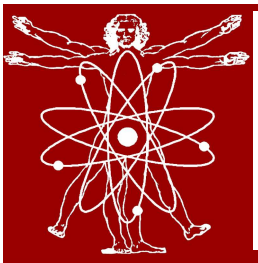
A Publication of the Graduate Biomedical Engineering Society (GBMES) and the Biomedical Engineering (BME) Department

Carnegie Mellon



The Scope

Volume 1, Issue 2 Spring 2007

A Message from the BME Department Head

Professor Todd Pryzbycien
Head of the Department of BME, CMU

Greetings. I hope you enjoy this, the second issue of The Scope, chronicling the activities of the BME Department. Since the first issue last fall, we have welcomed two new faculty members. Gustavo Rohde joined us in January 2007 as an Assistant Professor following his postdoctoral appointment at the Naval Research Laboratory in Washington, D.C. Gustavo's interests are in biomedical imaging processing and he is profiled in this issue. Kerem Pekkan also joined us as an Assistant Professor in January 2007 following an appointment as a research faculty member at Georgia Tech. Kerem's interests are in pediatric cardiovascular biomechanics; he will be profiled in an upcoming issue. A tip of our hat to the organizers and participants in the Second Annual Graduate Biomedical Engineering Society Research

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GBMES Symposium 2007 Highlights

Chris Highley
Ph.D. candidate, 1st year, Advisor: Dr. Stefan Zappe

On Friday, April 20th, while Carnegie Mellon's long-standing yearly tradition of Spring Carnival brought people outdoors, the second installment of one of the University's newest annual research symposiums was drawing an audience inside. The 2007 edition of the *Biomedical Engineering and Biotechnology Research Symposium*, sponsored by the Graduate Biomedical Engineering Society and the Department of Biomedical Engineering, showcased the work and creativity of the students in labs across campus.

The symposium took place all day in Doherty Hall and featured twelve students and a keynote address from Andrey Zarur, Ph.D. MIT, an accomplished scientist and entrepreneur. It was followed by a poster session which was open to presentations both by graduate and advanced undergraduate students.

The 20 minute presentations were organized into blocks which highlighted areas of biomedical research at Carnegie Mellon: bioimaging, medical devices and instrumentation, biomechanics, and tissue engineering. The symposium began with four members of Carnegie Mellon's Center for Bioimage Informatics: Charles Jackson, Gowri Srinivasa, Justin Newberg, and Ting Zhao. They presented research on efficiently collecting images and data from microscopes, analyzing data using specialized techniques, applying image analysis techniques to data and images widely available online in the Human Protein Atlas, and using algorithms to create image models based on machine learning from previous data analysis, respectively. Hsun Hsien Chang followed with a presentation on using MRI to assess heart malfunction in transplantation.

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Alumnus Focus

In this issue, we highlight Dr. Linsenmeier as a Carnegie Mellon alumnus who has made an impact in the field of the Biomedical Sciences and Engineering.

Dr. Robert Linsenmeier
Professor, Northwestern University

I'm very happy to see the continuing progress in biomedical engineering at Carnegie Mellon. When I graduated from Chemical Engineering, in 1972, it was not possible to major in BME at more than a few universities, and I had never heard of the field as a high school student. My introduction to biologically-related engineering was in a biochemical engineering course with Professor Ed Cussler, who was a great instructor, and I began to see how an integration of biology and engineering could be more interesting than process thermodynamics (he told us how he made yogurt when he was camping by putting a yogurt culture and milk at the bottom of his sleeping bag, which had just the right temperature). Later, I took one of the typically diverse "Intro to BME" courses that now exist at many schools, with Prof. Michael Weissman. This led me further into two elective biology courses: genetics and microbiology, both rather old-school by current standards. Both courses had labs, which I especially liked, even though I think I got the genotype of my fruit flies wrong. I considered both environmental engineering and biomedical engineering as my next move, and finally decided on the latter as my profession and the former as one of my hobbies. I went to graduate school at Northwestern because unlike some of the BME graduate programs that were emerging, it had more of a transport focus, and less of an electrical focus. Electricity scared me, because as a ChemE, I had never taken circuits (now I do electrophysiology to study transport, but still haven't taken circuits. We do not let undergrad BMEs get away with this). The particular area I work in, metabolism and oxygen transport in the retina, happened accidentally because I was intrigued by a project that never worked out. What did work was a combination of physiology and mathematical modeling. We make intraretinal recordings of oxygen and pH from intact mammals, and we try to understand aspects of blinding diseases. I teach mainly physiology in both the departments of BME and in Neurobiology and Physiology, where I am also appointed. While I'm not particularly fond of the administrative parts of the job, I have served as department chair of BME at Northwestern and on more committees than I can count. When I was chair, the department grew, and we began to achieve more recognition from the other engineering departments. Our undergrad enrollment is now about 80-90 per year. I continue to wear various administrative hats for national organizations. The two great things about being a faculty member are that you have no supervisor and no two days are ever the same.

