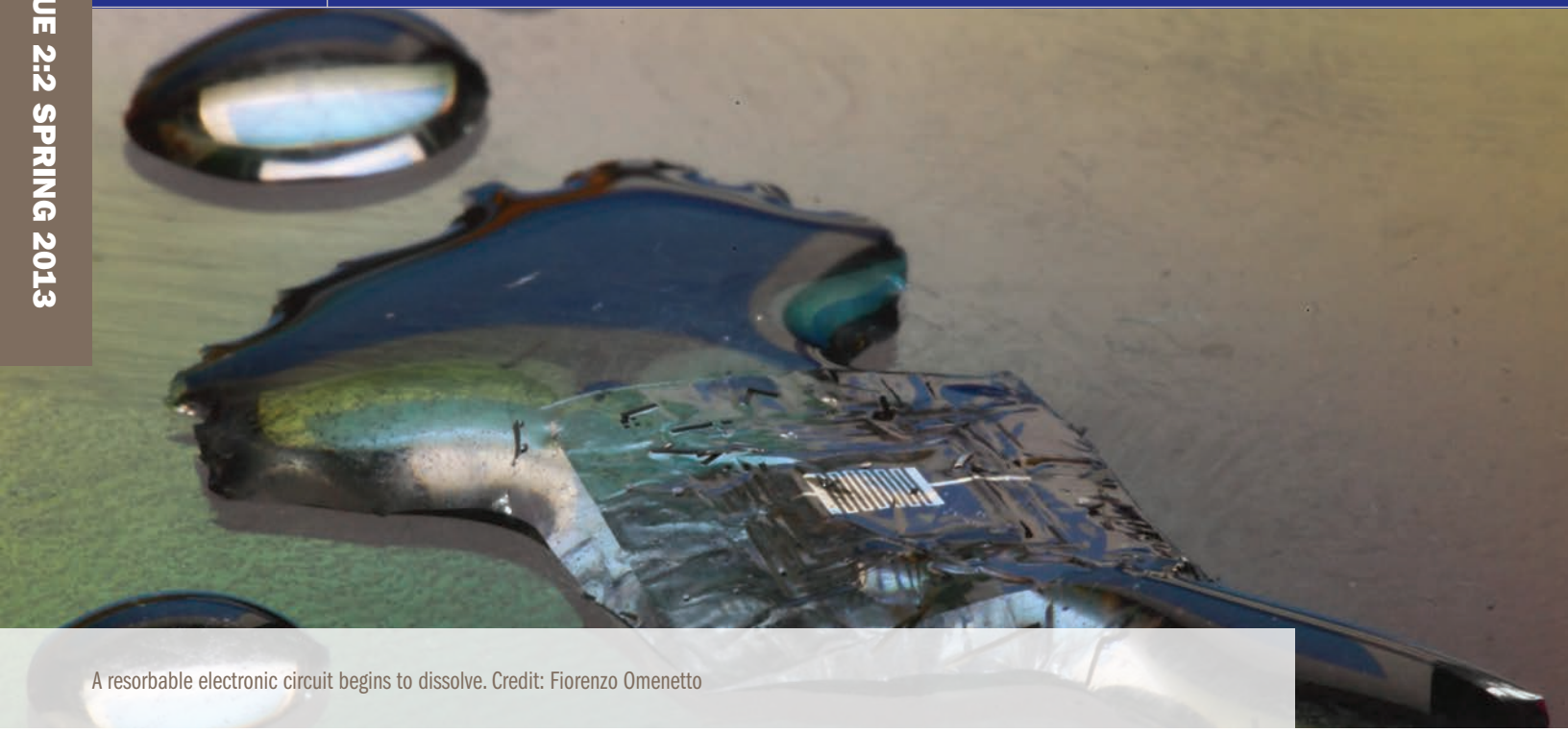
NEWSLETTER ISSUE 2:2 SPRING 2013

Tufts UNIVERSITY | School of Engineering

DEPARTMENT OF BIOMEDICAL ENGINEERING



A resorbable electronic circuit begins to dissolve. Credit: Fiorenzo Omenetto

DISAPPEARING ACT

"Transient Electronics" Dissolve in Body or Environment

Tiny, fully biocompatible electronic devices that are able to dissolve harmlessly into their surroundings after functioning for a precise amount of time have been created by a research team led by biomedical engineers at Tufts University School of Engineering in collaboration with researchers at the University of Illinois at Urbana-Champaign.

