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Newsletter

2014

NSF ERC-REVOLUTIONIZING METALLIC BIOMATERIALS
(ERC-RMB) STUDENT ASSOCIATION

From the desk of Director Sankar

Welcome to the fifth student-generated newsletter of the Engineering Research Center for Revolutionizing Metallic Biomaterials (ERC-RMB). Our Gen 3 ERC's mission 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.

Over the years of the ERC-RMB's existence, it has been incredibly satisfying for me personally to observe the growth in maturity and communications skills of our Student Leadership Council membership as they rally behind the Center philosophy "One Team, One Dream" and report on the Center's outstanding accomplishments on multiple fronts. My colleagues and I are truly excited about the intellectual growth and leadership of these ERC-RMB students—our next-generation innovators and thinkers.

With our motto of "One Team, One Dream", our Year 6 research efforts demonstrate the maturation and refocusing of Years 3-5 projects, with greater engagement by clinicians and industry collaborators in order to focus on translational opportunities. In particular, the development, processing and testing of novel degradable alloy systems has emerged to be of strategic interest among ERC-RMB member companies. In Year 06, the ERC-

RMB also engaged with industry and the global community through ASTM-ISO to develop *in vitro* and *in vivo* testing standards.

We enhanced opportunities for industrial engagement by successfully initiating revisions to the Membership Agreement during this reporting year. On October 25, 2013, InCube Labs, LLC, entered into an option-to-license agreement to explore the translational potential of ERC-RMB materials-based technologies for orthopedic applications. This collaboration between InCube Labs and the ERC-RMB represents a key validation and critical step in moving center technology toward commercialization. SBIR/STTR/SECO grant activities with nanoMAG/Thixomat and OrthoKinetics Technologies became further synergized and mature.

Additionally, advances in ERC-RMB science have been matched by ERC-RMB milestones in education and outreach. In 2013-2014, ERC-RMB/NCAT saw the history-making graduation of its first BS and MS students from the nation's 1st seamless offering of undergraduate and graduate bioengineering programs at an HBCU.

ERC-RMB students and staff have garnered national and international recognition and citations. Their accomplishments and leader-



Dr. Sankar appearing on a UNC-TV feature discussing ERC-RMB research at NC A&T.

ship achievements are proudly documented on our website, <http://erc.ncat.edu>.

On behalf of the entire ERC team, I also take this opportunity to extend special appreciation to our Educational Advisory Board, Clinical and Scientific Advisory Board, and Industrial Advisory Board (EAB, CSAB and IAB) members for their incredible dedication and time.

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-RMB Center Director

Welcome to the 2014 issue of the student-produced ERC-RMB newsletter. This has been an astonishing year for our center as we broadened the level of scientific research while increasing our impact on our communities. The Student Leadership Council (SLC) is pleased to report the outstanding progress we made in research activities, educational and outreach, and student accomplishments. Featured articles include knowledge gained

from student travel and conferences. We saw a significant increase in research collaboration as students visited member institutions to advance their objectives. The talent in our center was showcased in the highest level as Leon White obtained recognition from the White House. The SLC was able to host professional development workshops throughout the year and as part of our Student Retreat in order to increase awareness

of opportunities after graduation and discuss ways to effectively obtain a career in industry. Graduated students have successfully transitioned into professional careers as showcased through the alumni highlights.

As always, we greatly commend the effort put forth by our newsletter team, editors Jingyao Wu and Da-Tren Chou, as well as the continued support and guidance from the ERC-RMB leadership team.

SLC Co-Presidents: **Leon White**
North Carolina A&T (NC A&T)

Yonghai Zhang
University of Cincinnati (UC)

Satish Singh
University of Pittsburgh (Pitt)

A closer look at projects
within the ERC-RMB

Research Highlights

Thrust 1: New Materials Development

Extruding Novel Alloys: Researchers at NC A&T over the past year successfully equipped their lab with a hot extrusion press to generate long, thin rods of as-cast Mg alloys. This is a major milestone for the ERC-RMB because of the enormous improvement in alloy properties that come as a result of extrusion. Dr. Zhigang Xu and Dr. Yongjun Chen set up the equipment, and have extruded well over a dozen alloys from novel compositions from NC A&T and Pitt. Testing on these extruded alloys has shown a reduction in corrosion rate and increase in strength, with alloy peak strength reaching up to 565 MPa, which surpasses that of all other reported biomedical Mg alloys!

Growing Single Crystals: Dr. Shanov and his team at UC are growing magnesium single crystal growths to provide a more defect free and corrosion resistant material. High purity single crystals with different dimensions and sizes were grown using the Bridg-

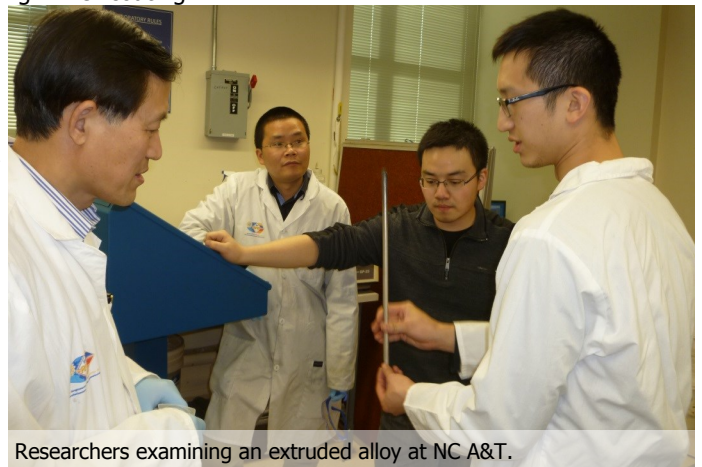
man directional solidification approach in this innovative work.

