

Newsletter 2011

ERC-REVOLUTIONIZING METALLIC BIOMATERIALS
STUDENT ASSOCIATION

From the desk of Director Sankar

I am truly excited to welcome the readers once again to the second student-generated newsletter of the Engineering Research Center for Revolutionizing Metallic Biomaterials (ERC-RMB). The *raison d'être* of our Gen 3 ERC is to transform current medical and surgical treatments by creating "smart" implants to improve treatments for orthopedic, craniofacial and cardiovascular ailments coupled with the development of a vibrant, diverse workforce well-prepared for the multidisciplinary and global challenges and opportunities of the new millennium.

Our ERC-RMB team has continued to work hard with an even sharper focus on our strategic plan as the foundation to integrate research areas, educational and outreach activities, and partnerships with industries, innovation and global leaders. The Center's operations have thus become more "mission-driven," like an industry, connecting all the needed dots while retaining the "full freedom to dream big" afforded by a University setting, connecting across

the boundaries of research and educational disciplines.

This year, the Student Leadership Council has excelled in bringing together the numerous details covering various aspects of the Center and rallying behind the Center philosophy "One Team, One Dream". The 2010-2011 Newsletter aims to document the *Converging Technologies, Translational Research, and Education and Innovation Ecosystem* philosophy of the Center, and, more importantly, to instantiate how our ERC students - our next-generation innovators and thinkers, have become an integral part of these thought processes.

Again, welcome to our Center. I look forward to your feedback and participation as we continuously strive to improve.

Sincerely,

Jag Sankar
sankar@ncat.edu
ERC Center Director



Welcome to the Fall 2010 issue of the student-produced ERC-RMB newsletter. We are in a very exciting period for our ERC. As we enter our third year of existence, the Student Leadership Council is pleased to report on the outstanding progress of several educational, research, and outreach efforts.

In addition to industry and research updates, two important events are highlighted in this current newsletter. The first is the year two site visit, which took place in Greensboro, North Carolina from May 26th-28th, 2010, where our new strategic plan emphasizing medical device development was introduced to NSF reviewers. The other is the second annual student-faculty day, which took place in Greensboro from August 1st-3rd, 2010, where students were able to present their research progress to faculty members and take part in the strategic planning for year three. Finally, we report on the positive impact our education and outreach undertakings are having at each site within the ERC-RMB.

As always, we greatly appreciate and commend the effort put forth by our newsletter editors, Da-Tren Chou, Mitesh Oswal, and Ashlynn Worthy, as well as the excellent guidance and mentorship from the ERC leadership team.

SLC Co-Presidents:

Leon White
North Carolina A&T (NC A&T)

John Vennemeyer
University of Cincinnati (UC)

Satish Singh
University of Pittsburgh (Pitt)

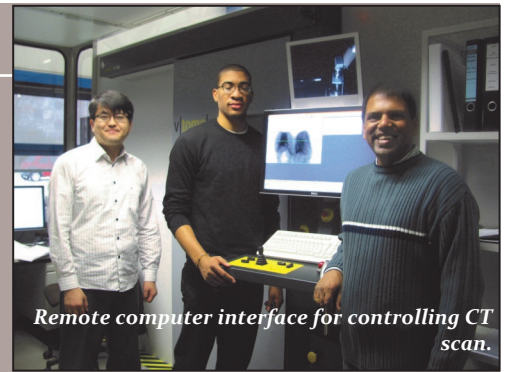
NC A&T researchers travel to Hannover

In November 2010, NC A&T PhD students Venkataraman Giridharan and Leon White along with Dr. Yeoheung Yun, associate professor of Bioengineering, visited Hannover Medical School (MHH) in Germany. The visit lasted 7 days with the following objectives in mind: (a) Visualization of Mg implanted bone sample using a micro-CT facility, (b) measurement of corrosion rate of Mg implants using a eudiometric system, and (c) histology of hard tissue implant with Mg alloy. These objectives were undertaken with the supervision of Dr. Frank Witte at 3 different facilities: Implant Immunology lab at MHH, CrossBIT lab at MHH, and v|tome micro-CT facility at Technische Universität Dortmund.

The group traveled with a PhD student at MHH (Maria Branneis) to Dortmund. Using rabbit condyle samples implanted with cylindrical rods of a Mg alloy, they gained an understanding of how the micro-CT facility is used to perform sample mounting on the

CT specimen stage, calibrate the CT system, and initiate scanning of the sample from a remote computer interface. Once raw data was obtained from the CT scan, it was converted to various imaging formats (DICOM, TIFF, Analyze) using VolumeGraphics Studio Max software. This software also performed a 3D reconstruction of the scan data for volume rendering. Sample image data was brought back to NC A&T for visualization as well as conversion to CAD formats for use in modeling and simulation. One of the bone samples implanted with Mg was sectioned using a microtome for histology analysis. Both H&E (Hematoxylin and Eosin) and Toluidine Blue staining were demonstrated at the Implant Immunology lab.

One corrosion measurement method is the measurement of hydrogen evolution rate which is typically generated from the cathodic site of an electrochemical cell. An eudiometric system is one way to measure hydrogen gas evolution from a Mg sample

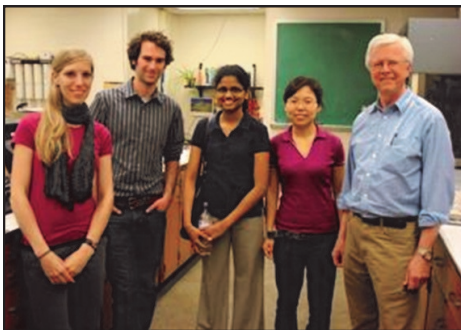


Remote computer interface for controlling CT scan.

subject to corrosion. The eudiometer resembles a graduated cylinder, with the bottom end immersed in water, the chamber filled with gas, and the top end closed. For the experiment, the Mg sample was placed inside a cell culture medium and hydrogen gas evolution and pH were measured over a 3 day period. The results from this experiment will yield weight loss as well as volume of H₂ gas. These results aid in the selection of the Mg alloys for implant use.

- Contributed by Venkataraman Giridharan (NC A&T)

Pitt researchers visit UC



From L to R: Julia Kuhlmann, Andrew Brown, Dr. Madhumati Ramanathan, Xufei Guo, and Dr. William Heineman.

