is very important in the growth and spread of tumors. We are interested in learning about signaling systems in cells that make this energy transduction possible and in applying what we learn to improve our understanding of disease and potentially develop new treatments."

Three main thrusts in the Kumar lab focus on the self-renewal and differentiation of neural stem cells, the growth and spread of malignant brain tumors, and their newest focus, the design of materials that mimic some of the same molecules that are found in the structural networks of living cells.

Neural stem cells in the brain are capable of differentiating into neurons or other types of brain cells, such as astrocytes and oligodendrocytes. In collaboration with David Schaffer's Laboratory, Kumar's lab has been able to show that if they change the mechanical properties of the ECM, they can control neural stem cell differentiation into neurons. This would be of tremendous use in the treatment of neurodegenerative diseases, basically replacing damaged neurons.

"But more interesting, I think," said Kumar, "is that we can use gene delivery technology to directly control the way in which these cells process mechanical forces. We are re-engineering the signaling pathways cells use to sense and respond to mechanical cues and are beginning to exploit this approach as a second, independent design input along with ECM mechanical properties to steer the differentiation of a neural stem cell into a neuron. Our hope is to eventually extend this paradigm to other stem cell systems, with the long term goal of both better understanding stem cell biology and developing novel cell replacement strategies."

When it comes to cancer, we know that a number of defining features of brain tumors are very sensitive to the mechanical properties of the extracellular matrix. Kumar Lab recently found that when they fabricated artificial ECM and systematically changed the mechanical properties, they could control the rate of brain tumor cell migration and proliferation. They were also able to identify specific signaling systems in these cells that made this happen. They hope to understand this mechanism and its role *in vivo*, and eventually develop therapeutic approaches that take advantage of this.

# code in the Kumar Lab

Their third research thrust is funded by Kumar's Presidential Early Career Award for Scientists and Engineers, to examine biomimetic or bioinspired materials. For example, there is a particular protein found in the structural framework of nerve cells that is able to form networks that resist compressive forces. These proteins resemble a class of polymeric molecules long used in industry called "polymer brushes," which are often used to prevent aggregation of suspensions such as paints and to lubricate surfaces. Because it appears that nerve cells have found a way to use proteins to accomplish the same function, Kumar is examining whether he can mimic that design strategy to make completely new unstructured protein- and peptide-based materials for biotech applications.

In addition to standard cell biology, polymer chemistry and high-resolution optical microscopy, the lab uses several other more exotic techniques. Atomic force microscopy measures the stiffness both of materials and individual cells - using a micrometer-scale force probe to poke at a material and ask how hard the material pushes back.

They also use the specialized technique of "laser nanosurgery," which allows them to measure the mechanical properties of micron-sized structural elements inside living cells, such as those found in the cellular cytoskeleton. When ultrashort, intense pulses of laser light are carefully focused on structures inside cells, they can destroy or sever the structure without killing the cell or damaging surrounding structures. By observing how the structure responds, the researchers can make quantitative statements about its properties and how it contributes to cellular shape and mechanics. For example, cut a stress fiber and it will snap back - measuring how quickly it snaps back will tell how much mechanical load it bore.

Asked about why this area of research is important, Kumar has instant answers, both about his particular field and bioengineering in general.

"We know a great deal about how individual components of cells work in isolation, but we understand much less about how cells integrate and manage complex signals, particularly physical signals, and generate an orchestrated response," he said. "Developing a better understanding of this is critical to being able to describe how cells work in quantitative, engineering terms and the first step toward being able to design smart interfacial technologies that either control cell behavior toward some therapeutic end or incorporate living components as sensors and actuators."

"The reality is that most of the work we do is a couple of steps away from translation, but I think it is very important to understand basic design principles before jumping into translation. Applications will come naturally as our understanding progresses, and there are many historical examples of this in the manufacturing and computing industries. What gets me most excited is using my engineering background to make quantitative sense of a biological process, as a step to solving a problem."

"This is the kind of research that thrives at Berkeley," Kumar noted. "One of the best things about this place is how much people value innovative and high-risk approaches to problems in science and engineering. I really appreciate that at Berkeley, cross-disciplinary research is encouraged, and mechanisms are in place to facilitate that. It seems like an obvious ethic to nurture, but there are a lot of places that don't get it right, and Berkeley has it down to a T."

*Graduate students Theresa Ulrich and Sophie Wong at work*

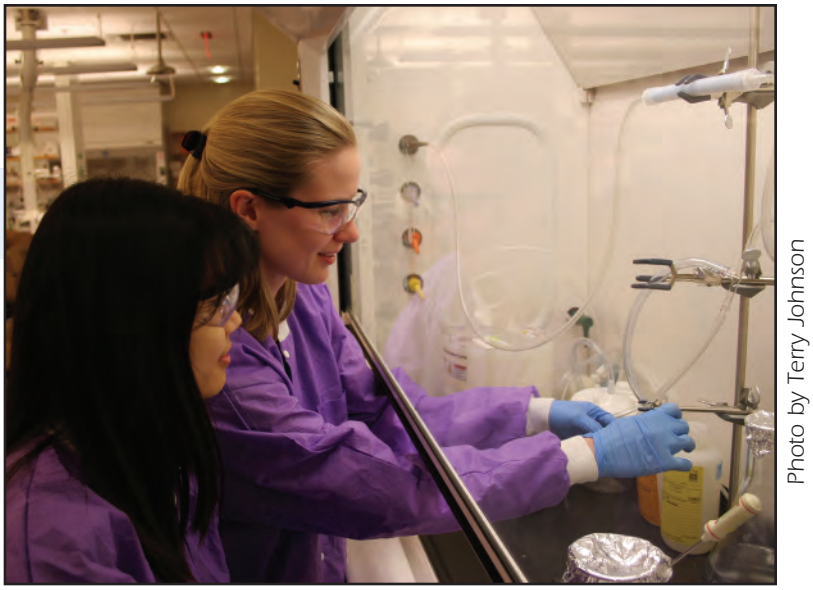


Photo by Terry Johnson

# Professor Fletcher

***Associate Professor Dan Fletcher spent 2008-2009 in Washington D.C. as one of fourteen White House Fellows. We sat down with Dan on his return to Berkeley and got him to dish the dirt on his year in the Capital City.***

***Can you describe the program?***

The program was started in 1965, and is aimed at educating early career professionals about government, leadership and high levels of public service. It is really about getting a better idea of how to get things done more effectively to serve the public good. Our cohort included scientists, doctors, lawyers, teachers, business people, and members of the military.

***Why did you decide to apply to spend a year in DC?***

Well, first of all, I'm always up for an adventure. It's a fantastic chance. Also, I do feel a sense of responsibility. I've had amazing opportunities, and much of the ability to do research is through government money. I'd like to give back in a way that would make better use of the perspective we have as scientists. I think it is important to figure out how universities can play a bigger role in solving societal problems, and to link the creativity of the university with the practical realities of problem solving.

