

Silk art contest entries, clockwise, top left: Beta Sheet Sculpture (Dan Hines); Nerve Cell Patterns (Marie Tupaj); Fatal Attraction (Tim Lo); Dollar Bill Spider Origami (Sree Krishnaji Tarakkad)



letter from the chair

new faculty join BME, students thrive post-graduation, initiation of external advisory board

It is always a pleasure to communicate with you, our Tufts BME family and friends, as the Department continues to prosper and to grow roots throughout the University, the community and around the world.

We have been fortunate again this year to add an outstanding new faculty member, **Prof. Qiaobing Xu**, who comes to us with terrific credentials from his graduate and post doctoral studies at MIT and Harvard. He brings scholarship in the areas of microfluidics, device

design, and biomaterials. Most importantly, Qiaobing brings a strong collaborative spirit. He is already off to a wonderful start with his research and teaching.

We are also pleased to welcome a new full-time Research Faculty member to the Department, **Prof. Barbara Brodsky**. Barbara is one of the foremost authorities on collagen self-assembly. After a distinguished career at Robert Wood Johnson Medical School, she has transitioned to Boston to work with the Department on various collagen-related research projects. This brings our BME faculty to 8 full-time tenure/tenure track and 5 research faculty.

Our students, from undergraduate and graduate to post-doctoral, continue to

prosper with their next steps into medicine, graduate school, industry and academia. In a tight economy this is very encouraging and bodes well for the quality of the students we attract to our program and the impact of the program on their futures.

Research in the Department continues to thrive. (con't on page 2: Chair)

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international silk art contest winners

2010

The Kaplan group's annual Silk Art Contest was an international effort this past summer with colleagues in **Thomas Scheibel's** lab (University of Bayreuth, Germany). Each group submitted 3 works to an impartial judge, **Dek Woofson** (University of Bristol, UK). *See select entries from the contest above.*

The winners:

1st Place - **Dan Hines** for Silk Beta Sheet Sculpture (Tufts)

2nd Place - **Felix Bauer** for Caddisfly Necklace

3rd Place - **Marie Tupaj** for Nerve-cell Patterns Grown on Silk Substrates (Tufts)

awards & fellowships:

1. Leah Bellas, PhD candidate
ISR Fellowship Travel Award

2. Jeff Brown, PhD candidate
Awarded the Savio L-Y Woo Young
Researcher Award at the 11th
International Symposium on
Ligaments and Tendons, Jan. 2011

3. Profs. Lauren Black, Catherine
Kuo & Qiaobing Xu
Tufts Faculty Research Award
(FRAC) recipients

4. Profs. David Kaplan and Fio
Omenetto
MIT's *Technology Review* selected
their research on a silk-based brain
implant as one of the top 10
emerging technologies

BME seeks ABET accreditation

The Bachelor of Science in Biomedical Engineering (BSBME) program was launched in 2005, with the first class graduating in 2009. We are now working toward requesting ABET accreditation, a long process that will lead to an accreditation decision in the Summer of 2012. We would be the eighth ABET-accredited program in the Tufts School of Engineering, adding on to the current ones in Chemical Engineering, Civil Engineering, Environmental Engineering, Computer Science, Electrical Engineering, Computer Engineering, and Mechanical Engineering.

BME retreat, cape codder resort

The 2010 BME retreat took place in Hyannis, MA, September 24-25. More than 80 students, postdoctoral associates and graduate students attended. Fun activities at the conference site were held during the day. A banquet dinner was then held to kick-off the science symposium of posters and talks given by students, postdocs, and professors:

From **Prof. Black's** lab, **Kathy Ye** spoke about the development of a mechanical distention bioreactor and preliminary results on the effects of cyclic distention on engineered myocardial tissue. **Josh Resnikoff** presented on perfusion decellularized ECM as a tool for aiding in the differentiation of stem cells to cardiac muscle cells.