Two researchers from the University of Pittsburgh visited the Heineman Lab at the University of Cincinnati on May 6-7, 2010 to discuss plans for collaboration between biosensor development and *in vitro* evaluation of magnesium alloys. Andrew Brown, a graduate student in Charles Sfeir's lab at Pitt, is interested in incorporating sensors for H₂ gas and Mg²⁺ ions being developed at UC into his *in vitro* test bed in order to track magnesium alloy degradation in real time and its resulting effect on human bone cells. Madhumati Ramanathan, a post-doctoral researcher in Prashant Kumta's lab at Pitt, is developing sensors capable of detecting bone biomarkers, such as BMP-2, to allow real-time evaluation of cell behavior when exposed to magnesium alloys.

UC's expertise in sensor development allowed Brown and Ramanathan to identify the steps that would need to be taken to enable implementation of sensors into their specific projects. In addition to collaborative discussions with the Heineman Lab, Mark Schulz and students provided a tour of the NanoWorld manufacturing facilities at UC, while Sarah Pixley and John Vennemeyer showed off the biological assessments being performed in their lab. This visit to UC laid the groundwork for what is sure to be an impactful collaboration between ERC-RMB thrusts.

- Contributed by Andrew Brown (Pitt)

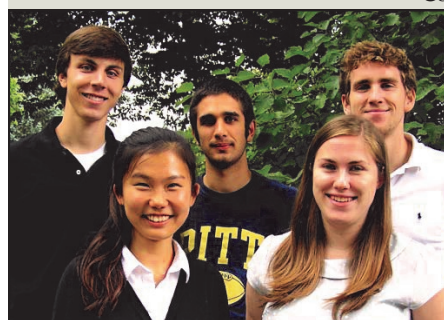
Summer REU in Germany

Dr. Frank Witte, Director for Biomaterial Research at Hannover Medical School (MHH) and Global Site Coordinator of the ERC-RMB intends to broaden and strengthen the international exchange among ERC-RMB institutions in order to create the fundamental knowledge and know-how to allow students to research metal implants and magnesium based implants. During the summer of 2010, five undergraduate students from Pitt visited Dr. Witte's labs in Hannover for the Research Experience for Undergraduates (REU) program. Each of them had their own research paper to complete, as well as a presentation on their last day of stay.

The students conducted research in craniofacial and orthopedic applications, and responsive biosensors for implants. The program allowed the students to lay a solid foundation for their researching career and to elaborate upon interesting science-based questions to improve patient treatment. In addition, the program is also designed to give the students the opportunity to create long-lasting ties with research professionals guiding the program and facilitating the research.

Dr. Witte hopes that in the future, an exchange program will be built to allow students of Hannover Medical School and the American institutions to visit each other's lab facilities on a regular basis.

- Contributed by Dr. Frank Witte



Pitt REU students (L to R): Dan Maskarinec, Dandan Hong, Sanjeev Khanna, Jennifer Huling, and Richard Jeffries.

ERC-RMB well represented at BioMetal 2010

Members of the ERC-RMB join experts from all over the world in Maratea, Italy to discuss the state-of-the-art in biodegradable metals research.

The 2nd Symposium on Degradable Metals in Biomedical Applications was organized by Dr. Frank Witte and Dr. Diego Mantovani and held in Maratea, Italy on August 31st - September 4th, 2010. The world-wide meeting sponsored in-part by the ERC-RMB brought together prestigious researchers to share results and thoughts on biodegradable metals. Graduate students Sung Jae Chung (Pitt) and Dae Ho Hong (Pitt), as well as; Dr. Prashant N. Kumta (Pitt), Dr. Charles Sfeir (Pitt), Dr. Vesselin Shanov (UC), Dr. Zhigang Xu (NC A&T), and Dr. Jagannathan Sankar (NC A&T) attended the conference. Dr. Sfeir and Dr. Sankar also served as session chairs during the conference. Accepted manuscripts from the symposium are to be published in a special issue of *Materials Science and Engineering B*, whose Editor-in-Chief is Dr. Kumta.

The pristine location of the conference on the coast of the Mediterranean Sea and the local delicacies facilitated fruitful discussion during the symposium, which was structured in sessions characterized by open discourse, instead of the more traditional lecture/question-answer format. At the end of each session, (which ranged in subject from metal design, processing, and mechanical properties, to animal models, diagnostics/analytcs, biocompatibility, and sensors) panelists, session presenters, and audience discussed open issues brought up during the session. Even outside of the conference sessions, open dialogue was encouraged and opportunities to forge new relationships were provided during breakfast, lunch, and dinner provided on-site to all attendees.

The ERC-RMB was well represented at this meeting of the leaders in the biodegradable metals community, giving the ERC-RMB valued exposure. Dr. Sankar proudly introduced the goals of the ERC-RMB employing the three layer chart as seen on page 10, and 8 ERC talks or posters were presented. This year's Symposium on Biodegradable Metals will be held during THERMEC'2011 in Quebec City, Canada, where the ERC-RMB will share novel year 3 progress and continue to build on its impact in the field of metallic biomaterials.

- Contributed by Dae Ho Hong



ERC-RMB attendees at the 2nd annual Symposium on Degradable Metals in Biomedical Applications.



Julia Kuhlmann (R) and Laura Dzugan (L) at UC poster session.

REU Student excels under ERC mentorship

This summer, Julia Kuhlmann, a PhD student in Dr. Heineman's lab at UC, had the opportunity to mentor an NSF Research Undergraduate Experience (REU) student. Julia supervised Laura Dzugan as they worked on comparing the effects of electrode biofouling on voltammetric and potentiometric measurements. Their work was centered on the hypothesis that voltammetric measurements, which are dependent on the surface area of the working electrode, would be affected by the adhesion of biomolecules (biofouling) more than potentiometric measurements *in vitro*. In their experimental setup, Laura and Julia used different biomolecules and a biological fluid to incubate the working electrode for several different time periods. Potassium ferricyanide was used as a model analyte. The results of their research supported their hypothesis that the voltammetric measurements of an electrode would be more profoundly affected than potentiometric measurements as a result of biofouling *in vitro*. For this work, Laura and Julia won an intra-university poster contest at UC and are planning to present their results at the spring 2011 ACS meeting. A manuscript summarizing their findings is being prepared as well.