***What did you spend most of your time doing?***

There are three parts to the program: first there were activities planned for us, such as lunch meetings with senior officials, or trips to visit facilities and events. Second was my work while I was there, I was placed at the Office of Science and Technology Policy. Fellows carry out a job, usually a staff job in a government office, working with policy folks. The third is more casual time with other fellows, getting to know the other thirteen and getting a sense of their experiences.

***What did you do at the Office of Science and Technology Policy?***

We say that the office provides science for policy and policy for science, so it's a very busy place. They keep the president and staff informed on science matters, and help formulate policies and budget advice to stimulate research and development in the country. I was a policy analyst, so I was in charge of helping to move projects forward in the areas of life sciences, the biotech industry, biosecurity, and some health information and health technology.

2008-2009 White House Fellows with President Obama

***What did you learn about science in the Capital?***

I learned that science is often only the beginning of a solution to a problem, there is a long way to go before even a great idea can solve a problem or help people. There is a whole other side to implementing or acting upon good research ideas, and universities may not play as big a role in the implementation side as we could. There is inevitably a separation between the people who are trying to solve problems in Washington and those trying to imagine what the future is going to be like.

Also, I learned that people are working really hard. The vast majority of people I met are very dedicated public servants who want to do the best they can. I was really impressed by how hardworking and dedicated people are.

I am convinced that universities have a central role to play in addressing national problems, but we could go much further in promoting our ideas for the future. At a research level, publishing a paper is only the first step, we have to go beyond that to moving that idea out the door either to industry or advocacy organizations.

***What insights can you offer students and colleagues from your experience?***

The most important thing I learned is that you have to think broadly in order to even communicate in DC. People are handling every known issue from contaminated agricultural products to threat from meteors. It's such a wide range of issues that they are incredibly busy, and they are always having to put some topic into context for others to understand.

# goes to Washington

If our students can't provide the context, they are going to have a harder time communicating. You need to be able to express why you are doing what you are doing, why it's important, what are the impacts, what other things will it help or hurt. Those are the things policy makers think about.

Being broad is very important, but what graduate school is about is teaching people to be narrow. We have got to find a way to achieve that significant depth while not losing touch with the range of other topics that anything we do might impact.

Dan, and his hair, at the White House

In addition, I realized that famous people are just people. It took me a while to get over that. They've done amazing things, so let's have a substantive discussion. Take the opportunity not to fawn but really to understand what they see and why they see it.

***Another take home:***

It is important for our students to share their vision of what the world will be like. What are the challenges, what are we going to face? It's important to have opinions and act on our ideas: write an opinion piece, talk to your representatives, make friends outside your discipline and have those conversations - that is how to have an impact. Really challenging yourself to create that vision is a hard thing to do, but is an important step to make your ideas influential.

***How is this new perspective going to influence what you do at Berkeley?***

I'm trying to bring the lessons I've learned into my classes, to give insight into how the world works. I also came back with the idea that I want my graduate students to be well rounded. I've got a plan for voluntary (but encouraged) activities I would like them to engage in: giving a public lecture, developing educational tools, and interacting with with individuals who make policy decisions at the university or in government.

For undergraduates who want to take a bigger step there is the UC Berkeley Washington Program, which is right there in DC and provides some great resources.

***You've lived and worked in Washington before?***

I was a congressional page in my sophomore year of High School. I was fascinated by the decision-making process I saw and think that interest in how people get together to solve multifaceted problems has stuck with me. It helped me to realize that for all the public airing of grievances, everyone recognizes the need to work together at the end of the day. The vast majority of people are there to make a positive difference.

***Any amusing things happen?***

There were *lots* of complaints about my hair. Karl Rove told me to get a haircut, as did a four-star Air Force general and a random person on the street. So, of course, I did not get a haircut. I think I showed them that people with unkempt hair can also argue late into the night about national issues.

***What was your favorite thing about living in DC?***

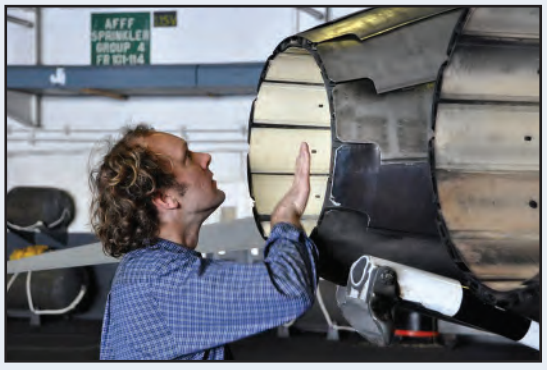
The museums. I never, ever get tired of the Air and Space and Natural History museums.

***Least favorite thing?***

Having to wear ties and suits every day.

***What makes you happiest be back in Berkeley?***

My group. And my wife, of course!



Examining a jet engine on the USS Truman

# Timeline

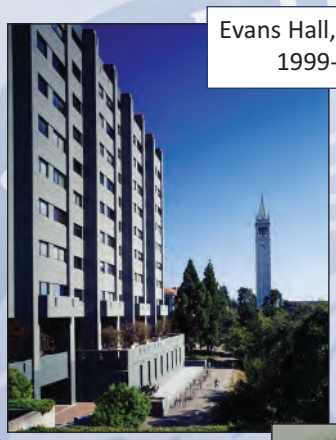
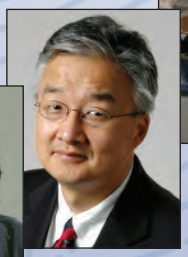


Photo from the Atkinson Collection

Evans Hall, our home 1999-2007

BioE 115 - our first lab course, at the Richmond Field Station



Seven additional Berkeley faculty join the department as founding members: Berger, Casey, Cohn, Karp, Keaveny, Liepmann, Sastry

First new faculty members hired: Adam Arkin and Luke Lee

Kevin Healy hired

Teresa Head-Gordon, Song Li, Kimmen Sjölander hired

Dan Fletcher hired

**1983** — UC Berkeley - UCSF Graduate Group founded

**1998** — UC Berkeley Bioengineering Department founded

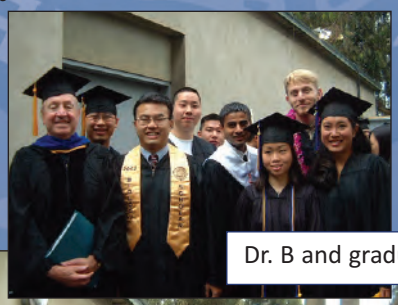
**1999** — Professor Tom Budinger appointed as founding Chair

**2000** — Summer internship program launched, known as the Guidant Program

**2001** — Eleven BioE courses offered, including first lab course: BioE 115

**2002** — More than 300 applications submitted to Ph.D. program

**2003** — More than 100 Ph.D. students enrolled



Dr. B and graduates, 2002

BioE summer interns 2000 (the Guidant Program) and 2009 (Berkeley Summer Bioengineering Research Program)