"The particular area I work in, metabolism and oxygen transport in the retina, happened accidentally, because I was intrigued by a project that never worked out."

Back to Carnegie Mellon: I met my wife early in freshman year, although we didn't get married for 6 years. We lived for the most part in Welch Hall, the first of the co-ed dorms. The second most memorable activity (of many) was playing in the bands. We went on tour and performed in Carnegie Hall in New York every year that I was an undergrad, which I don't think has happened before or since. Because my wife's family is from Pittsburgh (about 7 Carnegie Tech and Carnegie Mellon University degrees total), I am on campus a lot, and we often use the stadium to play a family game of Frisbee or touch football. I didn't have much contact with engineering, but recently gave a seminar in BME and spent some time with the faculty. I look forward to having the Biomedical Engineering Society Meeting in Pittsburgh in the fall of 2009, and hope that BME at Carnegie Mellon will play a big part in helping Professor Harvey Borovetz (Chair of Bioengineering at University of Pittsburgh) run that meeting.

Surgery for Engineers

Surgery for Engineers is an integrated medical and engineering course offered in collaboration with Allegheny General Hospital. This course has been highlighted on the radio show "Voice of America."

Dr. James Burgess
Neurosurgeon, Allegheny General Hospital

This spring semester is the third time of the "Surgery for Engineers" course has been offered. The course originated in the fall of 2005 during a discussion with Jim Osborne, then the executive director of Carnegie Mellon's Medical Robotics and Information Technology for Medicine and Surgery ("MERITS of Pittsburgh") about the need to provide engineering students with a real-world experience in medicine. I was aware of a similar program a Johns Hopkins University started by Russ Taylor, MD, PhD as an element of the Computer Integrated Surgical Systems and Technology (CISST) Engineering Research Center located in Baltimore, Maryland. I offered to organize and facilitate the class (to claim to teach the class is a little overreaching). He agreed. We suggested the concept and both the Robotics Institute and the Department of Biomedical Engineering agreed to list it as a Special Topics offering.

Most of the research faculty that I've met on campus agree that emersion during their training in medical or surgical environments provided them with early inspiration for their sub-sequent research interests. Research skills seem to be broadened when engineers and physicians work in close quarters on projects of similar interests. Professor James Antaki, one of the BME faculty, has related that while working with Bartley Griffith, then division chief of Cardiovascular Surgery at the University of Pittsburgh Medical Center (UPMC) in the 90s as a graduate student, learned the fundamentals of cardiac surgery, defined engineering solutions to urgent human cardiac surgery problems. He went on to develop the "Streamliner" a unique and greatly superior left ventricular assist device (LVAD). We hope in some small way to repeat this experience for our students.

"Most of the research faculty that I've met on campus agree that emersion during their training in medical or surgical environments provided them with early inspiration for their subsequent research interests."

Volunteer faculty

One of the most surprising and gratifying aspects of the course has been the willingness of physicians to mentor engineering students. I find myself cold-calling surgeons throughout Pittsburgh requesting mentoring commitments and have uniformly been greeted with enthusiastic responses. Most surgeons are frustrated inventors without time to invent. An interested engineering student will usually find an eager collaborator with a little effort. I have been repeatedly amazed at the innovation shown by the students and physicians and the depth that some of the semester projects have revealed.

The seminar/project structure

The class is organized around the development of a project with volunteer surgical faculty. Although time permits only a cursory effort towards discovery, important lessons are taught. The skills necessary to appreciate clinical problems, discuss them intelligently, and to suggest rational solutions are the most important. Other skills like accessing the surgical literature, carving out time in a surgeons schedule, and even learning a little animal surgery are also important.