- Contributed by Julia Kuhlmann (UC)



A closer look at projects
within the ERC-RMB

Research Highlights

Interference Screws for ACL Reconstruction

The overall objective of this project is to develop Mg-based interference screws as fixation devices for anterior cruciate ligament (ACL) reconstruction. Dr. Savio Woo's lab at Pitt has produced and evaluated first generation Mg-based interference screws both *in vitro* and *in vivo*. First generation interference screws from pure Mg, and Mg alloys AZ31 and Mg-4Y were developed utilizing various fabrication techniques developed by the ERC materials team (in collaboration with Drs. Schulz, Kumta, and Xu). The effectiveness of these screws was assessed to secure an ACL replacement graft in the cadaveric goat stifle joint and will be compared with results using commercially available degradable polymer screws (Milagro®, Johnson & Johnson), in collaboration with Dr. Alonzo Cook of J & J. The AZ31 screw yielded the best performance and is being tested in an *in vivo* goat model of ACL reconstruction. Results will be compared to Milagro® screws in terms of a) histomorphological appearance of the bone-patellar tendon bone (BPTB) graft, ACL screw, and surrounding bone, b) degradation of the Mg-based screw, and c) the biomechanical properties of the BPTB graft and its contribution to joint stability. It is the hope that these initial findings will result in exciting initial data to provide insight into the design of future generations of Mg interference screws as well as obtain extramural funding.



Mg ACL interference screw.

- Contributed by Dr. Matthew Fisher (Pitt)

TMJ Replacement Systems

It is estimated that 10 million Americans suffer from temporomandibular joint (TMJ) disorders in the United States. When symptoms of TMJ disorders become so severe that quality of life is drastically diminished, patients resort to TMJ replacement systems. The intended application for a biodegradable magnesium TMJ implant is to stimulate regeneration of the native bone and fibrocartilaginous tissues of the joint while providing mechanical support throughout this process. As a first course of action, the TMJ lab lead by Dr. Alejandro Almarza at Pitt is working with Biomet Microfixation on the development of a degradable magnesium screw. The pull out strength and degeneration timeline of the screw will first be determined using a rabbit model. The goal is to create a screw that will begin to degrade 6 months following implantation as revision surgery is a major concern following this procedure. After performing *in vivo* studies and establishing the feasibility of the biodegradable magnesium screw, efforts will be made to apply the concept to an entire TMJ device.

- Contributed by Catherine Kunkle Hagandora (Pitt)

Thoracic Stent

Pediatric airway obstructions demand immediate attention and can require life-long treatment. Stenting is a common strategy for maintaining tracheal patency, but the permanent nature of current stents often leads to perforation of the trachea and aorta. In the case of tracheomalacia, permanent stenting is usually not needed since the cartilage typically matures over time. As such, Dr. Thomas Gilbert at Pitt is leading efforts to develop a degradable metallic stent. Two studies begun in Winter 2010 consist of a) magnesium tracheal stents developed in collaboration with Dr. Prashant Kumta's group and evaluated in a rat model to determine the effects of the stent on existing and developing epithelium and b) magnesium reinforcement and replacement cartilaginous ring in a canine model. These studies will provide the first data describing the host response to magnesium structures in the trachea.



Mg ACL thoracic stent.

- Contributed by Sarah Luffy (Pitt)

Nerve Repair

The goal of this project is to make devices that use carbon nanotube (CNT) thread and magnesium to promote recovery of nervous tissues after injury. The first goal is a scaffold for peripheral nerve repair. Dr. Kacey Marra (Pitt) is placing UC-made CNT thread inside a biomaterial nerve sleeve that she developed, holding threads in place with a novel keratin gel made by KeraNetics (Wake Forest Univ.). The sleeve keeps the nerve ends in place while CNT thread promotes cell guidance across the gaps. CNT thread has physical and electrical properties that suggest superiority over other biomaterials for this purpose. Magnesium will then be added in wire form (wrapped with CNT thread), because ionic Mg aids recovery of nervous tissue after injury (by blocking calcium and glutamate ion channels). The Mg metal will deliver Mg ions locally, avoiding problems with blood-stream delivery. In preparation for this, Dr. Pixley's group at UC have developed cell culture assays for neural cell effects of CNT thread and Mg, vital steps before doing animal experiments. They have shown that, with an optical counting method and a crystal violet staining and plate reader rapid assay, neural stem cell numbers increase with 3-10 mM, but decrease with 20 mM or higher Mg ions. They have also begun tests on Mg effects on injured neural cells in cell culture.

- Contributed by Dr. Sarah Pixley (UC)

ERC-RMB member profiles

The people and companies
behind the **ideas**



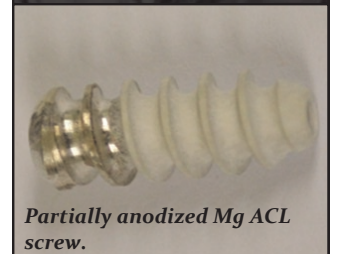
STUDENT PROFILE

Catherine Kunkle Hagandora is a second-year graduate student at the University of Pittsburgh. After receiving her B.S. in Medical Physics from Presbyterian College in 2009, Catherine started pursuing her Ph.D. in Bioengineering under the direction of Dr. Alejandro Almarza. Her research is focused on utilization of novel biodegradable magnesium alloys to enhance temporomandibular joint (TMJ) prosthetic devices. In order to determine the impact of magnesium on the cartilaginous tissues of the joint, she is assessing the effect of pure magnesium on the extracellular matrix production of fibrochondrocytes using a scaffoldless approach. She has also been assisting with establishing the design criteria for a biodegradable magnesium screw for a TMJ implant. In the future, Catherine plans to investigate the effect of magnesium alloys on the extracellular matrix regeneration potential of various cell types *in vitro*.