Commencement 2002

Commencement 2007

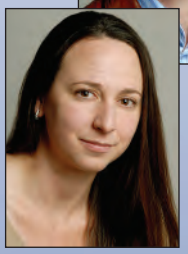


Irina Conboy, Steve Conolly, Ian Holmes, Sanjay Kumar hired

Mohammad Mofrad hired

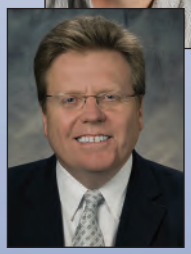
Seung-Wuk Lee hired

Stanley Hall



Chris Anderson and Amy Herr hired

Gerard Marriott hired



John Dueber and Matthew Tirrell hired

**2004**

Dorian Liepmann becomes Department Chair

**2005**

Over 100 B.S. degrees awarded

**2006**

Committee of students, faculty and staff redesign undergraduate curriculum

First annual BioE Department BBQ, 2006

More than 1,000 freshman applications

**2007**

BioE faculty and staff move to Stanley Hall

Introduced undergraduate capstone design course

**2008**

Entering Freshman class is over 100 students, total enrollment more than 400 BioE majors

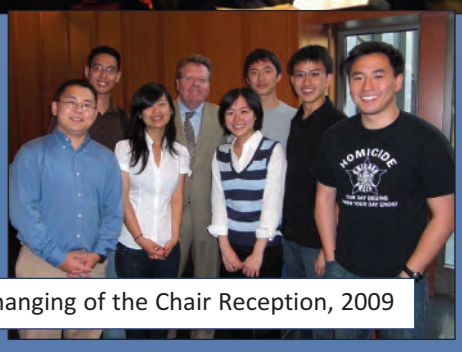
**2009**

Matthew Tirrell becomes Department Chair

Freshman orientation 2009

Luke Lee and undergrad Dino DiCarlo in 2001

Luke and Dino with his Ph.D. in 2006, now a professor at UCLA!



Changing of the Chair Reception, 2009

Photos by Terry Johnson, Cindy Manly-Fields, Ana Maron, Pam Reynolds, Steven Zhao. Faculty photos by Peg Skorpinski.

# Holmes takes genome browsing to the next level

There has been an explosion in the amount of genome data available, but visualization of the data has lagged behind. Assistant Professor Ian Holmes and collaborators have launched a new open source, portable, JavaScript-based genome browser, JBrowse, that can be used to navigate genome annotations over the web. JBrowse is uniquely defined by its ability to offload much of the computation-intensive work of data visualization to a user's web browser.

Like existing genome browsers, the application displays a portion of a genome annotated with sequence features such as genes, transcription factor binding sites or epigenetic marks. But unlike available browsers, where the computation occurs on a remote web server, JBrowse obtains data from the internet and graphically displays it using a self-contained JavaScript program that is loaded into a user's web browser on the fly from a web page. JBrowse (http://jbrowse.org) is open source and free for academic and commercial use.

This new platform may enable some exciting future developments in collaborative annotation and data visualization, including embedded genome browser widgets in user's own web pages, or genome data 'mashups' similar to what is done with Google Maps. (Genome Research, July 2009)

JBrowse annotated genome

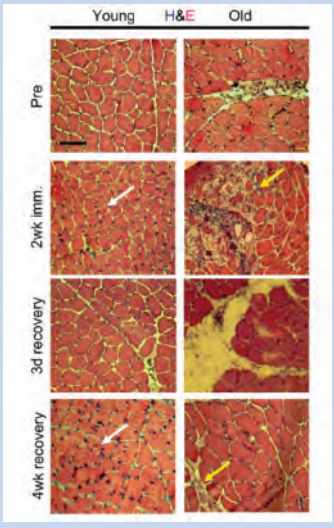
# Research Updates

## *Conboy discovers clues to muscle aging*

Assistant Professor Irina Conboy and collaborators have identified a critical biochemical pathway linked to the aging of human muscle. By manipulating these pathways, the researchers were able to restore the muscle's ability to repair and rebuild itself, offering hope for future injury repair and anti-aging techniques.

Conboy and collaborators at the Institute of Sports Medicine and Centre of Healthy Aging, at the University of Copenhagen in Denmark compared muscle tissue from nearly 30 old and young healthy men in an exercise physiology study.

Previous research in animal models led by Conboy revealed that the ability of adult stem cells to repair and replace damaged tissue is governed by the molecular signals they get from surrounding muscle tissue, and that those signals change with age in ways that preclude productive tissue repair. This more recent study revealed that the same pathways are at work in human muscle.




Young, pink, healthy muscle versus old, scarred and inflamed muscle cells

This work uncovers the molecular culprits responsible for the lack of tissue maintenance and repair seen in older humans and shows that particular molecular cues or exposure to young human serum restores 'youthful' responses to muscle stem cells isolated from 70 year old humans, rendering them similar to cells from 20 year olds.

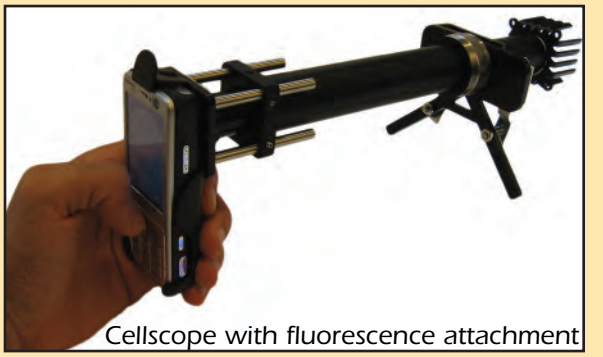
The findings were reported in the September 30, 2009 issue of *EMBO Molecular Medicine*, a peer-reviewed, scientific journal of the European Molecular Biology Organization. Collaborators included Dr. Michael Kjaer from the University of Copenhagen, Dr. Morgan Carlson and Dr. Michael Conboy, researchers at UC Berkeley, and Dr. Charlotte Suetta, a researcher in Kjaer's lab.

# Research Updates

## Fluorescence CellScope shines light on TB

In a major PLoS One publication in June 2009, Berkeley BioE researchers unveiled their revolutionary cell phone platform for remote fluorescence microscopy. Associate Professor Dan Fletcher's team has developed a cell phone microscope, or CellScope, that not only takes color images of malaria parasites, but also of tuberculosis bacteria labeled with fluorescent markers. The device shows great promise for medical diagnostics in remote areas of the developing world, where health care workers in the field can capture images and send them to experts for analysis.

"Fluorescence microscopy requires more equipment – such as filters and special lighting – than a standard light microscope, which makes them more expensive," said Fletcher. "In this paper we've shown that the whole fluorescence system can be constructed on a cell phone using the existing camera and relatively inexpensive components."

