“If we could identify the changes that occur early on, before a cancer invades blood vessels and other areas of the body, in most cases we could cure the patient,” says Associate Professor Irene Georgakoudi. Photo: Kelvin Ma

Lasers could help doctors diagnose cancer earlier and more reliably, and in a less invasive way

Associate Professor Irene Georgakoudi is researching methods to diagnose cancer at a cellular level, well before it grows into a visible lesion or tumor. In a process she calls an “optical biopsy,” she eschews needles and knives, and turns to much more exotic tools—finely tuned lasers.

By employing a high-powered pulse of light, she says, her team can take a “snapshot” of the complex chemical reactions at work inside a cell, revealing abnormal activity before any tumor actually forms.

Molecules to Watch

Georgakoudi’s team is able to spot those changes thanks to a unique property shared by two enzymes called nicotinamide adenine dinucleotide (NADH) and flavin adenine dinucleotide (FAD). These molecules play a key role in every cell’s metabolism, the process through which it breaks down sugars to create the energy it needs to survive.

Hit the molecules with the right frequency of laser light, Georgakoudi says, and they’ll momentarily glow, or “fluoresce.” Researchers can measure how bright the glow is, how fast it decays and where it occurs in the cell, picking up clues about how active the enzymes are—and, by extension, how healthy the cell’s metabolism appears to be.

Georgakoudi notes that her team doesn’t yet have a clear sense of how NADH and FAD are linked to specific shifts in metabolism. At the moment, they’re using the molecules almost like a car’s “check engine” light—although they don’t point directly to the root problem, they provide a useful sign that something is amiss. Still,

Continued on page 3
Friends and Colleagues,

It has been another eventful year in the Department of Biomedical Engineering! We are excited to see that our undergraduate student population has significantly increased, as the main course concentration leading to the Bachelor of Science in Biomedical Engineering is now open to all students. Students have the option of taking lecture-based courses as concentration electives or, alternatively, a set of limited-enrollment research and design courses (BME 3-6). For more details, please visit: engineering.tufts.edu/bme/undergraduate/bsbme.htm

Expansion of our program has come in other forms as well, all reflective of the vibrant growth and impact of biomedical engineering at Tufts and beyond. Our faculty and students continue to publish in prominent journals and see growth in research support. Recognitions include: Associate Professor Irene Georgakoudi, elected Fellow of the Optical Society of America; Sarah Lightfoot-Vidal, awarded a National Defense Science and Engineering Graduate Fellowship; recent graduates Alana Lustenberger and Emily Gosselin, as well as current senior Yusi Gong won Tufts Awards in recognition of their scholarly achievements; and Olivia Hallisey, a high school student, won the 2015 Google Science Fair for her temperature-stable test for the Ebola virus that she worked on alongside post-doctoral scholar Benedetto Marelli in Professor Fiorenzo Omenetto’s lab.

We welcome Xiaocheng Jiang who joined our faculty as an Assistant Professor. His lab explores nano-/micro-technologies that can be integrated with living systems for interrogating and directing biological processes. Prior to Tufts, Xiaocheng was an American Cancer Society postdoctoral fellow at Harvard Medical School and Massachusetts General Hospital. This year, we also hired our first Professors of the Practice, Jean-Michel Molenaar and Janet Krevolin, who will develop new engineering design courses and coordinate the senior design projects.

As always, your thoughts are welcome. We value your continued involvement and rely on you as our compass, offering the best direction for our students and programs.

To a wonderful 2016 together,
David

Notables...

Sarah Lightfoot Vidal, a doctoral student in the NSF IGERT Soft Material Robotics program received a National Defense Science and Engineering Graduate (NDSEG) fellowship. Sarah’s prestigious fellowship is sponsored by the Air Force Office of Scientific Research for her research in material science.

Graduate students Kelly Sullivan and Joe Lyons both received 2016 School of Engineering awards for outstanding academic scholarship for their doctoral and master’s research, respectively. Doctoral student Pami Anderson received the 2016 School of Engineering Award for the Commitment to the Practice of Engineering for her work in completing a clinical study on breast cancer patients undergoing neoadjuvant chemotherapy at the Tufts Medical Center in collaboration with Drs. Roger Graham and Shital Makim.