Dubbed "transient electronics," the new class of silk-silicon devices promises a generation of medical implants that never need surgical removal, as well as environmental monitors and consumer electronics that can become compost rather than trash.

"These devices are the polar opposite of conventional electronics whose integrated circuits are designed for long-term physical and electronic stability," says Fiorenzo Omenetto, Frank C. Doble Professor, and a senior and corresponding author on the paper "A Physically Transient Form of Silicon Electronics" published in the September 28, 2012, issue of *Science* and featured on the cover of the journal.

"Imagine the environmental benefits if cell phones, for example, could just dissolve instead of languishing in landfills for years."

"Transient electronics offer robust performance comparable to current devices but they will fully resorb into their environment at a prescribed time—ranging from minutes to years, depending on the application," Omenetto explains. "Imagine the environmental benefits if cell phones, for example, could just dissolve instead of languishing in landfills for years."

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IN THIS ISSUE

FROM THE CHAIR

Dear BME friends,

It continues to be my pleasure to share the recent activities of our students, staff, faculty, and alumni. A significant highlight of the past year includes our successful ABET accreditation, a major milestone for the department. Professor Sergio Fantini—supported by our faculty, students, and External Advisory Board (EAB)—played an instrumental role in the process. In addition, numerous students and post-doctoral scholars received awards or fellowships. New grants, industry interactions, and start-ups have continued to fuel the growth and visibility of Tufts Department of Biomedical Engineering while providing ample opportunities for students to get involved in design and research projects.

We continue to focus on strengthening career and networking resources for our students. "Industry Days," a program initiated by Assistant Professor Qiaobing Xu has provided our current undergraduates direct access to internships and professional opportunities. Furthermore, many EAB members are participating in our annual Research Day in which BSBME seniors present their year-long projects and receive feedback from the accomplished members of our board, providing unique interactions and experiences.

Lastly, it has been heartwarming to follow the activities and achievements of our alumni. Last May, we hosted a dinner in their honor the Friday night prior to Commencement. We plan to make this an annual event and hope to see all of our alums at this year's dinner on May 17, 2013!

David Kaplan
Spring 2013

BME Reunion Banquet

Please mark your calendars for the second annual BME alumni reunion banquet dinner on May 17, 2013 at the Intercontinental Boston Waterfront Hotel. Look for e-mails from BME_Alumni@tufts.edu and check for upcoming details on our alumni page.

Music Theory Informs Biomaterials

An ear for music might be key to improving synthetic silk structures. With the help of MIT professor Markus Buehler and composer John McDonald, Professor David Kaplan and colleagues at Boston University and MIT are using category theory to identify what different musical interpretations of successful and unsuccessful synthetic protein structures could teach them about how to construct and reverse engineer new varieties of silk fiber structures.

Tissue Engineering Resource Center 2012–2013 Collaborators

Since 2004, the Tissue Engineering Resource Center (TERC), a collaboration between Tufts and Columbia University, has been the only NIH-supported Center on Tissue Engineering and Regenerative Medicine in the United States. This past year, TERC hosted students and faculty from around the world to disseminate the research and techniques developed within the program. This year's international collaborators included doctoral students, postdoctoral fellows, and faculty members from the following institutions:

- Politecnico di Milano, **Italy**
- Université de Technologie de Compiègne, **France**
- Poznan University of Medical Sciences, **Poland**
- Pharmazeutische Technologie und Biopharmazie LMU, **Germany**
- ETH, **Switzerland**
- Embrapa Genetics Resources and Biotechnology, **Brazil**
- University of Sydney, **Australia**
- CSIRO, **Australia**
- Ajou University, **Korea**

Watch David Kaplan and Fiorenzo Omenetto's presentation,The New Silk: A Thread of Discovery, given at Tufts University's "Back to the Future" event on November 27, 2012 at the Harmonie Club in NYC.