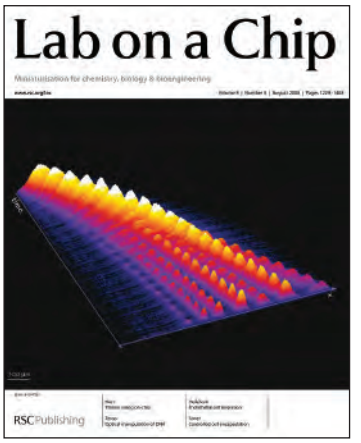

Cellscope with fluorescence attachment

Other researchers on the team include BioE graduate student David Breslauer, Berkeley BioE undergrad alumnus Robi Maamari, Biophysics graduate student Neil Switz, and BioE postdoc and UCSF pediatric hematologist Wilbur Lam.

Funding for the CellScope project comes from the Center for Information Technology Research in the Interest of Society (CITRIS) and the Blum Center for Developing Economies, both at UC Berkeley, and from awards from Microsoft Research, the Intel Inspire-Empower Challenge, and the Vodafone Wireless Innovation Project.

## Hot research by Herr

BioE Assistant Professor Amy Herr has been attracting attention with her work in on-chip microfluidic protein sizing. Her article, "Photopolymerized diffusion-defined poly-acrylamide gradient gels for on-chip protein sizing" made the cover and was declared a "Hot Article of 2008" in *Lab On A Chip*.




Her research describes a new diffusion-based fabrication method for microfluidic devices that are able to reliably sort proteins by size using linear and non-linear gradient gels. This method offers several improvements over current protein sizing methods, and allows an assay to be optimized for protein samples of interest – especially complex samples. Potential applications include high throughput bio-analytical instrumentation designed for portable use, such as diagnostics for in-field medical sampling.

## Lee's viruses may repair nerves

Research by Assistant Professor Seung-Wuk Lee may someday help regenerate injured spinal cords. Lee and his colleagues, including recent BioE Ph.D. recipient Anna Merzlyak, used a self-replicating, genetically engineered virus to create scaffolds to mimic supportive nerve tissue.

The phage virus M13 was engineered to display nerve cell friendly proteins on its outer coating, then put into a solution of neural-progenitor cells. In solution, the viruses aligned themselves to form long, nerve-like fibers of virus scaffold surrounded by cells. When injected into a simple culture medium, the neural progenitor cells multiplied and formed the long branches characteristic of neurons.

This technique holds promise for nerve repair, and may also be used to grow more complex structures by varying the concentration or using magnetic fields to control position. Next steps include animal trials to study the scaffold safety and how well they encourage nerve regeneration.

# Faculty and Student Awards

### Seung-Wuk Lee Receives NSF CAREER Award

*Assistant Professor Seung-Wuk Lee has received a 2008 National Science Foundation Faculty Early Career Development (CAREER) Program award. CAREER awards are given to young researchers in science and engineering who have also translated their work into significant educational activities.*

*This CAREER award will support his work on understanding the interactions between well-defined hydroxyapatite crystals and their recognition peptides and how this mineralization is regulated. A molecular - level understanding of how proteins regulate the biomineralization process is critical for understanding ossification, osteoporosis, and many other bone- and tooth related diseases. In addition, the proposed studies may be useful for developing protein-based bone prosthetic regeneration materials and novel therapeutics for bone related diseases such as osteoporosis and osteogenesis imperfecta.*

### Berkeley grad students get down to business

BioE graduate student Kelly Karns won first prize with her team in the 2009 annual Berkeley Business Plan competition, held at Berkeley's Haas School of Business, and placed first in the Berkeley Venture Lab competition. Their entry automates diagnostics for tuberculosis.

In 2008, bioengineering Ph.D. students Adam Mendelsohn, Lily Peng and Kayte Fisher, and MBA student Stephen Dugan, took home 1st prize at the Business Plan Competition. Their entry uses nano-technology to create a high-precision, low-cost system to deliver therapeutic treatments for chronic diseases. The system, called NanoFlow, allows drugs to enter the blood stream at a steady rate in very low doses, cutting down on side effects. The same team also won the Venture Lab Competition in October 2008.

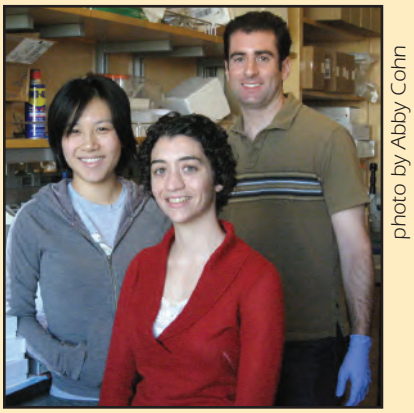
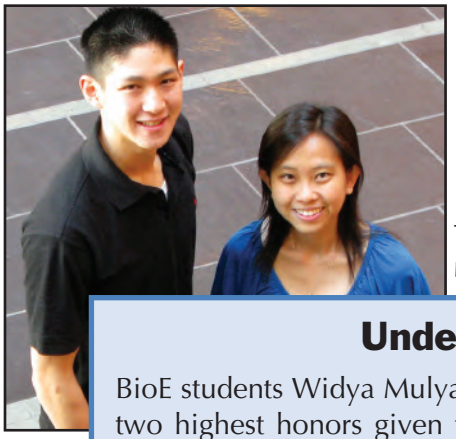


photo by Abby Cohn

*Lily, Kayte and Adam*



*Tim and Widya*
photo by Rachel Shafer

### Undergrad Honors

BioE students Widya Mulyasasmita and Tim Fei were awarded the two highest honors given to engineering undergraduates! Widya won the 2008 Bechtel Achievement Award, which is given to a senior with outstanding scholastic achievement and service to the College, campus and community. Widya was also our 2008 BioE Departmental Citation recipient.

Tim was given the Bechtel Engineering Scholarship, awarded to a sophomore or junior for scholastic performance, student leadership and potential for success in an engineering career.

### New Fellows

*Professors Dorian Liepmann and David Schaffer were elected Fellows of the American Institute for Medical and Biological Engineering. Adam Arkin and Jay Keasling are new Fellows of the American Academy of Microbiology, and Matthew Tirrell has been elected to the American Academy of Arts and Sciences.*

### Karp wins Kyoto Prize!

Richard Karp, University Professor of bioengineering, electrical engineering & computer sciences, industrial engineering & operations research, and mathematics, has been named a laureate of the 2008 Kyoto Prize, Japan's equivalent of the Nobel Prize, in recognition of his lifetime achievements in the field of computer theory.

The Kyoto Prize is awarded annually by the Inamori Foundation to those who have contributed significantly to the betterment of humanity in the categories of advanced technology, basic sciences, and arts and philosophy. A giant in the field of computer science and theory, Karp's recent work has been in the area of bioinformatics and computational biology, where computers and algorithms are used to analyze and model data to determine how genes and living cells work.

