NEWSLETTER ISSUE 8:1 SPRING 2014

Tufts UNIVERSITY | School of Engineering

DEPARTMENT OF BIOMEDICAL ENGINEERING

Assistant Professor Qiaobing Xu fabricates stronger collagen structures in his lab. Xu was recently named a Pew scholar for his work in nanotechnology related to tissue regeneration.

SLICE, STACK, AND ROLL

A new way to build collagen scaffolds

Assistant Professor Qiaobing Xu has developed a novel method for fabricating collagen structures that maintains the collagen's natural strength and fiber structure, making it useful for a number of biomedical applications.

Collagen, the most abundant protein in the body, is widely used to build scaffolds for tissue engineering because it is biocompatible and biodegradable. Collagen is, however, hard to work with in its natural form because it is largely insoluble in water, and common processing techniques reduce its strength and disrupt its fibrous structure.

Xu's new technique, called bioskiving, creates collagen structures from thin sheets of decellularized tendon stacked with alternating fiber directions that maintain much of collagen's natural strength.

Bioskiving does not dilute collagen's natural properties, says Xu. "Our method leverages collagen's native attributes to take advantage of the well-organized micro and nanostructures that nature already provides."

"Our method leverages collagen's native attributes to take advantage of the well-organized micro and nanostructures that nature already provides."

In their research, Xu and Kyle Alberti, a Ph.D. student in Xu's lab, cut small sections of collagen from bovine tendons. Using a specialized detergent, the researchers decellularized the sections, leaving intact only the extracellular collagen matrix made of bundles of aligned collagen nanofibers.

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IN THIS ISSUE

FROM THE CHAIR

Dear Alums and Friends,

Happy 2014! We look forward to an exciting and productive year ahead. Our programs continue to evolve with input from students, faculty, staff, alumni, and our board of advisors. We have tweaked our course requirements, expanded programs related to industrial engagement, and explored new options to enhance program access to undergraduate students. The faculty have continued to excel in research and our students continue to succeed in and out of the classroom as well as post-graduation from Tufts. Our dedicated staff has carried the load of keeping us on schedule and up to date with department, school, and university requirements, which seem to continue at an unending pace. We also note with pride the return of our alums to the annual May dinner, the participation of colleagues in Industry Days held for our current students, and the active role of our advisory board members in providing guidance for our program to enhance our impact. These and many other features allow us to continue to grow and excel in our mission.

Looking Towards the Future

The research enterprise today is global, with instantaneous information exchange, matriculated students from all parts of the world, and collaborative research on a global scale. As a department, we have been active in international activities with robust joint research programs throughout the world including in Europe, Africa, Asia, and South America. These programs—supported via the National Institutes of Health, the Department of Defense, and various foundations—provide important research opportunities for our students. We encourage our BME majors to study abroad to gain international perspective. Our graduate students and postdoctoral scholars also have opportunities to attend international conferences or spend time in collaborating laboratories around the world to enhance their research. We have opportunities to formalize these specific joint research and educational efforts with select universities; however, the administrative barriers to such endeavors can be overwhelming.

In the coming years, one of our goals is to plan a coordinated path forward with our international efforts, better integrating with various Tufts programs to enhance educational impact at all levels. This will take a lot of effort to review programs, to identify the most appropriate opportunities, and to avoid dilution of effort here in Medford. With a network of BME alums around the world already in place, we have a great starting point to build such an effort.

As always, we welcome your input, updates and engagement in ongoing department activities and we remain committed to making you a proud member of our Tufts BME family.

Cheers,
David

BME Reunion Banquet

Please mark your calendars for the third annual BME alumni reunion banquet dinner on May 16, 2014 at the Intercontinental Boston Waterfront Hotel. Look for e-mails from **BME_Alumni@tufts.edu** and check for upcoming details on our alumni page.

Notables...

Bertan Hallacoglu received the 2013 Outstanding Graduate Researcher Award in the School of Engineering. Bertan's doctoral research has resulted in a U.S. Patent application and eight peer-reviewed scientific publications, five of which he is listed as a first author.