Another aspect of the course is its seminar series. Local surgeons provide an overview of their discipline emphasizing its technological aspects. Technological problems and challenges are also stressed. We also encourage the surgeons to invite industry representatives of medical and surgical device companies. This allows a certain "hands-on" flavor to the lectures and, at the same time, emphasizes important design aspects of these instruments. Many students have shown notable interest in the business side of the medical device companies which the reps are happy to discuss.

One of the favorite class meetings occurs early in the semester. The "Introduction to the Operating Room (OR)" class is a field trip to an operating room complete with multiple lectures within the OR, a visit to the cadaver lab and practice with suturing, knot-tying, coagulation and electrocautery machines. The OR lectures generally cover anesthesia machines, mobile

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fluoroscopic machines, intra-operative navigation devices and cardiopulmonary bypass machines.

Enrollment in the course during its first two semesters hovered around fifteen per session. This spring, however, I was stunned when my first inquiry about enrollment numbered forty-two. Luckily, I was assigned a couple of teaching assistants that have shepherded me through the experience of managing a real college-level course. I guess it's nice to be popular. Aside from having to curtail some of the road trips, it's pretty much the same course.

Future evolution, thoughts

The class continues to evolve. This semester we are asking the students to independently identify Carnegie Mellon faculty whose research in some way connects to the concepts developed in their student-surgeons projects. We believe that this effort will add depth to the student's understanding of those concepts and possibly lead to further work later on in their careers. I hope that we continue to get a mix of undergraduate and graduate engineering students. The student interplay is one of the best parts of being involved in this course. The other is hearing that the students have remained committed to their projects once they have finished the course. My thanks to the Department of Biomedical Engineering and the University for the privilege of instructing such a unique course.

Tissue Engineering: a pillar of BME at Carnegie Mellon

Bone Tissue Regeneration and Restoration of Function and Form

As one of the five central pillars of the Biomedical Engineering Department, Tissue Engineering plays a prominent role at Carnegie Mellon. A major focal point of the tissue engineering research is BTEC.

Dr. Jeffrey Hollinger
Professor, Department of BME and Biological Sciences

The goal of the Bone Tissue Engineering Center (BTEC) is to design and develop practical clinical therapies *to promote tissue regeneration.* The Center scientists use synthetic biodegradable scaffolds derived from composites of polymers and bioactive ceramics that may be seeded with autogenous cells and augmented with wound healing biologicals such as fibroblast growth factor, platelet-derived growth factor, insulin-like growth factor, and bone morphogenetic protein. Bone morphogenetic protein and platelet-derived growth factor, for example, could be introduced in the scaffolds to promote cell chemotaxis, mitogenesis and differentiation. Scaffolds that are load bearing will have the mechanical properties of bone and promote osteoinduction. These scaffolds are being developed by the Bone Tissue Engineering Center and Vanderbilt team members in collaboration with a corporate partner.

To achieve functional enduring tissue regeneration, our collaborations with academic, Federal and corporate laboratories will produce:

1. Modular interface assemblies between tissues: e.g., muscle and bone, tendon and muscle
2. Scaffolds to promote physiological 3-D tissue architecture;
3. Bioactive biomaterials that will support and sustain tissue viability through 'smart engineering' of metabolic and physiological tissue requirement properties and that will regenerate into biofunctional, enduring and physiological anatomic units;
4. Modular tissue assemblies incorporating analgesics and antimicrobials.

Furthermore, scientists at the BTEC are studying bone wound healing in compromised wound healing conditions such as diabetes, osteoporosis and aging. The BTEC team and collaborators follow a pragmatic, clinically rational therapeutic approach to regenerative medicine that will facilitate a favorable regulatory outcome. Extensive *in vitro* and *in vivo* methodology using ASTM and ISO standards are followed to ensure regulatory compliance and clinical relevance.

For more information you can visit:
http://www.btec.cmu.edu/reFramed/main/mainPage.html

New Faculty Focus

Dr. Gustavo Rohde
Assistant Professor, Department of BME

I was born in Brazil and came to the US in the early nineties. In the US I finished high school and attended college and graduate school. During my undergraduate years, I studied Physics and Mathematics at Vanderbilt University, Nashville, TN. After completing four years of college I decided to stay at Vanderbilt to obtain a Master's degree in Electrical Engineering. While at Vanderbilt, I was exposed to the field of image and signal processing; first working with the living state physics group in the Physics department on their epicardial fluorescence mapping experiments, and then in the Medical Image Processing Laboratory in the Electrical Engineering department. The experience of working in these labs as an undergraduate and then graduate student was extremely rewarding and motivating since, for the first time, I was able to use the training I had received in school to produce things that people actually wanted to use.