Disappearing Act *Continued from page 1*

The futuristic devices incorporate the stuff of conventional integrated circuits—silicon—but in an ultrathin form that is then encapsulated in silk protein.

"While silicon may appear to be impermeable, eventually it dissolves in water," says Omenetto. The challenge, he notes, is to make the electrical components dissolve in minutes rather than eons.

Researchers led by UIUC's John Rogers—the other senior and corresponding author—are pioneers in the engineering of ultrathin flexible electronic components. Only a few tens of nanometers thick, these tiny circuits, from transistors to interconnects, readily dissolve in a small amount of water, or body fluid, and are harmlessly resorbed, or assimilated.

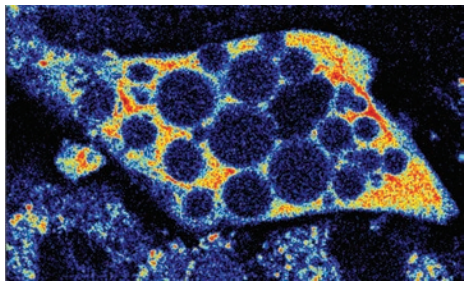
The researchers successfully demonstrated the new platform by testing a thermal device designed to monitor and prevent post-surgical infection (demonstrated in a rat model) and also created a 64 pixel digital camera. In the future, the researchers envision more complex devices that could be adjustable in real time or responsive to changes in their environment, such as chemistry, light or pressure.

Collaborating with Omenetto from Tufts Department of Biomedical Engineering were Hu Tao, research assistant professor and co-first author on the paper; Mark A. Brenckle, doctoral student; Bruce Panilaitis, research assistant professor; Miaomiao Yang, master's student; and David L. Kaplan, Stern Family Professor of Engineering and department chair.

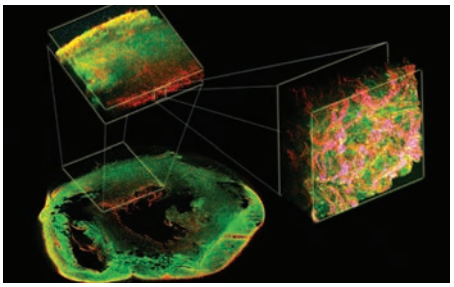
RESEARCH HIGHLIGHTS

In Assistant Professor Lauren Black's lab, **Ray Wang,** E12, was awarded an American Heart Association Summer Undergraduate Research Fellowship to carry out his project to understand role of alterations in the biophysical environment during the development of Left Heart Hypoplasia on cardiomyocyte phenotype and function. Postdoc **Corin Williams** was awarded an individual postdoctoral fellowship (F32) from the National Institutes of Health—National Heart, Lung and Blood Institute to study the role of extracellular matrix mediated signaling in neonatal cardiomyocyte proliferation.

In Professor **Sergio Fantini's** lab, doctoral student **Bertan Hallacoglu** is the lead inventor in a new patent application aimed at non-invasive optical measurements of brain tissue oxygenation. His research was published in the *Journal of Biomedical Optics.* Doctoral student **Michele Pierro** produced two major scientific articles on quantitative studies of cerebral hemodynamics to appear in *NeuroImage*. Doctoral student **Pami Anderson** has significantly advanced the clinical component of the optical mammography project funded by a $3.5 million grant from the National Institutes of Health in collaboration with Tufts Medical Center in Boston. Senior **Elizabeth Rosenberg**, E13, is a co-author on a paper exploring new tissue-like phantoms that allow for quantitative tests of new methods of image reconstruction and tissue oxygenation assessment in optical mammography. The paper has been provisionally accepted for publication in *Biomedical Optics Express*. Research Assistant Professor **Angelo Sassaroli** published an article in the *Journal of the Optical Society of America* on Monte Carlo simulations of light propagation in turbid media, which includes most biological tissues.