FACULTY PROFILE

Dr. Yeohung Yun is an Associate Professor in the Bioengineering Department at NC A&T. Dr. Yun received his Ph.D from UC where he also served as Research Assistant Professor in the Smart Materials Nanotechnology Laboratory. His research group objective with the collaboration of UC and Pitt as a team is to study and provide a scientific understanding of corrosion and corrosion control methods for biodegradable or resorbable metals. "Biodegradable and resorbable" refers to the electrochemical corrosion or degradation of magnesium metal. The role of his group in the ERC-RMB is to evaluate the initial corrosion and degradation of new ERC-RMB-designed materials and transfer the accumulated knowledge to specific bio-application groups. Two students involved in this research, Mitesh Oswal (UC) and Venkataraman Giridharan (NC A&T), are developing a simulation model of Mg corrosion. Dingchuan Xue (UC), Leon White (NC A&T), and Dr. Seonghyuk Ko (NC A&T) are studying corrosion and corrosion inhibition methods. Dr. Zongqing Tan (UC) is developing the animal model.

A course taught by Dr. Yun with students enrolled from both NC A&T and Pitt entitled, "Corrosion and Medical Microdevices," was specifically designed to provide a better understanding of Mg degradation and techniques for fabricating novel sensors and devices. It is one of the first courses of the newly established NC A&T Bioengineering Program for undergraduate and Master's level students (for more on the Bioengineering Program and its new faculty at NC A&T, see pages 8 and 9).



Partially anodized Mg ACL screw.

INNOVATION PARTNER PROFILE

Johnson & Johnson is one of the ERC-RMB's largest partners, a \$64 billion conglomerate. The ERC is working with a subsidiary of J&J, Advanced Technologies and Regenerative Medicine (ATRM), a research and development company with a focus on regenerative medicine, drug and biologic device combination products, and implantable devices. One of the projects ATRM and the ERC-RMB are collaborating on is the design and testing of biodegradable surgical screws for ACL repair. Surgical screws are one of the most common orthopedic implant devices, and the development of a satisfactory biodegradable screw would be a watershed event. To help make the idea a reality, ATRM is collaborating closely with the ERC in the design of screws and is assisting in the execution of critical initial *in vivo* tests, which are key to making biocompatible screws possessing the appropriate biodegradation properties.

Johnson & Johnson

EDUCATION & OUTREACH

Students and faculty in the ERC-RMB are dedicated not only to their research, but also to making an impact in their local communities and in the lives of the next generation of scientists.



Mitesh Oswal (L) and John Vennemeyer (R) use dry ice to demonstrate how magnesium burns in the presence of CO₂ as a Mount Healthy class watches.

UC Students Teach at Local Junior High

Five students from the University of Cincinnati spent a day at Mount Healthy Junior High teaching science as part of their partnership with local schools. Graduate students taught lessons to eighth-graders in their areas of research as it pertained to biodegradable metals. "A facet of this grant is pre-college education and community outreach," said John Vennemeyer, who is pursuing a doctorate in biomedical engineering. "Mount Healthy is the first school in Cincinnati that we have given lectures and we hope to continue working with them." Vennemeyer, along with fellow students Xuefei Guo and Julia Kuhlmann, who are both doctoral students in chemistry, Mitesh Oswal, who is working on a master's in mechanical engineering, and Dingchuan Xue, who is pursuing a doctorate in chemical and materials engineering, presented various lessons, video and lectures to four classes.

- Adapted from Northwest Press (August 2010)



UC student Xuefei Guo shows a PowerPoint lesson on pH balance and answers questions from junior high students.

Bioengineering Institute Summer Camp

The 2nd Bioengineering Institute at NC A&T was a weeklong event in which students from high schools participated in activities designed by Bioengineering and Nanotechnology undergraduate and graduate students at NC A&T in collaboration with Innovation Partner, Pittsburgh Tissue Engineering Initiative (PTEI). During the course of the week, the campers were exposed to a variety of bioengineering learning modules

such as stem cell and yeast culturing, blood vessel synthesis, use of biotechnology laboratory equipment and practices, and bioethics. The camp also exposed the students to principles inherent within bioengineering concepts, such as fluid viscosity and friction testing, materials science, biomechanics, and biochemistry, as well as the conceptualization of nanotechnology in terms of scale, practical applications, and manufacturing processes. The program was coordinated and supervised by Dr. Cynthia Waters, NC A&T Adjunct Professor in Mechanical Engineering and Associate Director for Education & Outreach for the ERC-RMB.

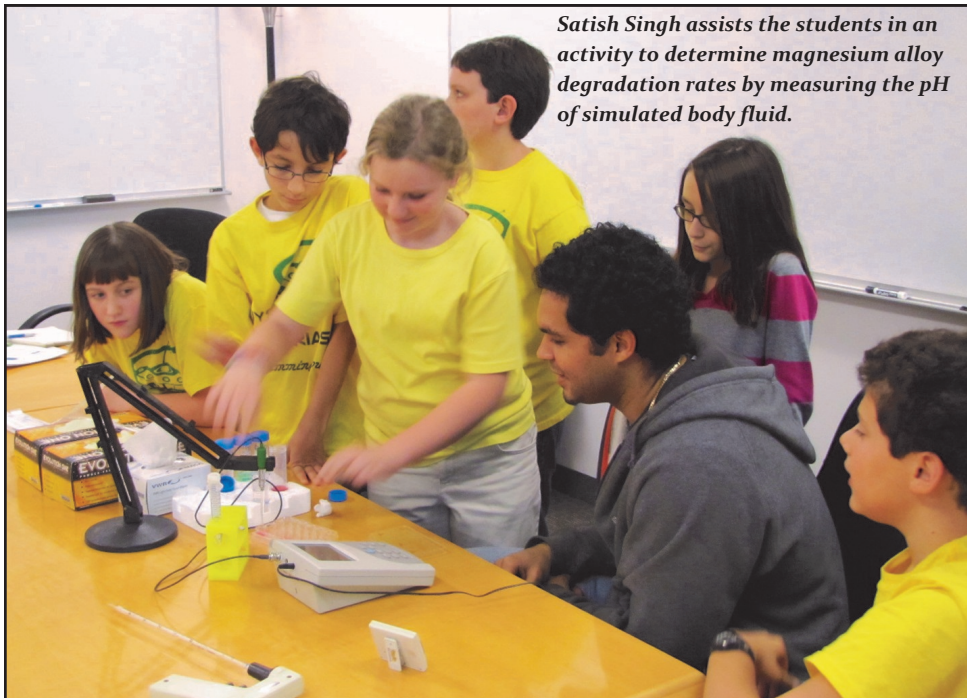
Students gained exposure to research practices and emerging technologies related to work within the ERC-RMB and PTEI. The students were able to prepare stem cells and observe the cells' ability to grow across a simulated wound. With the facilities provided by Dr. Noble, Departmental Chair for Animal Science, and Dr. Jenora Waterman of Animal Science, the students were not only able to prepare the stem cells in an actual research environment, they were also able to monitor the growth of the stems cells using inverted microscopy. Yeast cultures were grown to expose the students to toxicity of living tissue and how this can regulate tissue growth during magnesium degradation. The blood vessel synthesis activity provided an opportunity for the students to learn about how blood vessels work, and how they are manufactured artificially and expected to work by design. The friction testing activity introduced the students to the types of surfaces within the body that, by design, demand a proper surface condition. Finally, students debated relevant subjects in bioethics to attempt to come to a consensus on solutions for each issue. This gave the campers the opportunity to voice their own opinions based on their own moral codes and how that related to thought-provoking topics such as stem cell research, tissue engineering and implementations, and the marketability of FDA regulated products.

