Trip Report BME-Idea and BMES Meetings (v. 1.0)
Pittsburg, PA
October 7 through 9, 2009

Introduction

Most of the technical presentations at this meeting were more like science than engineering and nearly all of them involved some cell and molecular biology. However, I am convinced there are still a lot more opportunities for graduates to work at medical device companies and hospitals than research laboratories. Therefore, it seems reasonable to me for MSOE to continue to produce graduates who are fully prepared for immediate employment in macro engineering activities (electrical, mechanical and transport), and yet also prepared to pursue graduate study in micro (MEMS & tissue engineering) and nano (cells, receptors, biomolecular) areas.

Portions of the following prose are dense and full of technical terms. This document is intended to provide highlights of some very technical presentations. A background in biomedical engineering is assumed. Refer to the meeting program and proceedings for more information (available on CD).

October 7

BME-Idea Biennial Meeting

This all day program was organized by BME-Idea (www.bme-idea.org) with extensive involvement by NCIIA (www.nciia.org). It focused on BME innovation (design and commercialization). It had large translational research, technology transfer and entrepreneurial components.

The most significant news is that there will be a new design contest exclusively for undergraduates called BME-Start. Departments and schools may enter as many BME-Start teams as they want. The application deadline for BME-Start is May 14, 2010. The existing NCIIA BME-Idea contest will continue and is now being called the BME-Idea Open. It is open to graduate and undergraduate teams. It includes a limited number of $500 stipends for competing teams. Departments may only enter one team in the BME-Idea contest. The next BME-Idea stipend application deadline is November 5, 2009 and the next contest application deadline is April 2, 2010.

Sessions included discussions of innovations in the undergraduate design experience. Based I what I heard at these presentations, I am convinced that MSOE provides students with a much better than average general design experience. MSOE's BE program appears to be ahead of or on par with the best-in-class programs with regard to with regard to design process, documentation and regulation. However, we do not appear to be doing as well as our best competitors in the areas of facilities, industry support, tissue and cells and technology transfer.

There was a session on work at the University of Pittsburg attempting to quantify how students navigate the design process and factors that correlate with success. Results were preliminary, but teams reporting execution of fewer design elements (activities) appeared to produce inferior results. It was not clear if these teams spent less time overall on their design, or just did not use as many recognized techniques. Another predictor of poor outcomes was getting stuck in the early stages of the design process. Teams that kept revisiting the problem identification stage of the design process were not as successful as teams that completed this step and moved on through the later steps.

The speaker for the luncheon session, Peter DeComo, was very good. He is serial entrepreneur and described his experiences. Coincidentally, his company implemented ideas I worked on for both my Master's and Doctorate degrees and a company I once interviewed with for a job.

The afternoon consisted of an interesting hands-on session involving the design of a medical device with global social impact. The task is one used at Bucknell to introduce students to the design process.

The final session described web based resources that can be used for design. A variety of sites were mentioned. The most specific to BME include eBioDesign (www.ebiodesign.org) which is a companion site for the new book "Biodesign – The Process of Innovating Medical Technologies" by Zenios, Makower and Yock, eds. Copies of this book were distributed to everyone attending the session. Having glanced through the book, my conclusion is that it lacks some detail necessary for standalone use in an undergraduate BME design course, but it would make an excellent resource book for faculty use or a supplementary text for students. It stresses the innovative and entrepreneurial aspect of BME design. The eBidDesign site links to information on the www.bmesource.org source site, which was also recommended. Another BME specific site mentioned was BMEplanet (www.bmeplanet.org). This is a web 2.0 based professional networking and collaboration site. It is definitely a site students should join.

Council of Chairs (CoC) of Biomedical Engineering and Bioengineering Meeting

The Purpose of the Council is to promote excellence in undergraduate bioengineering and biomedical engineering degree programs.

CoC dues notices will be e-mailed soon.

There was an announcement about the Coulter young investigator grants (http://www.whcf.org/WHCF_EarlyCareerAward.htm). The eligibility criteria have been extended to 8 years from first appointment and that they are accepting preliminary applications (2 pages) by November 1, 2009. This program stresses translational research and apparently university investment in IP is no longer required.

A change was made in the CoC bylaws to create a committee to develop plans for periodic Biomedical Engineering Education Summits and Workshops.

The CoC website is being updated. The temporary site is http://galactica.ecn.purdue.edu/drupal. A permanent, more mnemonic site name will be announced later. Meeting minutes and announcement will be posted on the site.

There was discussion of a possible new chairs workshop, probably in combination with existing BME meetings.

It was announced that at the next BMES meeting there will be a meet prospective faculty candidates poster session.

The next CoC meeting with be at the AIMBE meeting in Washington on Sunday, February 21, 2010.