Joseph Brown won the 2013 Outstanding Graduate Student Contribution to Undergraduate Studies for his work in organizing and overseeing the Promoting Retention in Science and Engineering (PRISE) program.

Silk Pavilion

Watch a swarm of 6,500 silkworms create a geodesic dome. Professor Fiorenzo Omenetto teamed up with collaborators at the Mediated Matter Research Group at the MIT Media Lab and Harvard University's WYSS Institute to oversee the production the Silk Pavilion—a stunning geometric structure constructed by silkworms and guided by engineers. (See the back cover for a glimpse of the Silk Pavilion.)

Slice, Stack, and Roll *Continued from page 1*

Xu and Alberti sliced the sections into ultra-thin sheets using a microtome, and then stacked 10 slices, crisscrossing the sheets so that the fibers in one ran perpendicular to those above and below it. This process produced a scaffold material with tensile strength stronger than constructs made using common processing techniques, Xu notes.

The researchers also created tubular scaffolding by rolling layers of collagen sheets around Teflon-coated glass rods. The sheets were layered so that fibers ran along the length and the circumference of the rods. This process yielded tubes that were found to be stronger than similar tubes made of reconstituted collagen. They also maintained their highly aligned fiber structure.

"Alignment gives the scaffold the ability to guide the direction and orientation of cell growth," says Xu, who also has a faculty appointment at Tufts School of Medicine. "This capability is beneficial for tissue engineering applications where biocompatibility and the ability to guide unidirectional nerve growth are both desired, such as prosthetic or tissue engineering-based blood vessels or nerve conduits."

Read more about their research: Alberti, K. A. and Xu, Q. (2012), Slicing, Stacking and Rolling: Fabrication of Nanostructured Collagen Constructs from Tendon Sections. *Advanced Healthcare Materials*. doi: 10.1002/adhm.201200319.

For the full story on this technique, read David Stipp's article: http://now.tufts.edu/articles/slice-life

RESEARCH HIGHLIGHTS

Professor **Sergio Fantini** and his research team have developed a novel optical technique to study cerebral microcirculation with a number of potential diagnostic and functional neuroimaging applications.

Because this technique is based on the non-invasive measurement of hemodynamic oscillations that feature a significant coherence with respect to the driving physiological processes, it has been named Coherent Hemodynamics Spectroscopy, or CHS.

This novel technique is described, validated, and demonstrated in the clinical setting of the hemodialysis unit through a set of six scientific articles, all published in the first quarter of 2012: two in *NeuroImage*, and one each in *Physiological Measurement, Academic Radiology, Journal of Biomedical Optics*, and *Journal of Innovative Optical Health Sciences*. A U.S. patent application entitled "Coherent hemodynamics spectroscopy and model-based characterization of physiological systems" describes this technology and protects associated intellectual property.

Adjunct Assistant Professor **Bree Aldridge** has been awarded a two-year, $50,000 research fellowship from the Alfred P. Sloan Foundation for her research on understanding how the bacteria that cause tuberculosis are resistant to antibiotic treatment and how they evade the host immune response.

The World Health Organization reports about one-third of the world's population is infected with tuberculosis. Of that number, only a small number will become sick. In 2011, 8.7 million people became ill and 1.4 million died from tuberculosis. Despite efforts to simplify treatment strategies, tuberculosis still requires months of multi-drug therapy to cure.

Aldridge's research combines microbiology and engineering approaches to understand the virulence and survival strategies of the bacterium that cause tuberculosis. By working with a multidisciplinary team of researchers to combine molecular approaches with mathematical modeling, she hopes to shorten and simplify treatments for tuberculosis.

Aldridge is also an assistant professor in molecular biology and microbiology at Tufts University School of Medicine and a member of the Molecular Microbiology program faculty at the Sackler School of Graduate Biomedical Sciences at Tufts.

QUICK HITS

Assistant Professor Catherine K. Kuo co-chaired the Scientific Program for the International Symposium on Ligaments and Tendons in Arezzo, Italy in November 2013.