The student response to the camp was overwhelmingly positive, changing their perception of science, technology, engineering, and math (STEM) related careers, and showing that these career paths hold vast opportunity and involve a variety of interesting subjects. Some of the students even experienced an epiphany throughout the week and underwent a polar change in their original opinions regarding STEM based careers. The program was also featured on NC's only statewide news channel:

http://triad.news14.com/content/top_stories/628680/n-c--a-t-state-hosts-bioengineering-workshop-for-high-schoolers?ap=1&MP4

After only one week, the goals of this education and outreach program were met by inspiring these high school students to consider a future in bioengineering.

- Contributed by Jason Bartlett (NC A&T)



Satish Singh assists the students in an activity to determine magnesium alloy degradation rates by measuring the pH of simulated body fluid.



Andrew Brown leads a discussion on magnesium degradation.

ment of magnesium orthopedic devices and their possible applications.

The Pittsburgh Tissue Engineering Initiative has been an excellent outreach partner for the ERC-RMB, providing a number of events to educate aspiring engineers and scientists about its work. Even more events are sure to come in the future.

- Contributed by Andrew Brown (Pitt)

Pitt Students Volunteer for Science and Engineering Fair

ERC-RMB students at the University of Pittsburgh volunteered as judges for the 71st Pittsburgh Regional Science and Engineering Fair (PRSEF) held at Heinz Field from March 26-27, 2010. It was the 71st year of the competition, which is the third oldest science fair in the United States. The event was organized by the Carnegie Science Center and showcased the talents of over 1000 high school and middle school students from over 100 schools in Pennsylvania, Maryland, and West Virginia competing for over \$1 million in cash prizes, scholarships, and trips. ERC-RMB students assisted in judging primarily senior division Chemistry, intermediate division Medicine and Health/Micro-biology, and junior division Life Sciences. This was a great opportunity for ERC-RMB students to not only interact with highly motivated high school and middle school students, but also to network with other volunteer judges from surrounding academic institutions and companies, such as Alcoa, Bayer, and PPG. Students within the ERC-RMB will continue to volunteer at this great event as plans have already been made to take part in the 72nd PRSEF, which will be held at Heinz Field on April 11, 2011.

- Contributed by Satish Singh (Pitt)



View of the science fair from inside Heinz Field.

Pitt Students Hold Workshop for Team of LEGO Builders

Three graduate students from the University of Pittsburgh held a workshop in conjunction with the Pittsburgh Tissue Engineering Initiative (PTEI) to educate five middle school students on concepts of degradable metal design. The middle school students were involved in the First Lego League (FLL), which allows students to explore actual engineering challenges by designing and building LEGO robots to complete tasks in a thematic playing surface. The students were faced with the 2010 Body Forward™ Challenge, where teams explored the cutting-edge world of Biomedical Engineering to discover innovative ways to repair injuries, overcome genetic predispositions, and maximize the body's potential, with the intended purpose of leading happier and healthier lives. Team Nysmith eXtra Terrestrials (NXT) won

their regional competition using tissue engineering and regenerative medicine as their theme, so their advisers arranged a visit to the University of Pittsburgh to see real-world applications of these fields.

Andrew Brown from Dr. Sfeir's lab and Satish Singh and Da-Tren Chou from Dr. Kumta's lab presented an interactive overview of bone tissue engineering and the limitations of currently available orthopedic biomaterials. Next, the middle school students were introduced to the concepts of degradable metals and the degradation mechanism of magnesium alloys. This introduction to principles of degradable metals culminated in an activity measuring the pH of different magnesium alloys degrading in simulated body fluid. The middle school students were able to successfully grasp the concept of using pH to measure magnesium alloy degradation and had many questions about the develop-

EDUCATION & OUTREACH

NC A&T Hosts National Educators Workshop National Conference

The National Educators Workshop (NEW) <http://www.nationaleducatorsworkshop.com/>

is an excellent example of dissemination and professional development efforts at the ERC. NEW was successfully held on March 7-9, 2010 in Greensboro, NC, hosted by NC A&T, in conjunction with the ERC-RMB's Outreach partners Edmonds Community College (EDCC) in Edmonds, WA, Guilford Technical Community College (GTCC) in Jamestown, NC, and the Guilford County Schools System (GCS). The 128 attendees (representing national and international educators and student participation) became well versed in the activities of the sponsoring organizations: the National Science Foundation; the ERC-RMB at NC A&T; the National Resource Center for

Materials Technology Education (MatEd), the Center of Excellence for Aerospace and Advanced Materials Manufacturing at EDCC, the Materials Science and Engineering Laboratory/National Institute of Standards and Technology (MSEL/NIST) in Gaithersburg, MD, the NC Biotechnology Center (NC Biotech), and Sandia National Labs.

The liason developed between NC A&T, MatEd, EDCC, NIST, Sandia and NC Biotech as a result of NC A&T hosting the 2010 NEW event in Greensboro represents the kind of relationship building that the ERC-RMB influence network is developing which directly contributes to long term sustainability as well as impact of the ERC-RMB in the next generation workforce.