Doug MacDonald, a student in **Prof. Georgakoudi's** group, presented a new way to analyze endogenous fluorescence images acquired from epithelial cells to characterize changes in mitochondrial subcellular organization. The work could ultimately lead to improved ways of detecting pre-cancerous changes.

Michele Pierro from **Prof. Fantini's** group presented his work, done in collaboration with **Feng Zheng**, on phase-sensitive detection of oscillatory concentrations of oxy-hemoglobin and deoxy-hemoglobin in cerebral tissue and its potential role in the study of networks of functional connectivity in the brain.

Zachary Schiller, from **Prof. Kuo's** group, gave a talk on controlling adipogenic differentiation as a function of cytoskeletal structure and oxygen tension.

Prof. Cronin-Golomb gave a talk on optical tweezers and azo-silk.



BME retreat: the group spent the weekend at the cape codder resort, introducing new students to our exciting research.

Chair, continued from page 1

Collaborative initiatives have grown among faculty. We also continue to expand our international relationships, with efforts in: Australia (biomaterials), France (medical imaging), Italy (medical electronics and neurological interfaces), India (tissue engineering and biomaterials), and China (biomaterials). Continuing ties in Switzerland have allowed a number of students to spend time in labs there to gain a broader perspective of research environments. Similarly, efforts in Africa have led to a new biomaterials course with participation by our faculty and others.

This past fall, we constituted our first External Advisory Board (EAB) to help guide our planning. The Board consists of a group of distinguished experts in biomedical engineering, from many areas of academics, industry and private practice. The board held its first formal meeting in September and the input was very helpful in addressing questions of undergraduate admissions and ABET accreditation needs. This year we are also preparing for our first ABET review for program accreditation.

As always, we welcome your news, involvement and inputs. Please find a way to get involved and let us hear from you.

- Prof. David L. Kaplan

undergraduate research day

On April 30th, 2010, the Department held its first Research Day symposium featuring the work of students from the BSBME classes of 2010, 2011, and 2012.

The symposium was held in the lobby of the Science and Technology Center, and was kicked off in the morning by the senior thesis presentations of the class of 2010. Lunch and a research poster session followed the presentations in the lobby of SciTech, with participation from faculty across the Schools of Engineering and Arts and Sciences.

SAVE THE DATE - This year's event will take place on May 5, 2011 – for more information please contact milva.ricci@tufts.edu

Class of 2010 Senior Thesis Presentations:

Alexis Burbank: Effects of paracrine signaling on myotendinous junction formation in direct co-culture of embryonic muscle and tendon cells

Cherisse Mecham: Endothelial cell perfusion in a cancer model

Jonathan Jo: Hormonal control of *Manduca sexta* cell culture for bioactuator applications

Lisa Yanushefski: Directed neuron growth through physical and chemical clues

Christina Thomas: Immunofluorescent profiling of differentiated and undifferentiated bone marrow mesenchymal stem cells

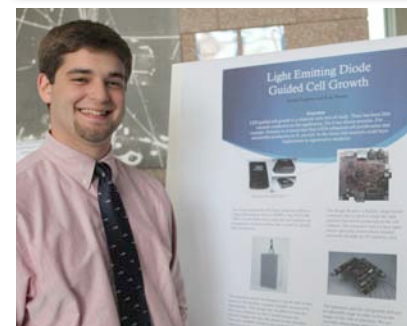
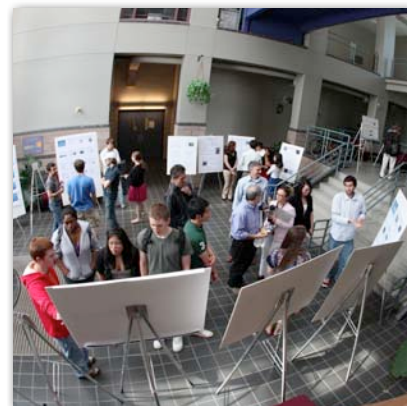
Russell Wang: Chlorophyll and silk-based oxygen producing biomaterials for tissue engineering