NADH fluorescence intensity of a maturing adipocyte acquired through TPEF microscopy used to non-destructively assess cell differentiation status and metabolic activity.



TPEF microscopy *(green)* and second harmonic generation imaging *(red)* provide 3D reconstructions of a decellularized heart used to explore the relationship between structure and mechanical function.

Postdoc **Kyle Quinn** and Associate Professor **Irene Georgakoudi** won first place for photography and illustration using two-photon excited fluorescence (TPEF) microscopy *(see above)* in the 2012 Tufts Research Visualization Award competition.

QUICK HITS

Assistant Professor Catherine K. Kuo received a National Science Foundation (NSF) CAREER Award to investigate how the cytoskeleton of tendon progenitor cells regulates developing tissue mechanical properties to influence tendon formation. This research could lead to improved medical interventions for orthopedic disorders. Professor Kuo has been invited to attend the 2013 German-American Frontiers of Engineering symposium (GAFOE), April 26–28 at The National Academies' Beckman Center in Irvine, California. The GAFOE symposium, organized by National Academy of Engineering and the Alexander von Humboldt Foundation, brings together 60 outstanding engineers, ages 30–45, from U.S. companies, universities, and government labs to discuss leading-edge research and technical work across a range of engineering fields.

Assistant Professor Lauren Black was awarded a R21 grant from the National Heart, Lung and Blood Institute to study the role of ECM mediated signaling in the development of altered myocyte phenotype in hypoplastic left heart syndrome. The Black Lab was also awarded a multi-PI R01 to study the basic mechanisms in calcific aortic valve disease with co-PIs Dr. Gordon Huggins of the Molecular Cardiology Research Institute and Dr. Phil Hinds of the Molecular Oncology Research Institute at Tufts Medical Center Cancer Center.

Professor Fio Omenetto's work on the reinvention of silk will represent international collaboration in science and technology as part of the 2013 Year of Italian Culture in the United States. The exhibit will open at the Italian Embassy in Washington in April 2013 and then travel to Boston's Italian Cultural Institute and the Tufts' SilkLab.

BMES 2012

The BME department was well represented at the 2012 Biomedical Engineering Society (BMES) annual meeting held in Atlanta on October 24–27, 2012. Professors Black, Georgakoudi, Kuo and Xu attended and graduate students and postdocs presented their work in poster presentations and platform sessions. Here's to another great showing in Seattle next fall!

Posters:

Kyle Alberti (Advisor: Xu): Slice and Dice: Re-engineering Natural Materials for Biomedical Applications

Pamela Anderson (Advisor: Fantini): In the Right Light: Broadband Optical Mammography with Quantitative Oximetry and Clinical Measurements

Mark Brenckle (Advisor: Omenetto): Rapid Lamination of Multilayer Silk Fibroin Films with Controlled Protein Crystallization

Jeffrey Brown (Advisor: Kuo): Differential Regulation of Axial vs. Limb Tendon Progenitors by Mechanical Loading

Ellen Fanti (Advisor: Kaplan): Fabrication of Coaxial Electrospun Silk Fibroin Mats

Amy Hopkins (Advisor: Kaplan): Silk Hydrogels as Soft Substrates for Neural Tissue Engineering

Alexander Mitropoulos (Advisor: Omenetto): Fabrication of Silk Fibroin Microspheres Using a Microfluidic Flow-Focusing Device

Zachary Schiller (Advisor: Kuo): Lipid Metabolism During Adipogenesis of Stem Cells Increases with Reduced Cytoskeletal Tension

Rachel Twardowski (Advisor: Black): Cardiac Fibroblasts from Different Developmental Stages as a Support Cell for Endothelial Cell Sprout Formation