Professor Fiorenzo Omenetto was named a Fellow of the American Physical Society for outstanding contributions to the development of silk-based optical structure and photonic devices. He also delivered the Fred Kavli Distinguished Lecture on Nanoscience at the Materials Research Society meeting in Boston in December 2013.

Research professor Barbara Brodsky was named a Fellow of the American Association for the Advancement of Science. Brodsky has made pioneering contributions to the understanding of collagen structure, function and dysfunction.

Assistant Professor Qiaobing Xu was named a Pew Scholar in Biomedical Sciences by the Pew Charitable Trusts for his research on nanotechnology for biomedical uses.

BMES 2013

Once again the department was well represented at the most recent Biomedical Engineering Society (BMES) Annual Meeting, held September 25–28, 2013 in Seattle. Professors Black, Kaplan, Kuo and Panilaitis attended and a number of graduate students and postdocs presented their work in both poster and platform presentations. We're looking forward to another strong Tufts contingent in San Antonio next fall!

Posters:

Corin Williams (Advisor: Black): Fetal Cardiac Extracellular Matrix Promotes Adhesion and Expansion of Neonatal Cardiomyocytes

Sarah Knupp (Advisor: Xu): PKU Enzyme Replacement through MSC Based Therapy

Nick Bayhi (Advisor: Xu): Novel Bioreactor for 3D Series Perfusion Culture and Drug Testing Studies

Joshua Gershlak (Advisor: Black): Effect of Complex Substrate Composition on the Ability of Mesenchymal Stem Cells to Sense Stiffness

Amy Hopkins (Advisor: Kaplan): 3D Tissue-engineered Model of the Neurovascular Unit for Study of Neurological Disease and Drug Treatments

The Tufts contingent dines at Elliott's Oyster House in Seattle.

Platform Presentations:

Professor Kaplan: Implantable and Degradable Optical Electronic Medical Devices

Professor Kuo: Structure-Property Relationships of Tendon during Embryonic Development

Matthew Applegate (Advisor: Omenetto): Direct Laser Writing of Three Dimensional Microscale Features in Silk Fibroin Hydrogels

Joanna Xylas (Advisor: Georgakoudi): Detecting Metabolic Changes Associated with Oncoprotein Expression Using Endogenous Fluorescence

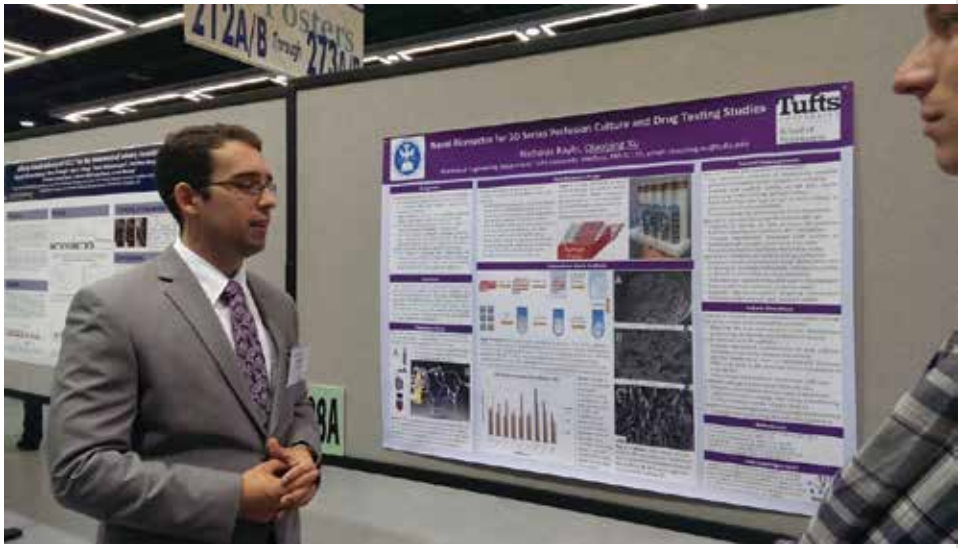
Jeney Zhang (Advisor: Kaplan): Stabilization of Vaccines in Silk