Rachel Engelberg: Silk encapsulated films for sustained release of buprenorphine

Alex Mitropolous: Examining the scattering elements of natural and man-made photonic crystals using the colorimetric response of *Morpho menelaus* wings and "smart slides" in the presence of fluids

Mike Brown: Silk-based immunosensors for the detection of hospital-acquired infections: A proof of concept

Matthew Ryder: Dual-source dual-detector probe geometry for improved depth discrimination in NIRS-based functional brain imaging



top: undergraduate research day poster presentations; middle: Kyle Boutin, Class of 2011, presenting his semester project on illuminating cells with a microprojector; bottom: Prof. Kaplan talking with (clockwise) BME students Rebecca Wang, Katherine Tang, Sean Seibert, Erin Coonahan, Kelly Flanagan.

2011 NSBE Convention

The Tufts Chapter of the National Society of Black Engineers (NSBE) gathered in St. Louis, MO on Wednesday March 23rd for the 2011 National NSBE Convention. BSBME major **Bentley Hunt** attended the conference. The theme of the convention was "engineer the gateway to success", and a multitude of workshops geared to topics such as career planning, networking, and engineering in the world today were featured. The convention featured a two-day career fair with over 200 companies present from all backgrounds of engineering and opportunities to further connect with the representatives from these companies in a dinner setting. There were also research presentations from students ranging from middle school to graduate school. Overall, the students who attended felt that the convention was a great experience; they were able to connect with each other as well as make new connections with students across the nation and discover the opportunities that engineering has to offer.

student papers at scientific meetings

BiOS Symposium (SPIE Photonics West) (San Francisco, CA, January 22-27, 2011)

Yang Yu: "Near-infrared optical mammography with broadband spectral imaging and depth discrimination"

Feng Zheng: "Phasor representation of oxy- and deoxy-hemoglobin concentrations at rest and during brain activation"

Bertan Hallacoglu: "Diet-induced alteration in brain microvasculature: A non-invasive, near-infrared spectroscopy study in rats"

post doc updates:

1. Aneta Mieszawska
Post Doctoral Fellow, Mt Sinai (NYC)

2. Monica Serban
Staff Scientist, Tengion, Inc

3. Bernke Papeburg
Project Leader, University of Twente (Netherlands)

4. Sang-hyug Park
Post Doctoral Fellow, Wake Forest

5. Eun Seok Gil
Staff Scientist, Spectrasilk, Inc

6. Corinne Wittmer
INSERM Universite Paris Descartes

7. Heather Currie
Angel Biotechnology (UK)

8. Xiuli Wang
Faculty, Dalian Institute (China)

BME welcomes new faculty

Professor Qiaobing Xu joins the Department as an Assistant Professor; his research interests lie at the intersection of materials science engineering, specifically nanoscience, and biomedical applications.

Specifically, the lab is interested in developing new biomaterials for the intracellular delivery of proteins for therapeutics. In one project, the mechanism of lipidoid nanoparticle-mediated protein delivery using various techniques is investigated. The goal is to understand the supermolecular assembly of synthetic vectors and proteins in order to quantify a correlation between the chemical structures of the delivery vectors and their efficiency in protein delivery. This knowledge will be used for the design of novel protein delivery systems (see Figure 1).

A second focus of the lab is to utilize natural materials as substrates for nanoskiving, a technique developed to fabricate nanostructures using microtome sectioning. The aim is to use nanoskiving to generate thin-sections of natural materials to be used as templates for the fabrication of metallic nanomaterials, or substrates for tissue engineering (Figure 2).

Figure 1 shows the successful lipidoid-mediated protein delivery to HeLa cells stained with X-gal: (A) β -galactosidase delivered by lipidoids nanoparticles (B) β -galactosidase only.