Ming Wang (Advisor: Xu): Combinatorial Cationic Lipid-like Nanoparticles for Efficient Intracellular Cytotoxic Protein Delivery

Kathy Ye (Advisor: Black): Varying Frequency of Mechanical Stimulation Induces a More Physiological Hypertrophic Pathway in Engineered Myocardium

Platform Sessions:

Stephanie McNamara (Advisor: Kaplan): Development of Novel Silk-Calcium Phosphate Ceramic Composites for Healing Critical-Size Bone Defects

Kyle Quinn (Advisor: Georgakoudi): Validation Of A Non-Destructive, Label-Free Optical Technique to Assess Stem Cell Differentiation

Kelly Sullivan (Advisor: Black): Infarct ECM Inhibits Mesenchymal Stem Cell Differentiation Towards a Cardiac Lineage in an In Vitro Model of MI

Kelly Sullivan presents her talk at BMES.

2012 BMES attendees *(from L to R)*:
Pamela Anderson, Ming Wang, Stephanie McNamara, Kyle Alberti, Alex Mitropoulos, Mark Brenckle, Kelly Sullivan, and Kathy Ye

Keep in Touch

1. E-mail **BME_Alumni@tufts.edu** with your news, stories, and updated contact information. If you're not receiving e-mails from us, please let us know!
2. Join our graduate and undergraduate LinkedIn groups.
3. Visit Tufts Online Community: **www.alumniconnections.com/tufts** (go to "Classnotes," then click on "Submit/Edit a Class Note")

ALUMNI SPOTLIGHT

'12 Kyle Boutin (B.S., 2012) is currently working as a Research Engineer at Reactive Innovations LLC, a chemical engineering firm in Westford, Mass. "My education at Tufts prepared me well for my first job!"

'12 Lauren Klinker (B.S., 2012) is currently working as a Biomedical Engineer at MC10 Inc., a technology start-up company based in Cambridge, Mass. that creates conformal electronic systems for medical, consumer, industrial, and military applications. Her work focuses on the integration of stretchable, flexible electronics on the skin, such as for health and sports monitoring devices, and within the body on cardiac devices for diagnosing and treating arrhythmias. A large part of her work is based on her undergraduate thesis, which she completed in Professor Omenetto's lab. She says, "I am happy to be close to Tufts campus and look forward to staying in touch with the department."

Congratulations to our Graduates

Bachelor of Science in Biomedical Engineering

Kyle George Boutin
The Effects of Electromechanical Stimulation on Myocardial Constructs

Brynne Meredith Cassidy
Optimization and Assessment of ClonePix FL 2 for Cell Line Development

Erin Sutton Coonahan
Improved Wound Healing in a 3D Skin Equivalent through the Application of External Stimuli

William George Curless
Light-Mediated Temperature Controlled Silk Films


Senior Dinner

Kelly Elizabeth Flanagan
Design and Development of a Silk Fibroin Tissue Sealant for Neurosurgery Application

Steven Ross Foglietta
Determining "Room Readiness" for Patient Handoffs and Transfers Using "Apps"

Lauren E. Klinker
Skin-Based Sweat Monitoring Using Radio Frequency Identification Sensors

Adhvait Miteshkumah Shah
Design and Therapeutic Assessment of Silk Fibroin-Based Implant for Sustained Release of Procarbazine and Adenosine in 2D Environment for the Treatment of Glioblastoma Multiforme

Sean Michael Siebert
Functionalized Silk Interfaces for Medical Sensors

Katherine Michele Tang
The Effects of the Cardiac Extracellular Microenvironment on the Differentiation of Mesenchymal Stem Cells


BSBME Class of 2012


Senior Cruise

David Ethan Wang
Stabilizing Pedvaxhib in Silk Films Over Time and Temperature

Rebecca Wang
Design of an Optimized Fibrin Scaffold for the Creation of Engineered Cardiac Tissue

Record-Breaking Doctoral Class

We had another record-breaking year for our graduate programs with nearly 200 applications. Twenty-three students enrolled, nine of whom are doctoral students. Matthew Applegate was awarded the Stern Fellowship and Aswin Sundarakrishnan was awarded a School of Engineering Dean's Fellowship.