October 8

BMES Technical Sessions

I started the day at the "New Advances in Detection and Therapeutics Session." The first presentation described using inhaled silver containing nanoparticles to treat cystic fibrosis related chronic lung infections. The work involved some excellent chemistry and the results were positive. The second presentation described a systems approach to targeted drug delivery using communicating nanoparticles. The approach barrows ideas from natural processes like

chemical signaling and cascades. The investigators used a modular approach that would lend itself to adaptation to numerous situations. The work reported was impressive. The third presentation involved more traditional approaches to targeted drug delivery using antibodies attached to the surface of nanoparticles. This series of presentations re-enforced my impression that BE has gotten increasingly cellular and molecular. Traditional electronics and mechanical topics will be needed to apply the new technologies, but the advances will come at the micro, nano and molecular scale and through an understanding of cell and molecular biology.

I next went to a session entitled "Mechanical Transduction and Vascular Oxidative Stress." The first talked described an investigation of endothelial cell gene expression associated with regions of disturbed blood flow. It was mostly molecular biology involving reactive oxygen species (ROS) and unfolded protein response (UPR). It appears that cells in regions of disturbed flow are susceptible to atherosclerosis due to ER stress, but the work did not address the initiating mechanisms. The next talk described micro-electro mechanical (MEM) flow sensor based on convective heat transfer. The active area of the sensor was 2 μm by 100 μm. The behavior of the sensor in a non-concentric cylindrical flow regime was modeled and compared to experimental data with good results. The third talk in this session was provided a new perspective on the problem of intimal hyperplasia of saphenous vein grafts. The traditional view is that the hyperplasia is the result of higher pressures and shear stresses in the grafts after they are moved from venous to arterial locations. The speaker provided preliminarily but persuasive evidence that it may in fact be the result of the change in P_{O2}. The evidence included enhanced reactive oxygen species (ROS) associated gene expression in venous cells exposed to P_{O2}s of 95 and 140 mm Hg relative to those exposed to a P_{O2} of 40 mm Hg. Further evidence was provided by the observed inhibition of intimal thickening in 14 day experiments at low P_{O2} and in the presence of ROS pathway inhibitors. It was noted that in vivo thickening appears to start immediately and to be substantial within a month.

BMES Exhibit Floor *(needs details and web links)*

The number of exhibitors at the meeting was rather limited. I spoke with representatives of and collected literature from the following companies:

1. Biomomentum – They make a multidimensional mechanical property testing devices optimized for biological specimens.
2. ADInstruments – They make a multi-function physiological measurement system that is similar to those available from Vernier and Biopac.

3. National Instruments – They had a very impressive breadboarding and instrumentation system, called Elvis, on display. It integrates with their LabView software and Multisim.

BMES Poster Sessions

Although there were multi, huge poster sessions at the meeting, I did not make any systematic attempt to explore them do to lack of time.

BMES Technical Session

I next attended a technical session entitled "Cell-Matrix Interactions." I only had time to attend the first talk at this session because I had to go to the AIMBE Academic Council meeting. The talk I attended involved a mechanical and thermodynamic model for predicting stress fiber orientation in cells grown in culture. The model incorporated both stress fiber and focal adhesion properties and minimized the derived potential energy function. The model matched experiment results under the somewhat limited conditions assumed in the derivation of the model.

AIMBE (http://www.aimbe.org/index.php) Academic Council Meeting

I was not particularly familiar with the American Institute for Medical and Biological Engineering (AIMBE) prior to attending this meeting. I now know that AIMBE is primarily an advocacy organization. The meeting began with a discussion of the role of the society and issues involved in encouraging greater participation by society fellows. The discussion then moved to the annual AIMBE employment survey. Apparently the return rate from last year's survey, sent out in February 2009 for the previous academic year was poor. The organization plans to re-survey institutions that did not respond to the first survey. They also plan to send out a survey for this academic year's graduating class. In the future, the intention is to send out surveys in October for the previous academic year. AIMBE is also creating a database to illustrate the impact of federal spending on biomedical research. It was noted that policy makers are most impressed by factors like GDP, jobs, patients saved, patents licensed and companies created. AIMBE is looking for help in creating this database. It was also reported that AIMBE has been contacted by the American Association of Medical Schools (AAMS) with the intention of enhancing collaboration between medical schools and engineering programs. To this end, a meeting to explore best practices may be held.

The discussion then moved to the AIMBE Annual Event that will be held in Washington from February 21 to 23, 2010. The theme will be "Balancing Risk, Benefit, and Ethics through Medical and Biological Engineering: Implications for Public Policy." Contributions regarding best

practices for technology transfer with emphasis on issues related to the meeting theme were requested. It was announced that limited travel funding for students to the meeting would be available. The goal is to have students join society fellows on visits to congressional staffers.

The activities of the AIMBE Advocacy Committee were then discussed. They are developing and advocacy kit for students and faculty members to better prepare them to talk to policy makers. They are looking for individuals willing to be involved in preparing position papers on issues like medical device taxes, graduate student visas and funding, translational research, medical and engineering school partnerships and diversity.

Finally, it was announced that elections for AIMBE officers will take place in November with nominations due by the end of October.