New Bioengineering Degree Programs Introduced at NC A&T

In June 2010, the University of North Carolina General Administration approved NC A&T's proposals to establish B.S. and M.S. degree programs in bioengineering. The programs stem directly from the education and outreach commitment of the ERC-RMB and mark a critical milestone as the nation's first seamless bioengineering degree offerings on a stand-alone basis at a historically black college or university. The BS and MS bioengineering programs have already started to attract a truly interdisciplinary student body, with current students drawn from fields such as chemical, electrical, and mechanical engineering, physics, chemistry, and biology. As has been seen at other institutions, there is already an outstanding participation by



students are also being achieved through the ERC-RMB's global research partner Hannover Medical School (MHH) in Germany and the Indian Institute of Technology Madras (IITM) in India.

The bioengineering programs are housed in NC A&T's Department of



Christopher Smith (seated right) is one of the first students of NC A&T's new Bioengineering program.

Chemical and Bioengineering. With ERC-RMB cost-share support funds from the University, the department has hired four bioengineering faculty members (**faculty profiles on page 5 and 9**) and is currently recruiting a fifth member to support collaborative research between NC A&T's Bioengineering and Biology Departments and the ERC-RMB. Undergraduate and graduate curriculum and lab development received strong technical support from the Pitt Department of Bioengineering with mutual faculty, staff, and student visits. NC A&T, Pitt and UC have developed a successful model of live video trans-ERC graduate course offerings leveraging the research strengths of each institution. Seminars on creativity, innovation, entrepreneurship and the regulatory process are also being offered on a trans-ERC basis.

female students

education and outreach plan. Global research and education experiences for these

NEW BIOENGINEERING FACULTY AT NC A&T

Meet the new Bioengineering faculty members at NC A&T!



Narayan Bhattarai, Ph.D.

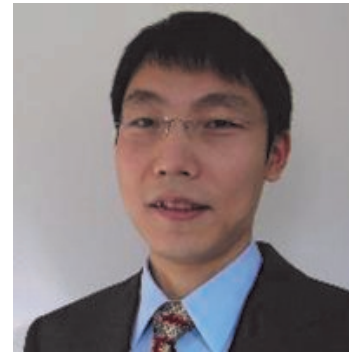
Before joining NC A&T, Dr. Bhattarai was a senior researcher at the University of Washington, Seattle, where he engaged with the UW Engineered Biomaterials- ERC projects. His research and teaching interests lie at the interface of materials engineering and biology, primarily in the field of biomaterials, polymer science, nanomedicine and tissue engineering. Previously, his research has focused on design, synthesis, and characterization of biomaterials for drug delivery, tissue regeneration and implants. By collaborating with the interdisciplinary faculties and researchers of the ERC-RMB, Dr. Bhattarai plans to surface engineer Mg-based biomaterials by a responsive coating that will allow reproducible drug delivery characteristics in the presence of external stimuli such as temperature, pH, and oscillating magnetic field. The coating comprises magnetic particles, therapeutic drugs and stimuli responsive polymers. Biomaterial surfaces will be engineered in such a way that it will behave as an "on-demand" type of drug delivery device where drug release characteristics will be controlled by the application of oscillating magnetic field and environmentally responsive behavior of polymers. In addition, the novel surface engineering techniques developed from this study will also improve tissue-implant integration at the site of implantation.



Matthew McCullough, Ph.D.

NC A&T Alumnus Matthew McCullough graduated from NC A&T in 2001 with a B.S. degree in Industrial Engineering. Dr. McCullough obtained his Ph.D. in Biomedical Engineering from the University of Iowa, under the advisorship of Dr. Nicole Groslund. His research focused on hand and wrist musculoskeletal biomechanics, focusing on total wrist arthroplasty and upper extremity kinematics. This experience was especially rewarding as Dr. McCullough was afforded the opportunity to work with Dr. Brian Adams, a well-known hand surgeon. In the summer of 2006, he began a post-doctoral fellowship at Mayo Clinic, working on orthopedic biomechanics and physiology cellular imaging laboratories. This provided the opportunity to work with outstanding clinical and research mentors like Drs. Kainan An, Kenton Kaufman, Gary Sieck, Ann Reed, Harold Kitaoka, as well as others. His research at that time focused on non-invasive imaging of muscle tissue as well as cadaveric studies of the foot and ankle.

Dr. McCullough's goal in the ERC-RMB includes educating undergraduate, and graduate students, as well as the general community in biomechanics and biomedical engineering. This will include research on the mechanical properties of biodegradable metals, as well as the surrounding environmental responses to these materials. This will be done from both theoretical (computational analysis) and experimental perspectives (material testing). He is planning to collaborate directly with Dr. Savio Woo at Pitt and Drs. Ram Mohan and Jenora Waterman at NC A&T, as well as the other bioengineering faculty.



Donghui Zhu, Ph.D.

Dr. Zhu received his Ph.D. in Biomedical Engineering from the University of Missouri-Columbia, after which he served as a post-doctoral researcher at the University of Rochester Medical School. In 2010, he published a book entitled, *Astroglial cells are not just bystanders in Alzheimer's: Oxidative stress and Alzheimer's amyloid-beta peptide on astrocytes*. The book provides meaningful insight into the mechanisms of how oxidative stress produced by excess reactive oxygen species and amyloid beta peptide affect astrocytosis, an abnormal increase in astrocyte number in the brain, critical in the pathogenesis of brain injuries and neurodegenerative diseases including Alzheimer's disease.

As assistant professor of Bioengineering at NC A&T, Dr. Zhu's research group now investigates: (1) Biocompatibility analysis of metal materials such as magnesium and its alloys; (2) Cardiovascular and neurovascular disease models as well as related physiopathology and therapeutic treatment; and (3) Novel nanomedicine for drug delivery and wound care. Various multidisciplinary approaches and techniques are applied to study the projects, including routine biochemistry analysis, cell/tissue culture, live cell imaging using confocal microscopy, animal models, etc.

The Year 1 review of the ERC-RMB by the NSF identified opportunities for overall organization and planning related to the objectives and goals. In response to this, the ERC-RMB leadership with input from the SLC and students defined a strategic plan that was presented as a part of the Year 2 review to the NSF. This new plan clearly outlines a framework which will guide the ERC-RMB toward its long term goals of delivering devices using biometallic implants for the following areas: craniofacial/orthopedic applications, cardiovascular and thoracic devices, and responsive biosensors and neural devices. The 3 layer chart (upper right) adds the layers of 'Enabling Technologies' and 'Fundamental Knowledge' to support the 'Engineered Systems' or ES layer which was defined during Year 1.