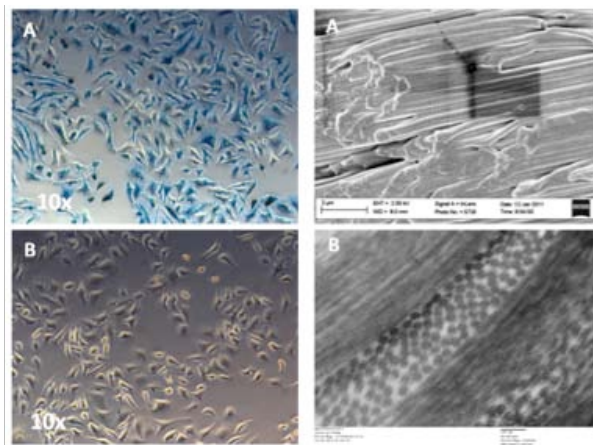


Figure 2 (A) SEM image of thin-sections of tendon and (B) TEM image of nanostructures formed from thin-sections of cornea by positive staining using uranyl acetate.

Professor Barbara Brodsky came to the BME Department in September 2010 as a Research Professor, after many years as Professor and Deputy Chair of the Biochemistry Department at Robert Wood Johnson Medical School in Piscataway, NJ. Her research interests have focused on structural aspects of collagen. Earlier work included fiber x-ray diffraction and electron microscopy studies on collagen fibrils in tissues. Over the past 20 years, collagen peptides have been designed and characterized to better understand the molecular features and stabilization of this triple-helix protein and the alterations that result in collagen diseases.

Recently, the group has expressed and characterized a *Streptococcus pyogenes* collagen-like protein, showing that it has the same thermal stability as human collagens despite its lack of the post-translationally modified hydroxyproline. These recombinant proteins have proved to be a good model for incorporating specific collagen binding and degradation sites, and for studying the effect of mutations on collagen stability and folding. The research has been continuously funded by the National Institutes of Health. Barbara is looking forward to developing biomaterial applications of this recombinant bacterial collagen and collaborating with others in the department.



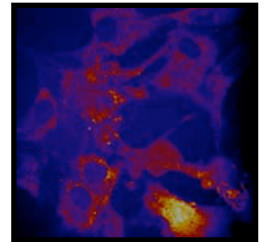
new approaches in non-linear optics

Professor Irene Georgakoudi is spending her sabbatical year at the Ecole Polytechnique, outside Paris, France. She is working as a visiting professor in the Laboratory for Optics and Biosciences with the group of **Emmanuel Beaurepaire**. She is gaining expertise in novel advanced non-linear microscopies, such as third harmonic generation, and the use of pulse shaping techniques to enable faster multi-wavelength image acquisition.

These new approaches bear great promise in terms of enhancing the non-invasive tissue characterization methods already pursued by her group. Irene also hopes that this initial work will serve as a springboard for continued collaborations between her group and the group in France.

Besides spending long hours in the lab, Irene has been enjoying the wonderful french cheese, bread, wine and pastries and the exquisite cultural life in Paris.

Left: The endogenous two-photon excited fluorescence of mesenchymal stem cells undergoing osteogenic differentiation acquired at the LOB with student Guillaume Labroille.



professor Omenetto speaks at TED

Professor Fio Omenetto presented his research on new applications for silk technology at the TED2011 conference in Long Beach, CA. The theme of the conference was "The Rediscovery of Wonder," and Fio demonstrated some of his work with silk photonics, including a diffractive optical element made of pure silk that, with a laser pointer, projected "TED" on to the wall behind him.

TED - Technology, Entertainment, and Design - holds this conference annually, bringing together an elite group of speakers to share insights and knowledge on a world stage.

grad student graduates (ms / phd):

1. Katherine Blanton (MS)

advisor: Kaplan; thesis: Lentiviral delivery of osteoinductive factors for accelerated bone regeneration

2. Debbie Chen (PhD)

advisor: Fantini; dissertation: Simulating heart valve mechanical behavior for planning surgical repair

3. Xiao Da (MS)

advisor: Fantini; thesis: Dual-source dual-detector optical probe for improved depth discrimination in functional near-infrared spectroscopy

4. Cherry Greiner (PhD)

advisor: Georgakoudi; thesis: Light scattering flow cytometry for the minimally invasive quantification of circulating leukemic cells

5. Peter Hammer (PhD)

advisor: Howe; thesis: Simulating heart valve mechanical behavior for planning surgical repair.