After graduating in the summer of 2001 I moved to Bethesda, Maryland, where I worked as a research assistant at the National Institutes of Health (NIH). There I gained practical research experience in image processing with applications to Magnetic Resonance Imaging (MRI) of the human brain. In particular, our group was involved with developing algorithms for analysis of Diffusion Tensor Imaging data including registration, motion and artifact correction, tracing, denoising, and model fitting, amongst others. While working at the NIH I also enrolled in the Applied Mathematics and Scientific Computation Ph.D. program at the University of Maryland. There I studied under the mentorship of Professors Dennis M. Healy, Jr., and Carlos A. Berenstein. In the summer of 2005 I defended my dissertation and became a National Research Council postdoctoral fellow working at the Naval Research Laboratory (NRL), Washington DC. After working at the NRL for one and a half years, I joined the BME department of Carnegie Mellon.

Imaging and image processing have fascinated me from the beginning. The type of problems that arise in these fields provides an excellent motivation for learning about engineering and mathematics, while the visual nature of the field facilitates understanding intricate concepts. Moreover, the field has had a profound impact in medicine and biology. The proliferation of image acquisition techniques (confocal microscopy, magnetic resonance imaging, computed tomography, etc.) has not only had a huge impact in medicine but also in quantitative sciences, where images are increasingly becoming the main source of experimental data. Digital image processing has enabled the automatic interpretation and analysis of massive amounts of data, improving accuracy and efficiency, and often inferring information not visible to the human eye.

The improvements in computational capacity over the past couple of decades have resulted in the proliferation of numerous image processing algorithms with applications to biology and medicine. Often such algorithms are developed independently from the sensing and application points of view – the so-called systems' level black-box approach. The approach has served us well for the past couple of decades but I believe many significant accomplishments will rely on skillful integration of image formation, processing, and biology together with the application of appropriate mathematical tools.

The Center for Bioimage Informatics (CBI) is positioned to lay foundations of biological image analysis for years to come. The unique combination of talents and interests from the faculty and students at CBI and the Biomedical Engineering Department, together with support and collaborations from other departments such as Biology and Computer Science, make Carnegie Mellon a very exciting place for working in bioimaging.

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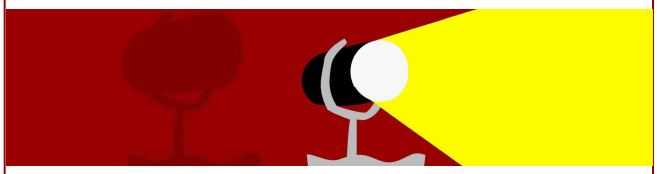
My family and I are happy to be joining the Carnegie Mellon community here in Pittsburgh. My wife and I have a baby daughter now and spend most of our time taking care of and playing with her. Whenever we have free time, we also enjoy playing sports (tennis, soccer, volleyball, etc.) and music (piano, guitar, etc.).

Dr. Rohde's Carnegie Mellon website:
http://andrew.cmu.edu/user/gustavor

In the Spotlight



Bob Murphy
Professor, BME and Biological Sciences

Dr. Murphy has been elected a Fellow of the American Institute of Medical and Biological Engineers (AIMBE), an advocacy organization aimed at advancing the awareness of medical and biological engineers and their contributions among the public, lawmakers, government agencies and professional groups. Election as a Fellow of AIMBE signifies broad recognition of the individual and their professional accomplishments among the biomedical engineering community. He joins Jim Antaki, Mike Domach and Todd Przybycien in the AIMBE College of Fellows.

Amina Chebira
Ph.D. candidate, 3rd year, Advisor: Dr. Jelena Kovacevic

Amina was selected as a finalist for two fellowship programs: the Microsoft Research graduate fellowship program and the IBM Ph.D. fellowship.

William Garrett Jenkinson
Undergraduate, Senior year

Garrett recently won a first place prize in the Lockheed Martin ECE competition and a second place prize in the CIT honors project competition for his work on tissue pattern recognition in histological images.