In Assistant Professor Lauren Black’s lab, doctoral student Lauren Baugh won a Best Thematic Poster award from the American Society for Biochemistry and Molecular Biology at the Experimental Biology Conference in April 2015. Doctoral student Ayhan Atmanli received a competitive travel award to attend the International Society for Stem Cell Research Annual Meeting in 2015.

Tufts Summer Scholar Elim Na worked with Professor David Kaplan on her project on the “Evaluation of Silk Fibroin Stabilization of Doxorubicin and Vincristine.”

With a donation from Lloyd Klickstein, the department supported Peter Clark, E18, who worked with graduate student Sarah Knupp Altingolu in the Xu lab, developing lipid-based nanoparticles for intracellular delivery of proteins for targeted cancer therapy.

Alana Lustenberger, E15, Emily Gosselin, E15, and Yusi Gong, E16, won Tufts awards in recognition of their scholarly achievements.

BME Reunion Banquet

Please mark your calendars for the fifth annual BME alumni reunion banquet dinner on May 20, 2016 at the Intercontinental Hotel in Boston. Look for e-mails from BME_Alumni@tufts.edu and check for upcoming details on our alumni page.
that might be enough to identify cancerous tissue, she says. The challenge is to get this information without harming the cell itself. Georgakoudi uses lasers that emit light in extremely short, repeated pulses, each one lasting less than a trillionth of a second. “By delivering high-powered pulses that quickly, we keep the average amount of energy that reaches the cells relatively low,” she says. “We’re still delivering enough photons to cause a fluorescent response, but we’re not cooking the tissue in the process.”

Penetration is also an issue, she adds. A focused laser beam reaches less than a millimeter into human tissue, so Georgakoudi is limited to examining cells only on the surface of the skin or organs. Yet this isn’t necessarily a disadvantage, she says. More than 80 percent of cancers initially form in the epithelium, a thin network of cells that form the lining of our skin, mouth, cervix, intestines, stomach and ducts in found in the breast, lung and prostate.

Most of those tissues are accessible to doctors using minimally invasive techniques—the skin, throat and gums are all easily examined, for instance, and even breast ducts and internal organs like the colon and bladder can be reached using special scopes that don’t require doctors to cut into the body. In theory, this would allow “optical biopsies” in areas where most common cancers form.

Read more about the future direction of Georgakoudi’s research at: now.tufts.edu/articles/biopsies-without-knives

Inkjet Inks Made of Bioactive Silk Could Yield Smart Bandages, Bacteria-Sensing Surgical Gloves & More

Inkjet printing is one of the most immediate and accessible forms of printing technology currently available, according to the researchers, and ink-jet printing of biomolecules has been previously proposed by scientists. However, the heat-sensitive nature of these unstable compounds means printed materials rapidly lose functionality, limiting their use.

Enter purified silk protein, or fibroin, which offers intrinsic strength and protective properties that make it well-suited for a range of biomedical and optoelectronic applications. This natural polymer is an ideal “cocon” that can stabilize compounds such as enzymes, antibodies and growth factors while lending itself to many different mechanically robust formats, said Fiorenzo Omenetto.

Read more at: go.tufts.edu/smartbandages

This research was supported by the Cariplo Foundation (2010-0807), National Institute of Biomedical Imaging and Bioengineering of the National Institutes of Health under award number EB016041-01, Italian Ministry of Health (grant RF-2009-1550218 and RF-2010-2316198) and Italian Ministry of Universities and Research, FIRB (RBFR1299KO).

Efficient Genome Editing Protein Delivery Using Novel Lipid-based Nanoparticles

Efficient genome editing and protein delivery are major goals in medicine and biology. However, current methods have limitations. Dr. Qi Wu and colleagues at Boston Children’s Hospital and Harvard University used RNA-guided protein delivery system to promote in vivo gene editing and protein delivery.