6. Eleanor Pritchard (PhD)

advisor: Kaplan; thesis: Silk biomaterials for controlled drug delivery

7. Feng Zheng (MS)

advisor: Fantini; thesis: Phase analysis of low frequency hemodynamic oscillations in near-infrared

alumni updates

Sevin Turcan (PhD, 2010): is now a post-doctoral fellow at Memorial Sloan-Kettering Cancer Center in New York.

Nrupen Baxi (MS, 2004): graduated from the University of Medicine and Dentistry of New Jersey - NJ Medical School with an MD in 2008, and is now a resident physician in Neurological Surgery at Albert Einstein-Montefiore Medical Center, Bronx, NY.

Leonardo Angelone (PhD, 2008): Leonardo Angelo is now working as a Staff Scientist at the US FDA in Silver Spring, MD.

BMES meeting (austin, tx; oct. 2010)

BME was well-represented at the Annual BMES meeting. **Professors Kaplan, Kuo & Black** attended, accompanied by group members, presenting a total of 4 talks and 12 posters. **Adjunct Professor Gordana Vunjak-Novakovic** (Columbia University) delivered the plenary talk "Stem Cells, Tissue Engineering, & Regenerative Medicine: Challenges Ahead."

Posters:

Amanda Baryshyan, (advisor: Kaplan)
Isolation and culture of myotubes from insect cells for bioactuation applications

Evangelia Bellas, (advisor: Kaplan)
Effect of dynamic culture on 3D co-culture of adipose derived stem cells and endothelial cells on silk scaffolds for sustained soft tissue regeneration

Roberto Elia, (advisor: Peattie)
Mimicking extracellular matrix via controlled thickness deposition of electrospun mats

Rebecca Hayden, (advisor: Kaplan)
Tissue engineering a 3D model of osteoporosis with PTH and GIP

Xiao Hu, (advisor: Kaplan)
Silk-human tropoelastin blend biomaterials

Biman Mandal, (advisor: Kaplan)
Hierarchical silk laminates for tissue formation

Alex Nectow, (advisor: Kaplan)
Controlled release of neurotropic function

Zak Schiller, (advisor: Kuo)
Hypoxia-mediated adipogenesis of mesenchymal stem cells may be regulated via the cytoskeleton

Amelia Thomas, (advisor: Kuo)
Immature and mature muscle cells secrete soluble factors to differentially regulate embryonic tendon cell tenogenesis in vitro

Lee Tien, (advisor: Kaplan)
Patterned silk film scaffolds for lamellar bone tissue engineering

Lindsay Wray, (advisor: Kaplan)
Development of a slowly degradable microfabricated perfusion system for vascularized tissues

Yang Yu, (advisor: Fantini)
Depth discrimination and quantitative oximetry in spectrally resolved optical mammography.

Presentations:

Dean Glettig, (advisor: Kaplan)
Hematopoietic stem cell culture on an adipogenic feeder layer

Joe Marturano, (advisor: Kuo)
Analysis of spatiotemporal changes in elasticity of developing tendon using AFM

Bruce Panilaitis, Research Assist. Prof.
Engineered bacterial cellulose as a scaffold of chondrogenesis

Amelia Thomas, (advisor: Kuo)
Co-regulation of tendon and muscle progenitor cells via paracrine signaling in a 3D culture system