The ERC-RMB has also developed a strategic plan (lower right) which identifies the Thrust Areas that define paths toward marketable devices as well as commercialization of spinoff technologies. The three 'Thrusts' are **Materials Development**, **Processing and Characterization**, and **Biocompatibility/toxicology/biosensors**. In addition to inputs from the industrial advisory board (IAB), this strategic plan will be supported by inputs from our newly empaneled clinical advisory board (CAB) and regulatory experts. All ERC-RMB projects will support this strategic plan.

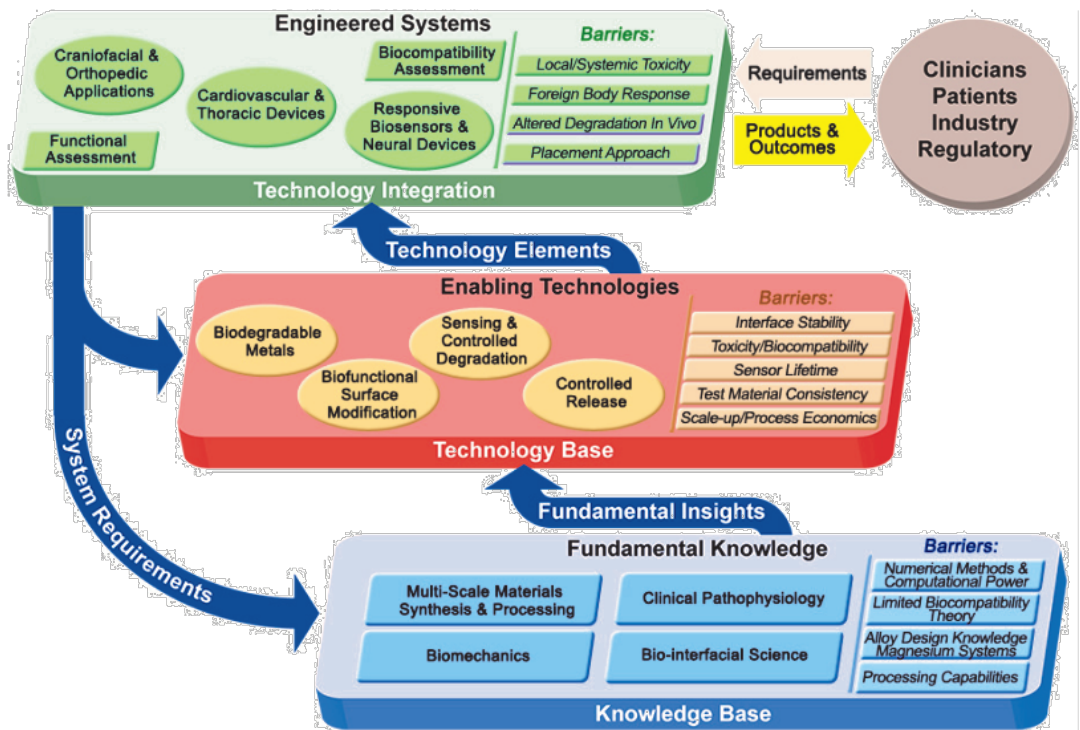
A plan for developing an ERC RMB database has also been proposed during Year 3. This database will support the strategic plan by acting as the repository for all research data related to all the thrust areas. The long term goal for this database is to be a "living repository" to be used by both industry and the research community as a knowledge base for materials selection that fits specific research goals and applications.

- Contributed by Giri Venkataraman (NC A&T)

REVISED STRATEGIC PLAN

A path to revolutionize metallic biomaterials.

3 LAYER CHART



STRATEGIC PLAN



2ND ANNUAL NSF SITE VISIT

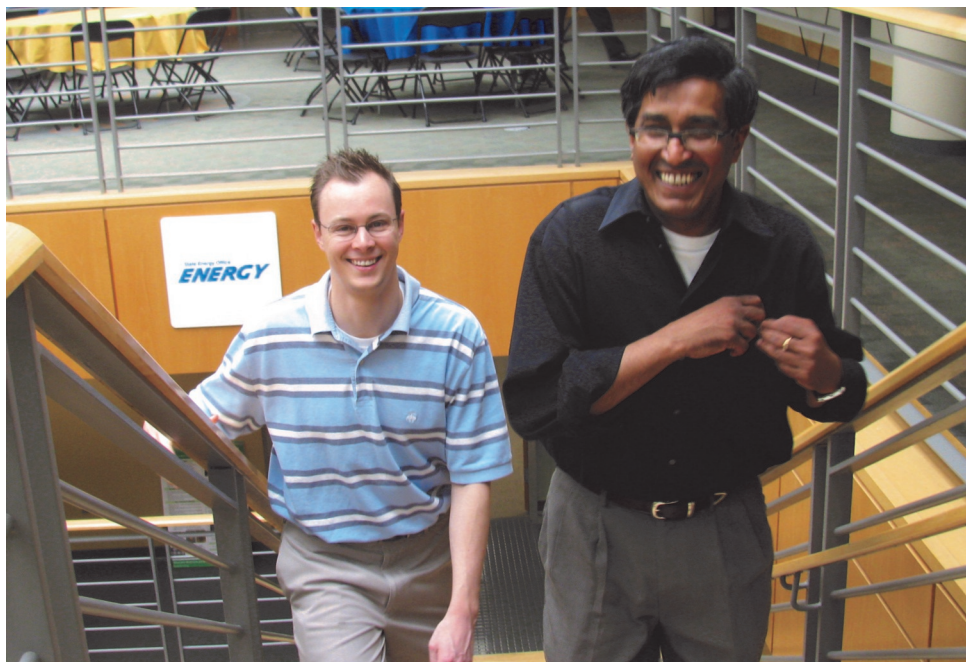
The ERC-RMB welcomed the NSF site visit team to NC A&T on May 25-26, 2010 for the Second Annual Site Visit. The esteemed team members were comprised of: Dr. Robert Bonner (NIH/NICHD/LIMB), Dr. Karen Burg (Clemson University), Dr. Barry Lieber (SUNY Stony Brook), William Herman (Office of Science and Engineering Laboratories, FDA), Dr. Richard Straight (University of Utah Research Park), Dr. Marvin Thrash (Miami University), Dr. John White (Vascular Surgeon, Niles, IL) and Dr. Leon Esoterowitz (NSF).