Technical Session

The final technical session I attended for the day was entitled "Mechanical Circulatory Support." The first presentation described an experimental study of the fluid dynamics in the left ventricle during LVAD support. It was noted that depending on the degree of circulatory support, the LVAD can act in series or parallel with the heart. The technique used was particle image velocitimetry (PIV) in which a sheet of laser light is shined through the flow and a camera views the arrangement from the side. The fluid of interest contains particle that are tracked in the resulting images to obtain velocity distributions. This particular study involved the use of a transparent dynamic ventricle simulator. The next presentation described research using PIV to study flow dynamics in a pediatric LVAD. The device studied was a second generation device being developed at Penn State. The first generation device was simply a geometric scaled version of an adult device. It exhibited poor hemodynamics with the associated problems. A transparent viscoelastic blood analog was used in the study. The second generation device exhibited improved hemodynamics. The next presentation involved a hemo-rheological assessment of the PediaFlow VAD in an *in vivo* sheep model. The device investigated was a third generation model and it was concluded that the device is not particularly damaging to blood. This presentation was followed by one describing in vivo studies of a pediatric pump-lung device (the combines pumping and gas transfer in a single device). The presentation began with a discussion of an attempt to develop ambulatory cardiac and respiratory support. Extensive modeling was used to predict performance prior to the construction of a prototype device. The device being developed was tested in sheep for 30 days and found to be well tolerated. The next presentation revisited the PediaFlow device described in an earlier presentation. It described a study of platelet and lymphocyte activation in an attempt to explain the observed increase in infection and stroke rates in VAD patients. It was found that the device did not

appear to activate platelets. Three antibodies that appear to be useful in the detection of lymphocyte activation were described. On-going lymphocyte activation was found in the study. It was postulated that this activation could result in decreased immune function and increased infection rate. The final presentation of the session involved a retrospective analysis of VAD failures by a clinical engineer. The study included 31 alarms among 28 patients over 17.4 patient years of VAD use. Drive line failures were the most common problem, some of which were due to patient weight gain that resulted in excessive tension on the drive lines. It was noted that 97% of the alarms were associated with only 8 patients in the study.

October 9

BMES Technical Sessions

The first session I attended was entitled "Advanced Orthopedic Biomaterials." In the first presentation, the performance of hyaluronic acid (HA) and poly-ethylene glycol (PEG) hydrogels for chondrogensis from mesenchymal stem cells was discussed. The impact of incorporation of RGD binding sites, polymer degradation rate and polymer cross-link density were studied. Degradation rate was controlled by the incorporation of acrylates, methacrylate and lactic acid functionalities. The role of CD44, I-CAM1, RHAMM and TGF-β were described. Microarray analysis was used to evaluation cell type by gene expression patterns. Gel formulations that could be photo-polymerized to provided patterned differential degradation for the control of cell morphology were described. Data from atomic force microscope measurement of physical properties was presented. The next presentation described attempts to understand and recreate the interface between bones and soft tissues (specifically tendons and ligaments). It was noted that the interface between the anterior cruciate ligament (ACL) and the bone spans only about 200 μm. It was claimed that understanding cell-to-cell communication between osteoblasts, chondrocytes and fibroblasts is critical to understanding these interface regions. And that understanding these regions is vital to successfully replicating them using tissue engineering. The production and *in vitro* and *in vivo* testing of a triphasic scaffold with co-cultured and tri-cultured cells was described. Photomicrographs of differential stained samples and micro-CT images of samples of these constructs were presented. Very distinct boundaries between mineralized and non-mineralized tissues were found in both the natural tissue and artificial constructs.

The last session I attended was entitled "Vascular Regeneration" and was focused on creation and performance of tubular scaffolds and tissue constructs. The first presentation compared single layer and bilayer tubular constructs containing entrapped cells. Cell viability and activity was tracked using collage, elastin and DNA density measurement obtained from micrographs of

differentially stained specimens. The next presentation described an *in vitro* analysis of SDF-1 release from electro-spun scaffolds. SDF-1 is a chemokine associated with neo-intima formation. Polycaprolactone and silk was spun using HFP solvent. ELISA was used in the analysis of results. It was found that for reasonable performance PEG had to be included in the polymer solution, apparently to protect the SDF-1. The final presentation of the session the creation of a scaffold based on a regenerated college fibers in a pseudo-elastin matrix. The college fibers were wet-spun. The pseudo-elastin was a tri-block copolymer consisting of Val-Pro-Ala-Val-Gly (hard segment) repeats and Val-Pro-Gly-Val-Gly (soft segment) repeats with Lys end caps for potential covalent cross-linking. The pseudo-elastin described exhibits the unusual behavior of gelling upon temperature increase. These materials were assembled into sheets having oriented college fibers. These sheets were then rolled into tubular constructs. The impact of fiber orientation angle on the physical properties of the constructs was systematically studied and optimized. The final constructions had mechanical properties similar to those of natural veins and arteries.