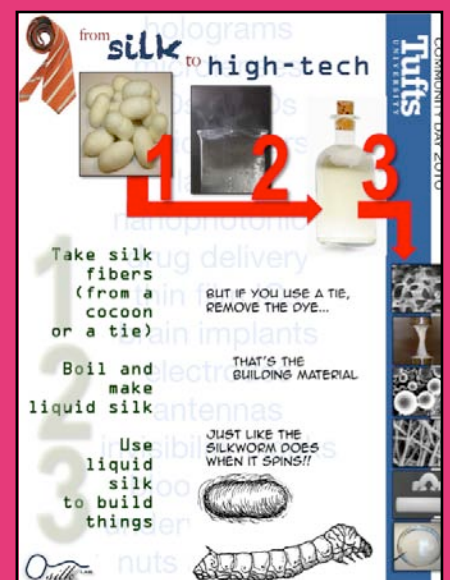


Leah Bellas, Rebecca Hayden, and Zak Schiller attend the BME / TERC booths.

tufts community day

Residents, neighbors, and friends of Tufts were on hand for the 8th annual Community Day on September 26. The event takes place on Tufts' academic quad in the Medford / Somerville campus with co-sponsorship by both cities.

The day features education, art, and entertainment activities. Thirty-eight organizations were represented, along with 30 Tufts departments. The BME department had a booth with silk games, featuring cocoon unwinding contests, cocoon coloring and Mr. Cocoon heads. Among the many who tried their hand at cocoon transformation were parents of BME students, colleagues, university professors, state senators and curious bystanders.



departmental research highlights: new projects

NIH - Biomaterial applications of recombinant bacterial collagens

Barbara Brodsky, David Kaplan

The development of a bacterial collagen system to incorporate biologically active sites and to form well-defined hierarchical structures would impact the use of this important protein in both fundamental and applied studies. Certain bacterial collagens contain no hydroxyproline and are expressed in high yield in *E. coli* and still form triple-helical molecules of high stability which self-assemble into fibrillar-type structures. We will develop this recombinant collagen system to control hierarchical structure and incorporate biological activities that match degradation, remodeling, and cell signaling requirements for a variety of biomaterial applications. A major outcome from this effort will be a new family of bacterial collagen-like biomaterials, providing an alternative to bovine sources.

DARPA - BioComponent robots

David Kaplan, Barry Trimmer

The goal of this program is to exploit tissue engineering, cell biology and protein biomaterials to build a next generation of organic, degradable and biocompatible robot systems, patterned after caterpillars. Robotic systems have progressed in many applications, however, for the full impact and utility of such devices to be realized, several limitations remain to be addressed: (a) energy or power requirements – which often exceed onboard resources for extended operations, (b) noise – which can be problematic, (c) fabrication costs and poor scalability of manufacturing methods, (d) limited morphing capability, and (e) biodegradability and biocompatibility, which can be useful in medical and environmental applications. Our approach to overcome these limitations is to exploit biological components in the design and fabrication of robot systems. Components and systems for robotic devices will be built from biological sources (biopolymers, insect cells, tissue engineering).

March of Dimes - Regulation of embryonic tissue differentiation by matrix elasticity and mechanical forces

Catherine K. Kuo

Professor Kuo received the Basil O'Connor Starter Scholar Research award grant from the March of Dimes Foundation to investigate how an abnormal mechanical environment during embryonic development will adversely affect musculoskeletal tissue formation. Successful outcomes of this research will enhance current understanding of an under-studied area of developmental biology, identify parameters with which to mechanoregulate stem cell differentiation for new tissue regeneration, and in the long term enable development of treatments for debilitating fetal abnormalities and disorders.

NIH - Functional near-infrared imaging using the phase of hemodynamic oscillation

Angelo Sassaroli

This grant exploits the unique sensitivity of near-infrared spectroscopy to both oxy-hemoglobin and deoxy-hemoglobin to investigate fundamental physiological and functional processes. In particular, this novel approach will be applied to investigate the evolution of phase relationships between oscillations of oxy-hemoglobin and deoxy-hemoglobin during the phases of sleep.