The purpose of the site visit was for the NSF to assess the strengths, weaknesses, threats, and opportunities of the program and provide recommendations for the direction the ERC-RMB should take moving into its critical third year. After opening words from Directors Drs. Sankar and Borovetz, Dr. Wagner discussed one of the main developments made in the past year: the definition of a revised Strategic Plan (page 10). The focus of the first morning was to highlight year two data, outcomes, and accomplishments and their potential scientific impact keeping in mind industrial and clinical applications. Thus, the first scientific presentations were given on the specific devices targeted by the ERC-RMB (page 4), followed by presentations on the three thrusts of the Strategic Plan aimed to define paths for the delivery of the marketable devices, as well as a talk by Global Site Coordinator Dr. Witte. The afternoon began with highlights of center research during a poster session presented by graduate students, followed by presentations on ERC-RMB education and outreach, assessment, and diversity activities. The Student Leadership Council presented their past year's achievements

in a closed-door session with the visitors, also giving their evaluation of student participation in the ERC-RMB and voicing any concerns. Day 1 concluded with a presentation on the ERC-RMB's industrial partnerships and collaborations, and finally an executive session of the site visit team, in which the visitors formulated key questions and recommendations regarding program research, as well as industrial and clinical impact.

Day 2 began with an early morning question and answer session with the site visit team, NC A&T administrators, partner university administrators, and ERC-RMB directors. The involvement of representatives from NC A&T, University of Pittsburgh, University of Cincinnati, and Hannover Medical School showed the profound dedication of each institution towards the continued success of the ERC-RMB and an appreciation for the NSF ERC award for bestowing such far-reaching opportunities to have a lasting impact. The questions posed by the site visit team from the end of Day 1 were then addressed in presentations made by the ERC-RMB leadership team, with plans for the upcoming year, such as the creation of a Clinical Advisory Board to increase understanding of critical clinical needs and to help guide medical device development. Day 2 was concluded with the site visit team composing a detailed report and analysis to the NSF. Feedback from the NSF has been very positive, and the ERC looks forward to continue their year 2 momentum into year 3 in areas such as manufacturing and testing of biodegradable metallic medical devices.

- Contributed by Da-Tren Chou (Pitt)



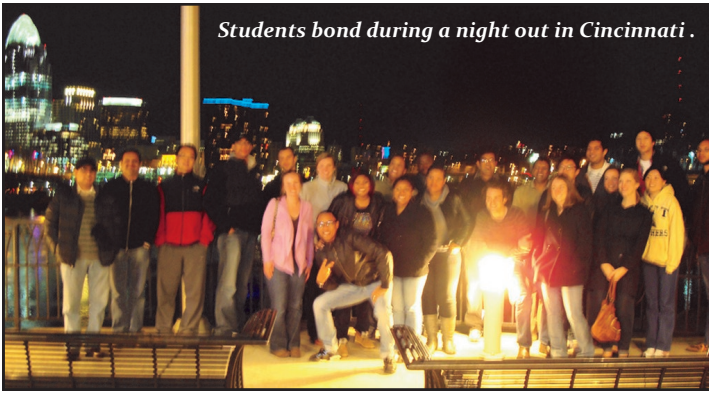
Former Pitt SLC President Dr. Matt Fisher (L) and Center Director Dr. Jag Sankar at the site visit.

2nd Annual Student-Faculty Day

The Student Leadership Council hosted the second annual ERC-RMB student-faculty day retreat on August 1st-3rd at NC A&T. The main focus of this year's retreat was the upcoming year 03 NSF site visit. The goals of the retreat were to communicate expectations and to start preparations for the year 3 site visit. The ERC-RMB leadership laid out a clear and concise vision on research plans, industrial outreach, product expectations, and material database updates to be completed this year. Several students and staff had the opportunity to share with the rest of the program their research activities and results. The retreat also created an ideal environment to have an open discussion on improving the effectiveness of ERC-RMB research, expanding collaboration between the different components of each school as well as with industrial partners, and the overall progression of the ERC-RMB program.

New staff members, Dr. Matthew McCullough, Dr. Narayan Bhattarai and Dr. Donghui Zhu were welcomed into the ERC family and the SLC took on new leadership with the introduction of its new presidents, Leon White of NC A&T, Satish Singh of Pitt, and John Vennemeyer of UC. Students and faculty also had an opportunity to enjoy 18 holes of putt-putt golfing at the Putt-Putt Fun Center in Burlington, NC. Overall, the second annual ERC student-faculty day retreat was a successful event. Through this annual retreat the ERC program is able to promote a sense of community among students and faculty and produce deliverables in the form of achievement plans and targeted outcomes.

- Contributed by Chris Smith (NC A&T)



Students bond during a night out in Cincinnati.

FIRST STUDENT DAY AT UC — A SUCCESS

During the weekend of February 18 – February 20, 2011, 7 graduate students from UC, 10 from the NC A&T, and 10 from the Pitt convened at UC for the inaugural ‘Student Day’, a student-led, student-organized and student-focused event intended to increase the impact of graduate students on the ERC-RMB.

After enjoying a night out on the town Friday, the students got to work early on Saturday morning. Throughout the day, students participated in seminars, a poster session, activities, and interactive discussions that focused on topics like the strategic plan of the ERC-RMB, standardization of protocols, internships, and translational research. On Sunday, UC students guided students from Pitt and NC A&T through the ERC labs at the University of Cincinnati. The event ended with a seminar on education and outreach where representatives from each school shared their outreach strategies with all of the students. This was followed by a brief SWOT analysis.

This event was hugely successful in the regard that it increased the volume and quality of communication between students, planted seeds for cross-university collaborations at the student level, and introduced the students to the basics of translational research, a topic that is critical to all NSF-ERCs. In a survey that was sent to students afterwards to evaluate their impressions of Student Day, every single student responded that they would like to participate in ‘Student Day’ events in the future. The SLC is looking forward to building on this success and is hoping to hold student-led events, like this one, every 6-months, with the next being during summer, 2011 in Pittsburgh.

- Contributed by John Vennemeyer (UC)

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