Amanda Baryshyan (Advisor: Kaplan): Metabolic Strategies for Long-Term Survival of *in vitro* Cultured *Manduca Sexta* Muscle

Waseem Raja (Advisor: Kaplan): Stabilization and Delivery of Vaccines with Silk Microneedles

Amanda Baryshyan (Advisor: Kaplan): Functional Three-Dimensional Insect Muscle Tissue for Bioactuation Applications

Kelly Burke (Advisor: Kaplan): 3D Adipose Tissue Model for Type 2 Diabetes Mellitus



Nick Bayhi presents his poster.

Kathy Morgan (Advisor: Black): Asynchronous Dual Electrical and Mechanical Stimulation Improves the Calcium Handling Dynamics in Engineered Cardiac Tissue

Stephanie McNamara (Advisor: Kaplan): Novel Silk-Based Fabrication Techniques to Prepare High Strength, Complex Geometry Calcium Phosphate Ceramic Scaffolds via Machining or Injection Molding

Alex Mitropoulos (Advisor: Kaplan): Characterization of Optically Transparent Silk Hydrogels for Biomedical Applications

Kyle Quinn (Advisor: Georgakoudi): Imaging Cell Metabolism in Diabetic Wounds Using Endogenous Sources of Contrast

Congratulations to our Graduates

Bachelor of Science in Biomedical Engineering

Nicholas L. Bayhi
Novel 3D Perfusion Bioreactor System for High-Throughput Drug Testing

Alan C. Chu
Developing a Depth-Sensitive Near-Infrared Diffuse Optical Imaging System for Optical Mammography

Thomas Vito Galassi
Design of an Apparatus Capable of Fabricating Nanofiber-Hydrogel Composite Scaffolds

Bentley Monique Hunt
Patterning of Polydimethylsiloxane and *Manduca sexta* Extracellular Matrix Proteins to Create Aligned Insect Muscle Constructs for Bioactuation

Jason Joseph Lau
Scaling up the Arbitrary Waveform Membrane Stretcher and Routinizing its Use

Jesse Alexander Mark
Designing an External Neural Interface for Prosthetic Limbs

Derek Lite Moody
RFID for Biomedical Sensing

Misaki Nozawa
Development of Silk Microneedle Patches for Drug Delivery of Hepatitis B Vaccine

Adam Michael Pardes
Development of a Dynamic 3D *in vitro* Model to Study the Wound Healing Response and Mechanoregulation of Embryonic Tendon

Elizabeth Dyer Rosenberg
Improving Spectral Information in Optical Mammography

Raymond Wang
Designing an Automatic Controller System for Custom-built Cell Stretcher Devices

Lawrence Xia
Characterization of Breast Tissue Extracellular Matrix Viscoelastic

Doctoral Recipients

Jeffrey P. Brown
Dissertation: Investigating Tendon and Ligament Development in Order to Inform a Tissue Engineering Strategy
Advisor: Dr. Catherine Kuo

Nicholas A. Guziewicz
Dissertation: Silk Lyogels for Sustained Local Delivery of Therapeutic Antibodies
Advisor: Dr. David Kaplan

Bertan Hallacoglu
Dissertation: Optical Characterization of Biological Tissues
Advisor: Dr. Sergio Fantini

Reynald M. Lescarbeau
Dissertation: *In vitro* and Quantitative Phosphoproteomic Modeling of Castration Resistant Prostate Cancer
Advisor: Dr. David Kaplan

Joseph Edward Marturano
Dissertation: Characterization of Embryonic Tendon Mechanical and Biochemical Properties to Inform Tendon Differentiation, Development and Scaffold Design
Advisor: Dr. Catherine Kuo

Joel A. Spencer
Dissertation: Characterization of Bone Marrow pO2 by Two-photon Phosphorescence Quenching Method
Advisor: Dr. Mark Cronin-Golomb