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Associate Professor Irene Georgakoudi was named a Fellow of the Optical Society of America for “contributions to the use of endogenous markers for optical imaging of metabolic processes in normal and diseased tissue and for tissue engineering.”

Professor Sergio Fantini was elected to the AIBME’s College of Fellows for “outstanding contributions to the development of quantitative techniques for diffuse optical spectroscopy and imaging of biological tissue.”

Assistant Professor Lauren Black was awarded a competitive Visiting Professorship to the University of Pavia’s Department of Drug Sciences as part of the Boston-Pavia Exchange Program.

Professor David Kaplan was named a Tufts Distinguished Professor, an appointment reserved for senior faculty members who have made exceptional contributions to their disciplines, their students, and the university as teachers and scholars.

In October, Frank C. Doble Professor Fiorenzo Omenetto gave a lecture at the annual science festival, BergamoScienza. Omenetto and Kaplan were both featured on NPR’s Science Friday. Learn more here: sciencefriday.com/spotlights/silk/

Xiaocheng Jiang joined the department in fall 2015 as an assistant professor. Prior to joining Tufts, Jiang was an American Cancer Society postdoctoral fellow at Harvard Medical School and Massachusetts General Hospital where he worked with Professor Mehmet Toner on microfluidic isolation and characterization of circulating tumor cells for early cancer diagnostics. In 2011, he received his Ph.D. in Physical Chemistry from Harvard University under Professor Charles Lieber with focus on the design and development of nanoscale materials and electronic devices for biomolecular detection, electrophysiological recording, and bioenergy conversion. His research lies at the interface of materials science and biomedical application, with specific interests in nanobiotechnology, bioelectronics, and microfluidics.

Students Build Biomedical Instruments

Tufts biomedical engineers, led by Professor Fiorenzo Omenetto, are using low-energy, ultrafast laser technology to make high-resolution, 3-D structures in silk protein hydrogels. The laser-based micropatterning represents a new approach to customized engineering of tissue and biomedical implants. The work is reported in a paper in PNAS Early Edition published September 15, 2015.

Artificial tissue growth requires pores, or voids, to bring oxygen and nutrients to rapidly proliferating cells in the tissue scaffold. Current patterning techniques allow for the production of random, micron-scale pores and the creation of channels that are hundreds of microns in diameter, but there is little in between.

Tufts researchers used an ultrafast, femtosecond laser to generate scalable, high-resolution 3-D voids within silk protein hydrogel, a soft, transparent biomaterial that supports cell growth and allows cells to penetrate deep within it. The researchers were able to create voids at multiple scales as small as 10 microns and as large at 400 microns over a large volume.

Further, the exceptional clarity of the transparent silk gels enabled the laser’s photons to be absorbed nearly 1 cm below the surface of the gel—more than 10 times deeper than with other materials, without damaging adjacent material.

The study received funding from the Office of Naval Research. See more at: go.tufts.edu/hydrogels

Congratulations to our Graduates

Bachelor of Science in Biomedical Engineering

Sydney Char
Scott M. DeIsle
Jesse A. Eaton
Emily R. Eickhoff
Robert W. Gifford
Emily Gosselin

Alumni

Dr. Jana Kainerstorfer, a postdoc in Professor Fio Omenetto’s lab (2012–2013) and Professor Sergio Fantini’s lab (2012–2015), is now an Assistant Professor of Biomedical Engineering at Carnegie Mellon University.

Dr. Arvind Saibaba, a postdoc in Professor Sergio Fantini’s lab and Professor Eric Miller’s lab in Tufts Department of Electrical and Computer Engineering (2013–2015), is now Assistant Professor of Mathematics at North Carolina State University.

BMES 2015

Once again the department was well represented at this year’s Biomedical Engineering Society (BMES) Annual Meeting, held October 7–10 in Tampa, Florida. Professors Black and Kaplan 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 Minneapolis next fall!