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(*Symposium, continued from page 1*)

The medical devices and instrumentation group contained the day's three top presenters, as judged by a panel of biomedical engineering faculty. Daigo Tanaka, one of the departments newest Ph.D.'s, took top honors for his presentation of a computational method of optimally locating cryoprobes to freeze tumors. Samuel Hund presented research on mathematically simulating thrombosis processes with the aim of optimizing device designs. Davneet Minhas discussed his work on guidable needle that can be used to reach tumors or other targets in deep portions of the brain with minimal disturbance to healthy tissue. Samuel and Davneet's presentations were honored with the second and third place awards, respectively.

After a midday lunch break which allowed students, professors, and guests to mingle, Dr. Zarur shared his diverse experiences and thoughts on topics ranging from graduate education to entrepreneurship to happiness and success. Speaking about the highs and lows of his own career, Dr. Zarur shared his experience with school, getting into and through MIT, starting a company to commercialize work he did on bioreactors, and the roles of a company founder versus CEO versus venture capitalist, touching on the flow of ideas from small university labs to large corporations. He left his audience with encouraging words about the importance of the work they were doing and the manner in which it was being conducted.

The symposium presentations concluded with the biomechanics and tissue engineering presentations. Alexandre Ribeiro presented his research into the effects of altering cellular mechanics– through expression of cytoskeletal components– on a cell's nucleus with implications for cell fate. Chao-Min Cheng presented work on a novel method of creating micropatterns from actin. The speakers concluded with Amrinder Nain's talk on highly controlled microfibrous scaffolds for tissue engineering created using MEMS devices.

The symposium closed with the poster session, which allowed advanced undergraduates to share and talk about their work alongside graduate students at the symposium. The organizers would like to thank all the students, faculty, staff, and friends of the program who helped to make the day so successful.

Student Focus from the M.D./Ph.D. Point of View

An important part of BME at Carnegie Mellon also involves the University of Pittsburgh: the joint M.D./Ph.D. program. We asked Dr. Afshar, who recently received his Ph.D., to write a few words about his experiences in the program and his interests in the Biomedical Sciences.

Dr. Pedram Afshar
Ph.D., M.D. candidate

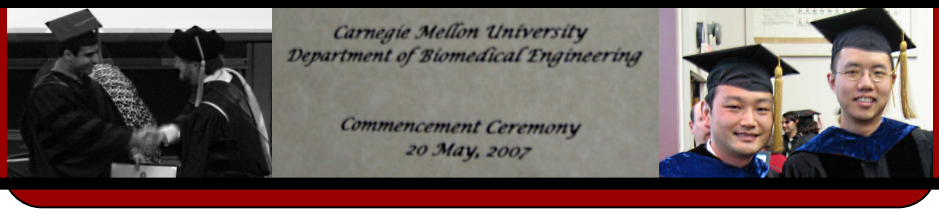
Modern challenges in medicine demand innovative, cross-disciplinary approaches that rely on extensive patient interaction as well as rigorous scientific expertise. The Medical Scientist Training Program (MSTP) is a program that provides both the foundations of scientific and medical training and the tools necessary to creatively marshal this training to develop healthcare innovations.

The purpose of the program is first and foremost to train physicians: people who diagnose and treat disease and foster human health and wellness. MSTP physicians, in particular, are also trained as scientists who conduct research that directly improves medicine. Students in the MSTP simultaneously matriculate in medical school (M.D. degree) and graduate school (Ph.D. degree). The program averages slightly less than 8 years and is designed so that the 4 years of medical school are split around the graduate school years. After graduation, M.D./Ph.D.'s typically pursue further study in a field of medical specialization (through a residency) that is often consistent with their graduate training. The traditional career goal is to become a physician who divides time between patient care and laboratory research. However, M.D/Ph.D.'s remain relatively rare in the academic and medical communities and have varied interests and specializations. As a result, their value is often poorly understood.

To the academic community, M.D./Ph.D.'s may simply be scientists with extensive knowledge about human physiology and pathology. To the medical community, M.D./Ph.D.'s may simply be physicians who can write grants and "do science". In reality, M.D./Ph.D.'s are a qualitatively different and unique product: a physician-scientist. Undoubtedly there are physicians who produce excellent science, and there are scientists who understand the approaches of medicine. But theirs is a second language, one acquired later in their careers. Physician-scientists are trained to be bilingual, not only speaking but also *thinking* both as scientists and clinicians with equal fluency. As a result, the MSTP trains students to solve problems beyond the horizon of their pure physician and academic colleagues. Their ability to identify and develop cross-disciplinary solutions to healthcare problems is invaluable in the creation of information technology, biomedical devices, pharmaceuticals, and life sciences.