Joanna F. Xylas
Dissertation: Shedding Light on Cancer: The Utility of Nonlinear Microscopy for Assessing and Detecting Events Associated with Cancer Initiation
Advisor: Dr. Irene Georgakoudi

Master of Engineering

Isaac Anderson

Brian J. Minie

Jason D. Murray

Michael A. Weiand

Miaomiao Yang

Yajing Zhu

Master of Science

Andrew J. Barry
Direct Sequencing of Phage Display Products Present an Unbiased Tool for Analysis of Protein Interactions

Roni Cantor-Balan
Depth Assessment in 2D Planar-Scanning Diffuse Optical Imaging

Tyler Chang
Non-Invasvie Monitoring and Quantification of Lipid Content in 3D Engineered Adipose Tissues Using Two-Photon Excited Fluorescence and Third Harmonic Generation Microscopy

Ellen Justine Fanti
Coaxial Silk-Based Electrospun Mats for Controlled Growth Factor Delivery

Kelly Elizabeth Flanagan
Design and Characterization of a Silk Fibroin Sutureless Dural Repair System

Christa M. Margossian
Development and Analysis of Synthetic Composite Materials Emulating Patient AAA Wall Material Properties

Beibhinn Mary O'Donoghue
Utilizing RF Resonators to Monitor States of Hydration on the Skin's Surface in Real-Time

Mark S. Paquette
Silk Film Embossing System

Gabriel S. Perrone
Silk Bone Screws and Plates as a Novel Fracture Fixation Device

Zachary Adam Schiller
Adipogenesis of Adipose-Derived Mesenchymal Stem Cells May Be Regulated via the Cytoskeleton at Physiological Oxygen Levels *in vitro*

Shannon L. Smith
Bioreactor Design Optimization for Mechanical Stretch and Noninvasive Imaging

Aashna Taneja
Enhancement of Proliferation of Schwann Cells on Magnetic Silk Fibroin Scaffolds

Thomas McShea Valentin
Silk Fibroin Hydrogels and Films for Neurological Applications

Nan Zhao
Establishment of in vitro Three-Dimensional Human Brown Adipose Tissue Constructs

Chensheng Willa Zhou
Protein and Virus Encapsulation for Delivery

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")

ON AND OFF CAMPUS

Biomedical Engineering Society

This year, the BMES executive board has focused on providing opportunities for students in three main areas: career development, socialization, and community outreach.

We started the year off with a general interest meeting at which we made liquid nitrogen ice cream, something that was very popular with students last year. We also organized the annual department barbeque at which professors and students played soccer and socialized over delicious food. On Halloween, we hosted a costume contest for students and faculty. We also started a new tradition of "reverse trick-or-treating" in SciTech, where we traveled the halls and labs, giving out candy and spreading joy and the Halloween spirit. Our final social event of the semester was another brand new event: "De-Stress with BMES," a fun night to help students relax before final exams and get to know other BMES members.

As a pre-professional society, providing career development opportunities is extremely important. In September, we hosted a resume workshop to help students prepare for the fall Career Fair. Professor of the Practice Sam Liggero, who teaches at Tufts Gordon Institute, led the workshop and taught students methods for crafting a powerful engineering resume, tips on making a good elevator speech, and important skills for interviews. We also organized a well-attended company tour to MC10, a biomedical company in Cambridge, Mass. that specializes in innovative, high-performance electronics.

Cultivating interest in biomedicine and STEM education through community outreach is also an important aspect of our club. This fall, BMES participated in Tufts Community Day, where we shared our love of science with children and their families by teaching them how to make oobleck, a colorful and fun non-Newtonian fluid. Next semester, we plan to participate in Kid's Day, as well as visit local high schools and talk to students about the research we do at Tufts, and how they can get involved.

Plans for the spring semester include: organizing a bonding event (such as painting the cannon) for the newly accepted BME freshmen, touring Boston Scientific, inviting guest speakers, and hosting more social events to encourage students of all class years to get to know each other. If you are interested in learning more, or want to get involved in BMES, email **bmestufts@gmail.com** or visit our website, **sites.tufts.edu/BMES**.