Doctoral Recipients

Dominick Blasioli IV
The Development of a Progressive In Vitro Cell Based Model Of Osteoarthritis
Advisor: David Kaplan

Alexander Mitropoulos
Silk Fibrin Nanostructured Materials for Biomedical Applications
Advisor: Fiorenzo Omenetto

Rodrigo R. Jose
Design of 3-D Bioinks, Printing Hardware and Printable Devices
Advisor: David Kaplan

Master of Engineering

Christopher Proulx
Michael A. Weinstein

Master of Science

Carlos Arellano
Jen-yu Lan
Steven C. Bench
Varuna Rao
Bryan Choi
Anthony M. Rinaldi
Nicole Danek
Daniel L. Smoot
Nikolaos
Joshua D. Spitzberg
Dimitrakakis
Zachary Tochka
Kaori Graybeal
Friedrich von Flotow
Dylan S. Haas
Qianrui Wang

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.


4. The department is considering starting an Alumni Association to continue to bring alumni together and also as a resource for future alumni. If you’re interested in being involved in the formation of the association, please contact Assistant Professor Lauren.Black@tufts.edu.

Posters

Kelly Sullivan (PI: Black): Isotropic Silk Patches for Myocardial Repair Following Infarction

Yuki Ito (undergrad) (PIs: Kaplan and Omenetto): Efficacy of Electrical Stimulation on Accelerating Wound Repair with Full Thickness In Vitro Skin Models

Ashwin Sundarakrishnan (PI: Kaplan): Self-Reporting Phenol Red-Silk Protein Dityrosine Crosslinked Cytocompatible Hydrogels

Disha Sood (PI: Kaplan): Bioengineering Brain Matrix Composition to Establish In Vitro 3D Physiological Brain Cultures

Lauren Baugh (PI: Black): Two-Photon Excited Fluorescence Imaging of Heart Valves Non-Invasively Identifies Calcific Nodules

Presentations

Assistant Professor Lauren Black – 2015 CBME Journal Young Innovator Award Presentation: Depolarization of Resting Membrane Potential Stimulates Neonatal Cardiomyocyte Proliferation In Vitro

Rosalyn Abbott (PI: Kaplan): Human Mature White Adipose Tissue Model for Studying Lipolytic Responses

Kyle Quinn (PI: Georgakoudi): Multiphoton Microscopy Reveals Altered Cell Metabolism During Skin Wound Healing

Maria Rodriguez (PI: Kaplan): Characterization of Gel-Spun Silk Vascular Grafts
Biomedical Engineering Society (BMES)

The Tufts chapter of the Biomedical Engineering Society has three main goals: hold social events, provide opportunities for career development, and serve our community through volunteer activities. With an increasingly large department, we have decided to focus on social events to ensure we maintain a close-knit community. We’ve started initiatives such as an anonymous questions forum for BMES to ask questions to our executive board, and we’ve also launched a mentorship program to connect underclassmen to upperclassmen. Lastly, we’ve started to hold general meetings for BMES members twice a semester to ensure that everyone is heard.

Last semester kicked off with a General Interest Meeting that featured “Periodic Table Cookies” followed soon after by Community Day, where we volunteered our time helping children make rubber band guitars. Our biggest event to date was our department barbecue, where professors, graduate students, and undergrads played soccer and shared some delicious grilled foods. We also helped organize the annual BMES department dinner at Nijiya, where students and professors socialized over all-you-can-eat sushi.

The executive board bonded when we went to the Tufts Mountain Club Loj in New Hampshire to go hiking. For career development, we were lucky enough to have alumnus Nick Bayhi take us on a tour of Immunogen. BMES also organized a resume workshop with Tufts Gordon Institute’s Professor of the Practice Sam Liggero to help prepare for the career fair. In addition, we held our first internship panel, where general members were able to hear about the internship experiences of BMES upperclassmen. We plan to hold a tour of the BME labs soon in order to inform the underclassmen of all the opportunities that are available to us. For the upcoming semester, we plan to explore other BME-related companies in the area. We also plan to interact with the community on Kids Day, organize another department dinner, and hold another barbecue event. We will continue to focus on our three main goals in order to ensure that future BMES will have the same great opportunities as the past classes. If you are interested in getting involved, please email bme-stufts@gmail.com or visit facebook.com/tuftsBMES/

—Yuki Ito, President, BMES

Clockwise from top: Ava Saneyei, Zack Lowenstein, and a Tufts police officer enjoy the BMES BBQ; BMES executive board hike around the TMC Loj; department dinner at Nijiya; Megan Tse (left) and Arin Naidu (right) make rubber band guitars with Tufts Community Day visitors; periodic table cookies at GIM.