# Awards

## Kumar collects honors

BioE Assistant Professor Sanjay Kumar was awarded a 2009 Presidential Early Career Awards for Scientists and Engineers by President Barack Obama. This award is the highest honor bestowed by the U.S. government on young professionals in the early stages of their independent research careers, and comes with five years of significant research funding. Awardees are selected on the basis of their pursuit of innovative research at the frontiers of science and technology, and a commitment to community service as demonstrated through scientific leadership, public education, or community outreach.

In Fall 2008 Kumar was also recognized with a 2008 NIH Director's New Innovator Award! This five-year, $1.5 million grant is the largest and most prestigious grant awarded to junior investigators by the NIH, designed to enable recipients to pursue exceptionally innovative approaches that could transform biomedical and behavioral science.

## Alumni Excellence

UC Irvine professor and BioE Ph.D. alumna Michelle Khine was featured as a 2009 Young Innovator in the *MIT Tech Review 35*. Khine was selected for her creative and innovative microfluidic devices, including devices made from Shrinky Dinks toys.

Ph.D. alumna Karen Christman, an Assistant Professor of Bioengineering at UCSD, received a 2008 NIH New Innovator Award. The five-year grant will fund research developing a multi-layer patterning technique that will provide step-by-step cues for cell and tissue development.

In 2007 *R&D Magazine* recognized Bioengineering Ph.D. alumnus Shyam Patel's work on nerve grafts in their list of the Top 25 Micro/Nano Technologies of the year. Patel has developed nerve graft materials composed of aligned, nanoscale polymer fibers that act as physical guides for regenerating nerve fibers.

### Herr receives DARPA Young Faculty Award

Assistant Professor Amy Herr is the recipient of a 2009 DARPA Young Faculty Award. Herr was recognized for her proposal on "An Integrated Micro/Nanosystem for Rapid Validation of Traumatic Brain Injury Biomarkers".

The Young Faculty Award program, from the Defense Advanced Research Projects Agency, is designed to seek out ideas from non-tenured faculty in order to identify the next generation of researchers working in microsystem technology.

Amy (right) with nominating faculty Amy Herr

## Outstanding Staff

BioE Department Manager Amy Robinson was honored in Spring 2008 with a Chancellor's Outstanding Staff Award.

These awards are among the highest honors bestowed upon staff by the Chancellor. They are presented to staff who in addition to performing all of their normal job duties with excellence, also take initiative and go above and beyond in their contributions to the UC Berkeley campus community.

## Jay Keasling - still our rock star

Photo by Bart Nagel

We've known it for years. Professor of Bioengineering and Chemical Engineering Jay Keasling is achieving worldwide recognition as a leading proponent of synthetic biology to solve the world's pressing health and energy problems.

Keasling is also now Acting Deputy Director of Lawrence Berkeley National Lab, as well as Director of the Synthetic Biology Engineering Research Center and CEO of the Joint BioEnergy Institute.

In the past year Jay was named one of *Rolling Stone Magazine's* 100 Agents of Change, appeared on tv on *the Colbert Report*, was featured in *Discover Magazine*, named a *Newsweek* "Person To Watch", received a UC Berkeley Chancellor's Public Service Award, and was awarded the first Biotech Humanitarian Award.

We may have missed some. It's hard to keep up.

# Extra Curriculars

UC Berkeley has been a key player in the annual International Genetically Engineered Machine competition, an undergraduate synthetic biology competition, since its inception as an international event in 2005. Working at their own schools over the summer, student teams use a kit of Standard Biological Parts and new components of their own design to build biological systems and operate them in living cells. Teams present their projects at the iGEM Championship Jamboree in November of each year, held at MIT.

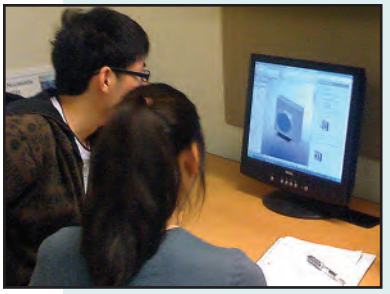
iGEM has grown from 13 teams in 2005 to 112 teams with over 1700 participants from countries across Asia, Europe, Latin America, and the US in 2009. Stiff competition! UC Berkeley has been fielding two teams for the past two years, a 'Tools Team' focusing on software development, and a 'Wetlab Team' focusing on biological parts. From 2006 to 2009 the teams have been mentored by BioE Assistant Professor Chris Anderson.

Some past projects have included the Display-O-Matic (cell-surface display device), Clotho (an integrated software toolbox for organizing biological parts), Clonebots (a genetic self-lysis device and a Gateway cloning device), and BactoBlood (an engineered blood replacement).

In 2009 the Tools Team tied for Best Software Tool, and both teams were rated Gold Medalists. In 2008 the Tools Team took the Best Software Tool Award, while the Wetlab Team was one of six finalists for the Grand Prize. In 2007 the single Berkeley team won Best Poster and was a finalist for Grand Prize. In 2006 Berkeley took Best Part, and 3rd place in Best Measurement and Part Characterization, and in 2005 won the Red-Eye Award, the XXXtreme Presentation Award, the Best Conceptual Advance Award, and the Most Innovative Brick Award.

Photo by Peg Skorpinski

2009 Wetlab Team



## Designing Health

BioE's new undergrad capstone design course, BioE 192, has received a special grant from the National Collegiate Inventors and Innovators Alliance.

In the intensive class, taught by Amy Herr, students are paired with UC San Francisco clinicians to design, test and prototype new or improved medical technologies. Student teams focus on the technical and business challenges of "Bringing Healthcare Home". This course strives to meet a societal need to educate our next generation of bioengineers in the challenging area of medical technology for in-home healthcare.

## Anti-Medical School

A new graduate seminar with a funny name, Anti-Medical School tries to turn traditional medical education on its head. In medical school, faculty teach what is 'known'. In anti-medical school, faculty teach what is 'unknown': the opportunities for invention.

Weekly meetings for this course consist of presentations by UC San Francisco medical faculty on current challenges in clinical healthcare, followed by interactive class discussions and brainstorming. Topics covered include drug delivery, informatics, imaging, materials, surgical instruments and devices. First taught at UCSF and now at Berkeley, the class has been a great success with a packed audience.

# Alumni Profile: *Vince Rubino*

***Catching up with alumnus Vince Rubino, who received his B.S. in Bioengineering in Fall 2001. After working for Bayer Pharmaceuticals in Berkeley for seven years, Vince took off for a new biotech job in Korea in 2007.***

***What are you doing for a living?***

I recently joined the Korean government's contract toxicology testing lab, Korea Institute of Toxicology, in Daejeon. I support the institute's Quality Assurance (QA) department and head up the global business development group, which is all about forming partnerships and cooperation. Business development is somewhat of a new discipline for me and it is always a challenge to learn new skills. I also work part-time for the Korean Ministry of Knowledge and Economy as a delegate to the International Organization of Standards.