—Sharada Sant President, BMES

BMES members Siran Wang (left) and Disha Sood (right) make silk-cocoon creations with families at Tufts Community Day.

Left: Students show off their costumes at the SciTech Halloween Costume Contest; Right: BMES social chairs Will Wong and Emily Eickhoff "reverse-trick-or-treat," by giving out candy, in SciTech on Halloween.

Industry Days

Assistant Professor **Qiaobing Xu** continued the career networking program "Industry Days" to help BME undergraduate students find internship opportunities and gain insights about life in industry. Thirteen companies, including Boston-based biotech and pharmaceutical firms, participated in three networking events, which included a question and answer session with industry professionals. Xu plans to organize tours to the local companies for students and to hold three to four Industry Days throughout the coming academic year. For a list of participating industries and representatives, please see **engineering.tufts.edu/bme/industrydays.htm.**

Research Scholars–TUBERS

This past summer was the second year of the Tufts University Biomedical Engineering Research Scholars Program (TUBERS), a summer program for local high school students who want to gain laboratory experience. Twelve rising juniors and seniors participated in the 10-week program assisting in the research of graduate students and postdocs, working on their own independent projects, and presenting their final work at a poster presentation session. Several students continued their work for use as their state science fair projects. Erica Budina, who carried out her work in Assistant Professor Black's lab, qualified for the Intel International Science and Engineering Fair, placing fourth in her division. She subsequently presented her work at the Tissue Engineering and Regenerative Medicine International Society–Americas Chapter meeting in Atlanta this past fall.

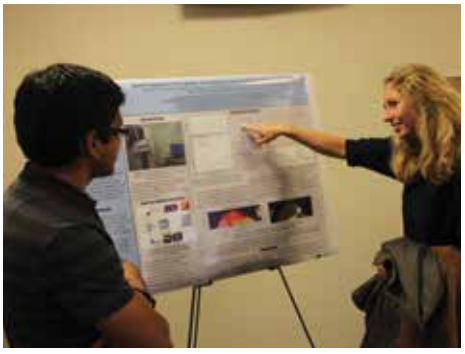
Read more about Erica's work at **go.tufts.edu/TUBERSErica**

Medford High School senior Erica Budina qualified for the Intel International Science and Engineering Fair and subsequently presented her work at a Tissue Engineering and Regenerative Medicine International Society meeting. (Alonso Nichols/Tufts University)

*We are seeking to expand the program beyond the Boston-area. If you have any suggestions for schools that might have interested students or know someone to contact at your local high school, please email **Lauren.Black@tufts.edu**.*

BME RETREAT

The 2013 BME retreat took place at the Wylie Conference Center on September 6, 2013 in Beverly, Mass. More than 100 students, postdoctoral fellows and graduate students attended. The event kicked off with a "two truths and a lie" event organized by graduate students Alex Mitropoulos and Pami Anderson. The day was filled with outdoor social activities and scientific podium and poster presentations. Poster judging was organized by Dr. Nathan Schiele (postdoc in Kuo Lab) who oversaw graduate student judges Zachary Glass, Saquib Ahmed Peerzade, Sarah Lightfoot Vidal, and Kristen Tgavalekos. Awards were given for best posters: Kelly Sullivan of Black Lab and Michael Polmear of Georgakoudi Lab won best Ph.D. and best M.S. poster, respectively.



Tufts UNIVERSITY | School of Engineering

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The Silk Pavilion explores the relationship between digital and biological fabrication on product and architectural scales. The primary structure, measuring 12 feet in diameter and displayed in MIT Media Lab, was created of 26 polygonal panels made of silk threads laid down by a Computer-Numerically Controlled machine. Inspired by the silkworm's ability to generate a 3D cocoon out of a single silk thread that measures 1km in length, Professor Fiorenzo Omenetto helped create an object of beauty and scientific application. (Photo credit: Steven Keating)