NSF - A combined experimental-computational method to evaluate abdominal aortic aneurysm wall stress

Rob Peattie, Luis Dorfmann

The primary aim of this multidisciplinary research collaboration is to develop an integrated approach to analyze abdominal aortic aneurysm (AAA) biomechanics, wall stress development and rupture risk for single patients. The transformative impact is that all steps of the analysis will be fully based on information exclusively derived from that patient, including lesion shape, wall material properties, experimentally measured flow field characteristics and wall pressure, and wall stress computation.

biomedical engineering society

The Tufts BMES Chapter aims to encourage active participation of not only biomedical engineers, but all of campus, in the exploration of the current state of the field and collaboration in various BMES activities. In order to maintain active participation, biweekly meetings are held to discuss and plan upcoming events.

The BMES works hard to maintain good communication and relations with the department faculty. In order to promote these relations, the society hosts faculty events such as a BME student vs. faculty soccer game that was held in the fall. Due to popular demand from both teams, look for more upcoming events in the spring!

The BMES also hosted an event during the University-wide Engineering Week: a Triple-Crown Relay in which each engineering team has to complete a set of three tasks at each of the three engineering buildings, such as constructing the tallest marshmallow tower.

The society is also planning on developing a department-wide t-shirt to showcase our BME pride! Look for fliers coming soon, and contact us if you have any questions or ideas: Valerie.Luks@tufts.edu or Trevor.Stack@tufts.edu.

project spotlight:

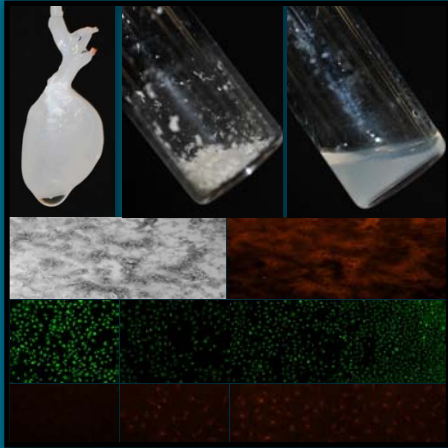


Figure 1, L to R: Top Row: A decellularized rat heart, the lyophilized powdered ECM, the solubilized ECM after pepsin digestion. Row 2: Solubilized ECM adsorbed onto a tissue culture plate in brightfield, and fluorescence. Row 3: Live dead stains for native myocardial cells on tissue culture plastic, adsorbed type I collagen, adsorbed solubilized heart ECM at 1 mg/ml and adsorbed solubilized heart ECM at 5 mg/ml. Bottom Row: Stain for early marker of cardiac differentiation Nkx2.5 tissue culture plastic, adsorbed type I collagen, adsorbed solubilized heart ECM at 1 mg/ml and adsorbed solubilized heart ECM at 5 mg/ml.

Fantini Lab

Collaboration with nutrition school results in publication in J Cereb Blood Flow and Metab:

Bertan Hallacoglu, Ph.D. student, is the lead author in an article entitled “Cerebral perfusion and oxygenation are impaired by folate deficiency in rat: absolute measurements with noninvasive near-infrared spectroscopy” that will appear in the Journal of Cerebral Blood Flow and Metabolism. This work is part of a collaboration between **Sergio Fantini’s** group and **Aron Troen’s** group at the Human Nutrition Research Center on Aging at Tufts. The main finding of this work is that a folate deficient diet in rats induces a cerebral microvascular and oxygenation deficit, which may in turn be responsible for cognitive impairment associated with folate deficiency.

Black Lab

The capacity of native heart extracellular matrix (ECM) to enhance mesenchymal stem cell differentiation to cardiac cells:

Many of the techniques to repair cardiac damage involve the use of stem cells derived from a patient’s own tissues but often result in limited cell implantation and lack of appropriate cell functionality. One innovative strategy for improving differentiation of stem cells to cardiac cells is to seed stem cells on matrices that mimic the properties of the developing or maturing heart. Current work being conducted by postdoctoral research associate **Corin Williams** and graduate student **Josh Resnikoff** aims to assess the capacity of ECM composition and substrate stiffness to effect the differentiation of MSCs to cardiomyocytes. Preliminary results indicate that native ECM resulted in significantly more early cardiac differentiation than normal tissue culture plastic (see Figure, left).

bme department

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