Vince in Hangzhou

***What is interesting about your current position in Korea?***

I really enjoy living and working in Korea and find it extremely fascinating. What is most appealing is expanding my cultural knowledge and having my perceptions and biases fundamentally challenged. I really have to think carefully about what is important and what is appropriate from a broader viewpoint.

***What made you decide to take this job in another country?***

I had been thinking about working overseas ever since graduating from Cal in 2001. Before starting work at my first company, I took a five week vacation to Korea and Hong Kong and decided I'd like to experience living here. Also, I have always been a bit of an explorer and grew up in a military family that moved frequently. It feels natural to be on the move and living overseas again.

***What interesting thing has happened to you since moving?***

I attended the Beijing Olympic torch rally in Seoul with a group of Chinese friends who were exchange students at a Korean university. Although mostly peaceful, some situations definitely got out of hand and the event became very, very complicated for everyone. That event, the aftermath and how it affected my friends and China/Korea relations in the short term really opened my eyes to how different things are here and some of the great challenges that lie ahead for inter-asian and east-west relations.

***What did you learn in your first job at Bayer?***

I started as a summer intern in 2000. After graduation I was a validation engineer, got caught up in a huge internal reorganization and ended up as a facility engineer, specializing in validation. Little did I know then that "reorg" is a bit of a mantra in big corporations. Corporate life is highly political and my experience at Bayer taught me a lot about how to communicate, and particularly for an opinionated, outspoken guy like me, about how *not* to communicate.

***Why do you stay involved with mentoring BioE students?***

I am naturally drawn to teaching and training, and although never my professional focus, the instinct is always with me. Soon after returning to work I knew I had a special opportunity to extend myself to students, faculty and administrators as an industry representative.

***What at Berkeley was great life training?***

Living in the University Students Cooperative Association was definitely the most important experience to prepare me for corporate life. It forced me to learn to pick my battles and become more realistic about how to better deal with problem issues involving groups of people.

***What is your dream job?***

I would really like to have the time to return to creating films and music, and write things that inspire and influence the way people think about important issues. While I strongly believe science makes major improvements in the world, perceptions are what drive human decisions. A lot of the problems we are tackling as scientists and engineers could be solved more effectively by changing the way people behave, particularly in healthcare and energy.

***Why do you stay in bioengineering?***

The beauty of bioengineering is its inherent interdisciplinary nature. Embrace that aspect of your education and run with it. The ability to jump from technology to technology and bridge gaps between various disciplines is of huge value. More and more, success will depend on the ability to communicate across specialties.

***Any advice for others?***

While it isn't as positive-sounding as the golden rule, I often tell expatriates: "Do not expect anyone to treat you better than they treat themselves".

# Bioengineering Faculty

## Bioengineering Core

*J. Christopher Anderson* - Assistant Professor

*Adam Arkin* - Professor

*Irina Conboy* - Assistant Professor

*Steven Conolly* - Associate Professor

*John Dueber* - Assistant Professor

*Daniel Fletcher* - Associate Professor

*Teresa Head-Gordon* - Professor

*Kevin Healy* - Jan Fandrianto and Selfia Halim Professor, also Professor of Materials Science & Engineering

*Amy Herr* - Assistant Professor

*Ian Holmes* - Assistant Professor

*Sanjay Kumar* - Assistant Professor

*Luke Lee* - Lester John and Lynne Dewar Lloyd Distinguished Professor and Co-Director, Berkeley Sensor and Actuator Center

*Seung-Wuk Lee* - Assistant Professor

*Song Li* - Associate Professor

*Dorian Liepmann* - Professor
also Professor of Mechanical Engineering and Co-Director, Berkeley Sensor and Actuator Center

*Gerard Marriott* - Professor

*Mohammad Mofrad* - Assistant Professor

*Kimmen Sjölander* - Associate Professor
also Associate Professor of Plant and Microbial Biology

*Matthew Tirrell* - Arnold and Barbara Silverman Chair of Bioengineering, also Professor of Materials Science & Engineering and Chemical Engineering

## Joint Appointments

*Paul Adams* - Adjunct Professor

*Stanley Berger* - Montford G. Cook Professor
also Professor of Mechanical Engineering

*James Casey* - Professor
also Professor of Mechanical Engineering

*Richard Karp* - University Professor
also University Professor of Electrical Engineering & Computer Sciences, Mathematics, and Industrial Engineering & Operations Research

*Jay Keasling* - Professor
also Professor of Chemical Engineering, Acting Deputy Director of LBNL, Director of SynBERC and CEO, JBEI

*Tony Keaveny* - Professor
also Professor of Mechanical Engineering

*Sharmila Majumdar* - Professor in Residence
also Professor in Residence of Radiology (UCSF)

*Jitendra Malik* - Arthur J. Chick Professor of Computer Science

*Sarah Nelson* - Professor
also Professor of Radiology and Co-Chair, Department of Bioengineering and Therapeutic Sciences (UCSF)

*Lisa Pruitt* - Lawrence Talbot Professor
also Professor of Mechanical Engineering

*David Rempel* - Professor in Residence
also Professor in Residence of Medicine (UCSF)

*S. Shankar Sastry* - Dean and NEC Distinguished Professor, also Professor of Electrical Engineering & Computer Sciences and Mechanical Engineering

*David Schaffer* - Professor
also Professor of Chemical Engineering and Co-Director, Berkeley Stem Cell Center

## Emeritus Faculty

*Thomas Budinger* - Professor in the Graduate School

*Boris Rubinsky* - Arnold and Barbara Silverman Distinguished Professor Emeritus

# New faculty

## Christopher Anderson

Assistant Professor J. Christopher Anderson joined the Bioengineering Department in 2007. He received his Ph.D. from The Scripps Research Institute and completed postdoctoral research with Professors Arkin and Voigt at UCB-UCSF from 2003-2007.

Dr. Anderson is a rising star in the growing field of synthetic biology, with significant worldwide recognition for his research in the field. Current work builds upon earlier tumor-killing bacteria efforts with a variety of innovative genetic devices to control the interactions between engineered bacteria and animal systems. Anderson is unique for his complementary emphasis on both applied and foundational research. At present, the lab works on automating technical design and assembly of synthetic DNA and identifying powerful, scalable solutions to protein engineering problems.

Anderson has also been the lead mentor of Berkeley's successful iGEM (International Genetically Engineered Machine) undergraduate teams for the past several years.

## Gerard Marriott

Professor Gerard Marriott joined the Bioengineering Department in 2008 recruited through a joint search by the Department and the Berkeley Nanosciences and Nanoengineering Institute. He joins us from the University of Wisconsin-Madison, where he was a Professor of Physiology and Director of the Graduate Physiology Program.