Doctoral Recipients

Evangelia Bellas
Dissertation: Adipose Tissue Engineering for Testing Platforms and Soft Tissue Regeneration
Advisor: Dr. David Kaplan

Mitul M. Desai
Dissertation: Optogenetic Stimulation Combined with High-Field fMRI (Opto-fMRI): A New Method for Examination of Evoked BOLD Responses and Functional Connectivity
Advisor: Dr. Mark Cronin-Golomb

Dean Liang Glettig
Dissertation: Engineering Environments to Prolong Long-Term In Vitro Culture of Human Hematopoietic Stem Cells
Advisor: Dr. David Kaplan

Konstantinos Tsioris
Dissertation: Silk Material Modification and Microfabrication Strategies for Applications in Biosensors and Drug Delivery
Advisor: Dr. Fiorenzo Omenetto

Marie Christine Tupaj
Dissertation: Multifunctional Silk Nerve Guides for Axon Outgrowth
Advisor: Dr. David Kaplan

Master of Engineering

Alexandra Bird

Umme S. Khan

Qui T. Luu

Master of Science

Scott T. Arno
The Effect of Astrocyte-Mediated Extrasynaptic Glutamate Currents the Dynamics and Firing of Hippocampus-like Neuronal Networks

Jason Edward Bressner
E-gel Films and Natural Silk Mats: Novel Processes for the Creation of Functional Silk Surfaces

Roberto Elia
Hyaluronic-Acid Based Hydrogels as a Novel Bioscaffold for Cell Encapsulation and Angiogenic Growth Factor Delivery onto Moving Tissue and Organs

Violet Grace Finley
Tendon Tissue Engineering: Development of Coaxial Nanofiber Scaffolds and Examination of the Effects of Mechanical and Soluble Cues on Tendon Progenitor Cells In Vitro

Rodrigo R. Jose
Development of Modified Electrospinning Hardware and Techniques to Enable Production of Novel Materials

Wei-Che C. Ko
Tissue Engineering Models of Polycystic Kidney Disease

Douglas Howell MacDonald
Intrinsic-Fluorescence Markers Reveal High-Risk HPV Infection and Cervical PreCancer

Elleesse Carlisle Navarro Pillas
Determining the Optical Properties of the Human Brain Using a Two-Layer Diffusion Model for Non-Invasive, Frequency-Domain Optical Measurements

Rachel L. Twardowski
Cardiac Fibroblasts as a Support for Endothelial Cell Sprout Formation in Engineered Cardiac Tissue

Andrew D. Ward
Perfusion Bioreactor System for Real Time Metabolic Profiling of 3D Human Adipose Tissue

Kevin Yu
Inhibition of Influenza Binding by a Liposome Targeting Viral Hemagglutinin

ON AND OFF CAMPUS

Biomedical Engineering Society

Members of Tufts Biomedical Engineering Society (BMES) kicked off the year with a general interest meeting where more than 40 students enjoyed ice cream made with liquid nitrogen. Later that week, BMES hosted a barbecue at which professors, grad students and undergrads ate, played games, and socialized despite the cold. Later in October, we hosted a Halloween movie night and the first-ever SciTech Costume Contest. Congrats to Yuji Takeda in Assistant Professor Qiaobing Xu's lab for winning "Best Costume"!

Outreach is an important part of BMES—we want to cultivate an interest in STEM education in young people. To this end, we have participated in Tufts Community Day in the fall and Tufts Kids' Day in the spring, making silkworm cocoon creations with the children from local elementary schools. Next semester, we plan to go to local high schools and talk to students about the research we do at Tufts, and how they can get involved.