BME Retreat

The 2015 BME retreat took place at the Longfellow Wayside Inn on September 18, 2015 in Sudbury, Mass. More than 85 students, postdoctoral fellows, and graduate students attended. The day was filled with outdoor social activities and scientific podium and poster presentations, including this poster by Nishanth Krishnamurthy (right, Fantini lab), discussing his research with Xiaocheng Jiang (left).

Industry Days

Assistant Professor Qiaobing Xu continued the career-networking program “Industry Days” to help BMES undergraduate students find internship opportunities and gain insights about life in industry. Companies including ImmunoGen Inc., Bard Inc., Teleflex Inc., Triton Systems, Inc., Monsanto Inc., and EMD Millipore participated in the events, which included a question and answer session with the industry professionals. Please email Qiaobing.Xu@tufts.edu if you would be interested in participating in future Industry Days events!
This past summer was the fourth year of the Tufts University Biomedical Engineering Research Scholars Program (TUBERS). In this program, we invite applications from high school students who want to gain laboratory experience over the summer. Selected students—who were all either rising juniors or seniors at high schools in Medford, Somerville, Arlington, Quincy or Concord—were invited to Tufts for eight weeks this past summer to gain hands-on laboratory experience. Students were assigned to work with a grad student or postdoc in one of the faculty members’ labs, and were encouraged to work on their own independent projects. In addition to gaining lab experience, students in the program attended biweekly presentations by faculty members on their lab’s research. The summer culminated in a poster presentation session where TUBERS students were able to present their summer work to members of the department as well as family, friends, and their high school science teachers. Several students continued their work as part of their state science fair projects, and two students were able to qualify for the Intel International Science and Engineering Fair. If you have suggestions for schools that might have interested students or know someone to contact at your local high school, please email Lauren.Black@tufts.edu.

**IN PRESS**

Quantitative Biomedical Optics: Theory, Methods, and Applications

**Authors:** Irving Bigio (Boston University), Sergio Fantini

**Date of Publication:** January 31, 2016

**Publisher:** Cambridge University Press

**ISBN:** 978-0521876568

This text covers a broad range of areas in biomedical optics, from light interactions at the single-photon and single-biomolecule levels, to the diffusion regime of light propagation in tissue. Subjects covered include spectroscopic techniques (fluorescence, Raman, infrared, near-infrared, and elastic scattering), imaging techniques (diffuse optical tomography, photoacoustic imaging, several forms of modern microscopy, and optical coherence tomography), and laser-tissue interactions, including optical tweezers. Topics are developed from the fundamental principles of physical science, with intuitive explanations, while rigorous mathematical formalisms of theoretical treatments are also provided. For each technique, descriptions of relevant instrumentation and examples of biomedical applications are outlined, and each chapter benefits from references and suggested resources for further reading, and exercise problems with answers to selected problems.

“Bigio and Fantini’s comprehensive text on biomedical optics provides a wonderful blend of accessible theory and practical guidance relevant to the design and application of biomedical optical systems. It should be required reading for all graduate students working in this area.”

—Rebecca Richards-Kortum

Rice University, Houston

**SILKLAB GOES TO FAB11**

In August, Doble Professor Fio Omenetto’s SilkLab team participated in the International Fab Lab Network gathering at MIT, birthplace of the Fab Lab concept. The SilkLab presented a moveable demonstration of silk fiber spinning and 3D silk printing, along with other demonstrations of silk products.
Silk Inspires Google Science Fair Winner

Olivia Hallisey, winner of the 2015 Google Science Fair, was inspired by Doble Professor Fio Omenetto’s TED talk on the uses of silk. Olivia worked with Omenetto and postdoc Benedetto Marelli to develop a thin-film silk that could stabilize the chemicals used to detect Ebola without the need for refrigeration.