Marriott is a distinguished leader in nanobiology and a renowned researcher in biological optics, with work spanning biophotonics, molecular biophysics, chemical biology, nanomaterials, devices, and synthetic and systems biology. His research interests center on understanding the molecular basis of cell motility and muscle contraction, incorporating unique expertise in devising new molecules that function as biological sensors and/or manipulate protein function remotely in complex environments. His advances include the design and application of new optical probes and microscope imaging techniques – these technologies allow him to study protein function and dynamics over a range of organizational levels, ranging from single molecules to cells within animals.

## Matthew Tirrell

We are pleased to welcome our new Department Chair, Matthew Tirrell. Tirrell comes to us after ten years as Dean of Engineering at UC Santa Barbara, and holds our new Arnold and Barbara Silverman Chairmanship in Bioengineering, and appointments in Chemical Engineering and Materials Science & Engineering.

A talented leader and an eminent polymer scientist, Tirrell has been a pioneer in the evolving field of soft materials, especially in macromolecular interface science and bionanotechnology. He has led UC Santa Barbara's College of Engineering through a period of remarkable growth to its present ranking in the top 20 nationwide.

From 1977 to 1999 he was on the faculty of chemical engineering and materials science at the University of Minnesota, where he served as head of the department from 1995 to 1999, and also as Director of the Biomedical Engineering Institute.

## John Dueber

Our newest faculty member, John Dueber received his Ph.D. in biological sciences from UC San Francisco, and completed a postdoctoral research position at UC Berkeley as a QB3 Fellow. He also served as interim Scientific Director of the Synthetic Biology Engineering Research Center (SynBERC) during 2007.

Dueber has already become a noted contributor to the field of synthetic biology, especially the area of engineering biological switches and optimizing flux through engineered pathways in microbes. He joins the department as an Assistant Professor in Bioengineering, recruited through a search for the Energy Biosciences Institute. We look forward to the energy and expertise he will bring.

*Welcome!*

# Recent Graduate Alumni

## Spring 2007
Sarang Dalal
Jill Ulrich
Grace Huynh
Esin Ozturk Isik
Paul DiCamillo
Craig Atencio
Carmel Levitan
Anat Caspi
Yasuo Yoshikuni
Krishna Asundi
Adam Kinsey

## Fall 2007
Suchandrima Banerjee
Joseph Osorio
Olivier Morin
Timothy Ham
Li Yan
Mansoor Nasir
Nicholas Toriello
Johanna Zumer
Nicholas Fawzi
Elizabeth Irwin
Ying Li
Shyam Patel
Samuel Wall
Adrian Lau
Mina Nikanjam
Michael Mueller

## Spring 2008
Mark Albers
Cornelius von Morze
Jeremy Risner
Hoi-Sze Christina Yau
Nathaniel Beyor
Michael Rosenbluth
Morgan Carlson
Craig Hashi
Anne Sakdinawat
Naraporn Somboonna
Sheryl Kane
Sapun Parekh
Chris (SungWon) Chung
Wilbur Lam
Yan Li

## Fall 2008
Carmen Taylor
Richard Cohen
Erik Douglas
Hayley Lam
Meredith Metcalf
Heather Filippini
Hang Ieng Yeung
Kyle Kurpinski
Joshua (Tanner) Nevill
Jiashing Yu
Yiping Gu
Hain-Ann Hsueh
Junyu Mai
Matthew Zierhut
Cheng Li

## Spring 2009
Anne Kim
Matthew Lin
Ovijit Chaudhuri
Anna Merzlyak
Margaret Johnson
Justyn Jaworski
Douglas Watson
Catherine Cheng

## Masters of Science
Xia Jiang, Spring 2007
Timothy Kubow, Spring 2007
Brian Carnes, Fall 2007
Daniel Shreter, Fall 2007
Yuri Bendaña, Fall 2007
Mimi Zhang, Fall 2007
Joseph Dale, Spring 2008
Jennifer Luu, Fall 2008
Zachary Lee, Fall 2008
Hsing-Yun Hsu, Fall 2008
Claire Herriot, Spring 2009
Kevin Kolahi, Spring 2009

**Alumni, keep us updated at:**

bioeng.berkeley.edu/alumni/ugradupdate.php
bioegrad.berkeley.edu/graduatealumni.php

**Find us on facebook!**

Keep up with the department by joining our alumni group: *UC Berkeley Bioengineering Alumni*, or friend *Berkeley Bioengineering*.

**Need help at work? Hire a student!**

Contact the BioE Department for help with recruiting graduating students, summer interns, or 6-month Co-Op interns.

Photo by Cindy Manly-Fields

2009 B.S. recipients line up for commencement

Justyn Jaworski gets hooded in 2009

photo by Peg Skorpinski

# Recent Bachelor of Science Alumni

## Spring 2007

Jon Akutagawa
Alexander Ansari
Nabil Azhar
Harvinder Chagger
Anders Chan
Joanne Chan
Alex Chen
Brandon Chen
Michael Chen
Richard Chen
Tao-Yang Chen
David Ding
Jennifer Dong
Byron Hsu
Jeffrey Hsu
Shwan Kazzaz
Insiya Khambaty
Aram Kim
Jayoung Kim
Amy Lam
Siu Lam
Denis Lankin
Cory Laws
Michael Le
Alexander Leung
Sander Leung
Elizabeth Lin
Jeremy Lin
Colin Lorentzen
Henry Lu
Jason Luo
Robi Maamari
Alexander Mok
Thomas Myint
Victor Ng
Deeshali Patel
Kunal Patel
Paras Patel
Sumip Patel
Ryan Quigley
Cheryl Russell
Josephine Shaw
Rabia Siddiqi
Jay Su
Brian Toy
Tsung-Ling Tsou
Yu Wan
Clement Wong
Janelle Wong
Calvin Wu
Charles Yong
Alen Zamanyan

## Summer 2007

Hans Cabrera
Felipe Cervantes
Erik Feest
Jason Hu
Eric Huang
Kimberly Krauze
Tran Ta

## Fall 2007

Tin Chan
Ding Chen
Hoi Cheong
Concord Cheung
Raymond Cheung
Yee Wan Cheung
Irene Choi
Andrew Fischer
Todd Fong
Alexander Huang
Michael Kurylo
Denis Lam
Chulsung Lee
Ronald Lee
Brian Lin
James Liu
Michael McGregor
Yiming Mei
Tawan Udtamadilok
Christopher Wolf
Francis Wong
Shaopeng Yuan
Katherine Zhang