BMES is also a pre-professional society. Before the fall Tufts Career Fair, we hosted a resume workshop session, and intend to hold another before the SciTech Fair this spring. We collaborated with Professor Xu on two "Industry Days" career networking events. A small group of us also visited Philips Medical Systems, a medical device company in Andover, Mass. that builds ultrasound technology. We look forward to more company tours, especially at companies that are more biotech- or pharma-focused.

We have much more planned for this upcoming semester and look forward to getting to know the newly accepted incoming BME class through similar types of events. If you are interested in learning more, or want to get involved in BMES, email bmestufts@gmail.com or visit our website: http:// sites.tufts.edu/BMES.

–Nick Bayhi, E13
President, BMES

BMES e-board member, Jason Lau, E13, enjoys some liquid nitrogen ice cream at the general interest meeting.

Some of the silk-cocoon creations made by local kids at Tufts Community Day

Industry Days

Assistant Professor Qiaobing Xu launched a career networking program called "Industry Days" to help BME undergraduate students find internship opportunities. Fourteen companies, including Boston-based biotech and pharmaceutical companies, participated in four networking events, which included a question and answer session with industry professionals. "These events definitely helped me plan my career path and provided a great opportunity for networking," said one student. Xu plans to hold three to four Industry Days throughout the academic year.

ES011 Museum Day participants

Yi Xuan shows a MoS visitor a DNA model.

John Kenney and a MoS visitor build DNA with pipe cleaners.

Museum Days

In 2010, Assistant Professor Kuo initiated a unique partnership with Boston's Museum of Science (MoS) to help educate the public about cutting-edge research and related fundamentals at the intersection of science and engineering. On December 1, 2012, Kuo and her students taught the MoS event "How does DNA make YOU?" In Kuo's Fall 2012 ES011 course, "Fundamentals of Biological Systems," Tufts undergraduate students designed interactive teaching tools with which to educate MoS visitors about how DNA provides instructions for life.

Research Scholars—TUBERS

This past summer, Assistant Professor Lauren Black created the Tufts University Biomedical Engineering Research Scholars (TUBERS) program for local high school students to gain laboratory experience. Thirteen rising juniors and seniors participated in the 10-week program working with grad students or postdocs on their own independent projects. In addition to gaining lab experience, TUBER students received greater exposure to biomedical engineering through biweekly research presentations by department faculty members. The program culminated in a poster session where TUBERS students presented their work to members of the department, as well as family, friends, and their high school science teachers. We are seeking to expand the program beyond students from the Medford, Somerville, Acton, Lexington and Concord areas. If you have suggestions for new participating schools or know someone to contact at your local high school, please email Lauren.Black@tufts.edu.

Professor Xu speaks to the TUBERS students about his lab's research at a biweekly seminar.

BME RETREAT

The 2012 BME retreat took place at the Craigville Retreat Center in Cape Cod, Massachusetts on September 14–15. More than 100 students, postdoctoral fellows and graduate students attended. The two-day retreat began with a lunch and social activities on the beach followed by an evening scientific session.

The retreat wrapped up with an awards ceremony for best postdoc and graduate student poster presentations. Poster judging was conducted by new graduate students, and awards were given for best poster by a postdoc, PhD candidate, and MS candidate.

Poster Contest Winners

Postdoc: Ming Wang

1st Place PhD: Andrew Reeves

2nd Place PhD: Tony Dinis

1st Place MS: Michael Doire

2nd Place MS: Joshua Gershlak

Beach activities, such as cornhole and volleyball, follow lunch.

"Family Feud" kicks off the first-day events.

Poster sessions presentations and talks wrap up the first-day events.

Tufts UNIVERSITY | School of Engineering

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Students from Acera Massachusetts School of Science, Creativity and Leadership in Melrose visit Professor Fiorenzo Omenetto's SilkLab at the Science and Technology Center. Postdoctoral scholar Benedetto Marelli *(foreground)* shows students how quickly silk structures dissolve. (Kelvin Ma/Tufts University)