I found the programs at Pittsburgh to be particularly farsighted in this regard. The MSTP prepares students to integrate their medical and scientific training and develop unique niches within which to apply this training. Furthermore, there is significant exposure to diverse career paths and a strong dedication to mentorship (both peer and faculty), allowing students the freedom and guidance to mature into successful physician-scientists. The individual medical and academic training environments are truly superior. The balance of evidence-based and holistic medicine at Pitt produces physicians who master the science of disease management, while maintaining the essence of humanness that is the hallmark of doctoring. Across the street, biomedical engineering and robotics at Carnegie Mellon use cutting-edge technology to create simple and efficacious solutions for practical problems. The spirit of entrepreneurship, creativity, and innovation pervading these programs produces physicians and engineers who identify and solve critical problems in their fields.

My personal interest is to explore the entrepreneurial aspects of healthcare science. Ultimately, I want to develop technologies to increase accessibility of medicine to underserved populations. I hope to start by creating and managing intellectual property for companies in the early stage of the product life cycle in the healthcare space. For this purpose, my combined degree training will be critical to scientifically evaluate innovations, ascertain market demand and utility, and communicate as a peer with both scientists and clinicians for product development and deployment.



2007 Carnegie Mellon BME Graduates

Ph.D. Degree Recipients

Pedram Afshar, "A Neuromuscular Framework for Motor Control"

Jerald Redmond, "Origins and Consequences of Silicon Carbide Banding in Silicon Alloyed Isotropic Pyrolytic Carbon"

Daigo Tanaka, "Computational Method for Cryoprobe-Layout Optimization via Finite Sphere Packing"

David Wang, "Automatic Common Carotid Artery and Internal Jugular Vein Identification and Tracking for the Sonic Flashlight"

Ting Zhao, "Generative Models of Protein Subcellular Location Patterns"

Master of Science Degree Recipients

Nick Gialias, "A Musculotendon Contribution to Multijoint Hand Control"

Rowena Mittal, "A Feasibility Study on a Novel Platform for Optimizing the Properties of Biohybrid Hydrogel Biomaterials for Tissue Engineering Applications"

Amol Shanbhag, "Data Mining Approaches and Databases for Interpreting Protein Subcellular Location Patterns in Fluorescence Microscope Images"

Megan Smith, "Natural Growth Variance and Reproducibility of Reactor Biofilms"

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Warren Ruder
Ph.D. candidate, 2rd year, Advisors: Drs. Philip Leduc & James Antaki

Warren has been nominated by the University to attend the Nobel Laureates this summer. He has also been selected for an NSF-sponsored slot as a member of the US delegation. He is one of 500 students who will spend a week at the ceremonies with past Nobel winners will in Lindau, Germany

Ariel Drummond
Ph.D. candidate, 3rd year, Advisor: Dr. Jim Antaki

Ariel received the Graduate Student Service award in April in recognition of her recruiting responsibilities for the Carnegie Institute of Technology (CIT), graduate peer mentoring, and for her service to committees on campus.

Sanna Gaspard
Ph.D. candidate, 3rd year, Advisor: Dr. Jim Antaki

Sanna was awarded an NIH grant, the Research Supplement to Promote Diversity in Health-Related Research, for her research on pressure ulcers.

(*Message from the Department Head, continued from page 1*)

Symposium this past April with special recognition to Daigo Tanaka who repeated with the best oral presentation award. In May 2007, we graduated 40 BME additional majors, 19 BME minors, 4 M.S. students and 5 Ph.D. students. We will miss our graduates and look forward with great anticipation of their achievements yet to come. Finally, during the past semester, plans crystallized for new BME research space: BME will occupy about 20,000 sqft of space in the "CIC II" building to be constructed on Panther Hollow across from the current Collaborative Innovation Center and Roberts Hall. CIC II is slated to open for business in September 2009. More on this exciting development to come in future issues.

Justin Newberg* and Warren Ruder
*Ph.D. candidate, 3rd year, Advisor: Dr. Robert Murphy

Justin and Warren were named co-recipients of the BME TA of the Year Award for the 2006-2007 academic year. This award recognizes their efforts in fall '06 BME Laboratory course.