## Spring 2008

Lizhi Cao
Ginger Chan
Whanwook Chang
Edward Chen
Alice Chung
Robert Collins
Ryan Cooper
Emmanuel Cua
David Dai
Myhanh Duong
Clare Gollnick
Harendra Guturu
Gee Ha
Brandon Hsu
Kevin Hsu
Richard Huh
Santoshi Indrakanti
Amit Jain
Ahra Kim
Winnie Kuo
Jacqueline Law
Brian Lee
David Lee
Yu Liang
Diana Lin
Katrina Lin
William Long
Adam Luce
Alison Lynch
Albert MacH
Widya Mulyasamita
Houy Nga
Elise Nguyen
Omid Rahmanian
Jennifer Rhodes
Ye Shen
David Shis
Edward Sim
Irene Sinn
Grace Tang
Sisi Tian
Adeeti Ullal
Amy Walters
Ke-Jun Wang
Clarissa Wong
Grace Wu
Yue Zhao

## Summer 2008

Michael Chen
Angelee Kumar
Nhu Nguyen
Leticia Rubalcava

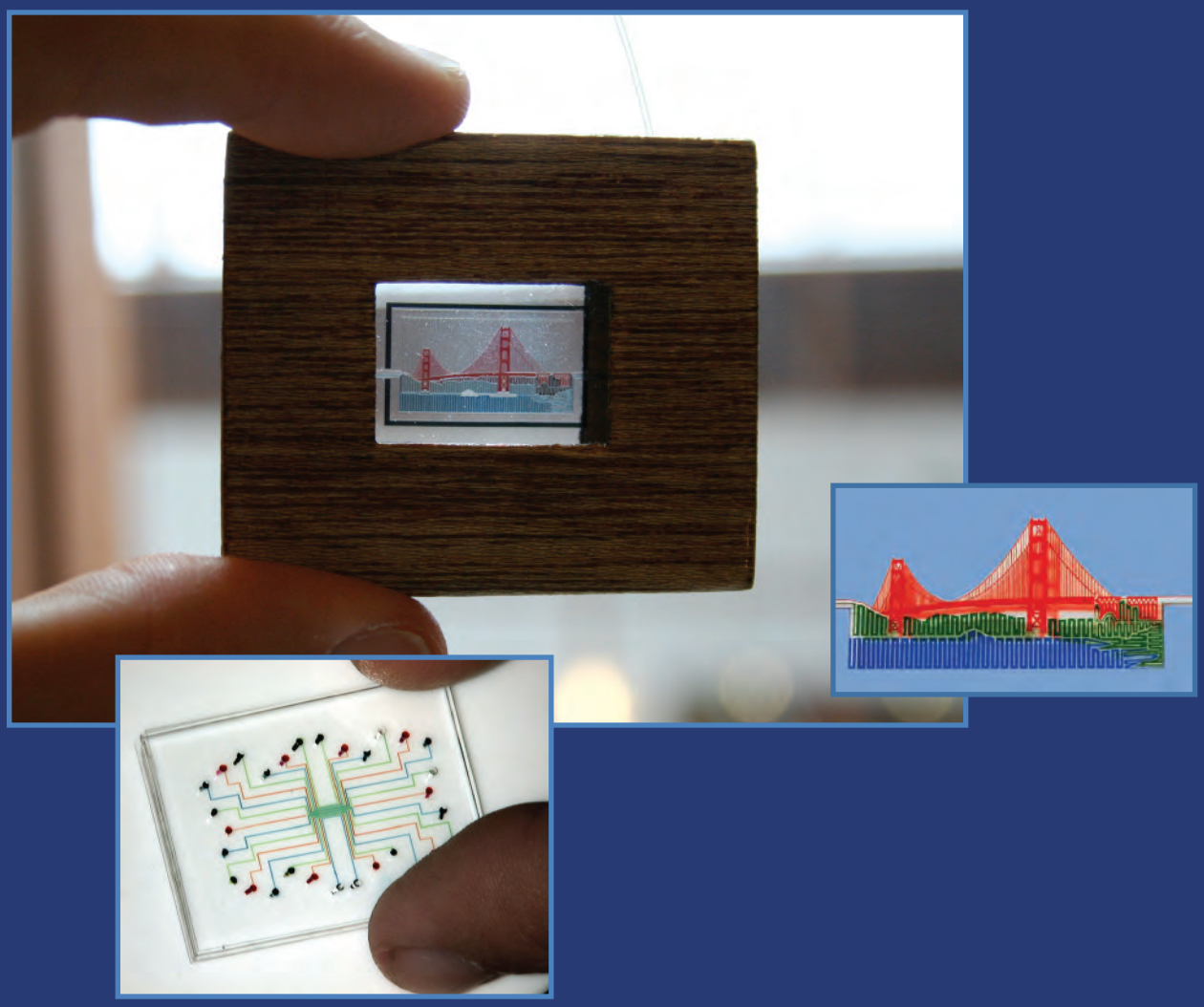
## Fall 2008

Christina Brown
Sheng-Wen Chou
Dexter Dsa
Merline Hidayat
Charles Hu
Nina Khoshnevisrad
Masae Kobayashi
Tizita Mammo
Brian McLucas
Bushra Samad
Parminder Singh
Jack Tung
Hilla Wahnishe
William Wu

## Spring 2009

Suruchi Anand
Madalyn Berns
Benjamin Casavant
Alvin Chan
Neil Chang
Hong-Chun Chao
Sterling Collins
David De Renzy
Alisa Dong
Dana Donnenwirth
Timothy Fei
Xiao-Yu Fu
Sydney Geissler
Xiaoqian Gong
Yueyang Guo
Hyun Han
Shyam Jani
Yisu Jiang
Matthew Johnson
Ryan Johnson
Peter Jones
Jason Keller
Gene Kim
Robert Lamorena
Amanda Laska
Aron Lau
Benjamin Lee
Elena Liang
Samantha Liang
Kate Liddle
Meng-Hsin Lin
Michael Lin
Henry Liu
Jennifer Lu
Daniel Madamba
Joy Makdisi
Rustin Massoudi
Ardeshir Mortazavi
Ganesh Nagaraj
Ahmad Namvargolian
Dean Nehama
Sam Ng
Christopher Nguyen
Thuc-Quyen Nguyen
Rina Parmeshwar
Eric Phoumthipphavong
Ye Qiu
Kavitha Ratnam
Nikhil Rode
Daniel Rosen
Atul Saxena
Justin Scheer
Kiranjit Sekhon
James Shi
Hank Shih
Sarmad Siddiqui
Nade Sritanyaratana
Eric Stone
Gabriel Sudario
Vivian Tang
Huy Tran
Anson Tsui
David Tulga
Dien Vo
Gabriel Wong
Leland Wong
Lavanya Wusirika
Daniel Yoo
Denny Yu

photos by Peg Skorpinski



## Microfluidic Masterpieces

Recent Ph.D. alumnus Tanner Nevill, now at Berkeley startup Fluxion Bioscience, designed these pieces of science art in Professor Luke Lee's laboratory.

Tanner works with microfluidic lab-on-a-chip applications, and developed a technique that allows for filling extremely long microfluidic channels with solutions to create a "painting" of an image.

The campanile image on the front cover was created with the help of another lab member, Austin Day, B.S. in Chemical Biology 2008.