The Mg single crystal has excited researchers throughout the ERC-RMB, with a number of collaborations taking place to test and modify the single crystal Mg. PEO coating was applied as described in the Thrust 2 research highlight below. The crystal's microhardness, tensile strength, and toughness were also improved by uniaxial compression cold work.

In vitro and *in vivo* testing of the crystals has been performed throughout the ERC, including single crystals being implanted into mice subcutaneous tissue by Dr. Dong and manufac-

tured into the ACL healing ring and implanted into a goat model (as described in Thrust 4). In the future, alloy single crystals will be grown using compositions from ERC collaborators to diversify the range of materials.

- Madhura Joshi (UC) & Da-Tren Chou (Pitt)



Researchers examining an extruded alloy at NC A&T.

Thrust 2: Coatings, Characterization, & Modeling

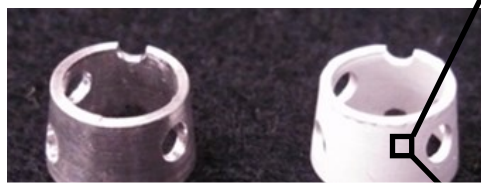
Efforts to improve the degradation performance of Mg-based biomaterials have led researchers to focus on novel methods in materials design, composition and surface modification. Surface modification in the form of a coating is one of the most effective ways to reduce degradation as the coating is able to protect the substrate by providing a barrier between the metal and the environment. The plasma electrolytic oxidation (PEO) (interchangeably called micro-arc oxidation [MAO]) method is being used in the ERC-RMB to place a ceramic-like coating onto Mg in order to reduce its degradation rate. This coating process is able to offer improved wear resistance and hardness, while allowing for controllable coating thickness and porosity, which is a result of the coating process. A porous coating would help to increase cell adhesion, alignment, and tissue integration. Also, with the specific method used in the ERC-RMB, these coatings are non-toxic which is critical for biomedical applications.

Since this coating method is able to coat both simple geometries such as flat surfaces as well as complex geometries such as screws, plates, and pins, it has become very useful. Recently, collaboration between NC A&T and Pitt has resulted in application of a coating to a single crystal Mg implant for anterior cruciate ligament (ACL) repair in the knee of goats. An initial study found that the rings were degrading too quickly, leading to the use of PEO to slow the degradation process to levels more consistent with healing of the ACL.

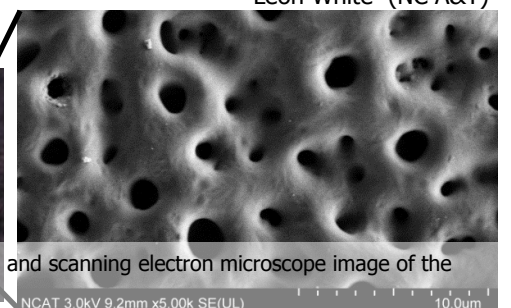
The ERC-RMB published related work recently in a special issue of "Emerging Materi-

als Research" and in the conference proceeding for the ASME 2013 International Mechanical Engineering Congress and Exposition. The future of PEO coating for biodegradable implants looks promising as researchers are now exploring multi-layer coatings that will help improve bioactivity and biocompatibility. With its cost effective nature and scalability for industrial use, PEO coatings for potential bio-absorbable Mg and Mg alloys can contribute significant value to the biodegradable coatings sector in the near future.

- Leon White (NC A&T)



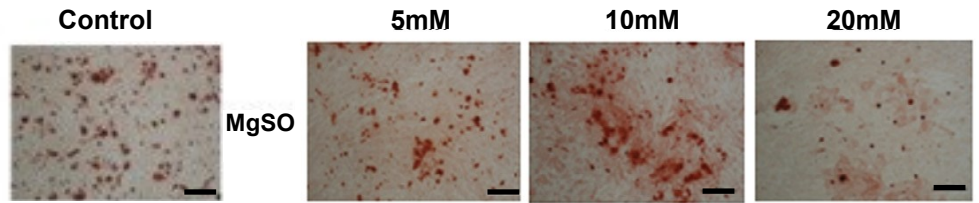
Left to right: Uncoated ACL ring, PEO coated ring, and scanning electron microscope image of the porous coating on magnesium.



and scanning electron microscope image of the porous coating on magnesium.

Thrust 3: Biocompatibility Testing

Since the ERC-RMB's inception, one of the basic science research objectives has been to identify the genes and signaling pathways that are affected by degrading magnesium. Many groups have shown magnesium to increase cell proliferation *in vitro* and enhance bone regeneration *in vivo*, but no one has identified the specific mechanisms leading to these phenomena.



Images demonstrating 5 and 10 mM $MgSO_4$ induced higher deposition of mineral (stained red) from the cells used in this study (scale bar is 200 μm).

Research associate professor Sayuri Yoshizawa, graduate student researcher Andrew Brown, and Biocompatibility Testing Thrust leader Aaron Barchowsky joined ES-1 co-director Charles Sfeir to perform an in-depth study of cell proliferation, osteogenic gene expression, matrix mineralization, and product synthesis by bone marrow stromal cells in the presence of magnesium. Their work entitled "Magnesium ion stimulation of bone marrow stromal cells enhances osteogenic activity, simulating the effect of magnesium alloy degradation" was published in *Acta Biomaterialia* this past February. This work was the first comprehensive study of the signaling properties of magnesium in osteogenic pathways.

The collaborators identified several gene pathways that were up-

regulated that resulted in an increase of genes related to blood vessel formation. This blood vessel formation is vital for bone regeneration following injury and could be one of the reasons we observe enhanced bone formation around magnesium implants *in vivo*.

In addition to the identification of genes and proteins that were affected, this study identified gene and protein targets for further investigation to better elucidate the signaling effects of magnesium. Continued work on this topic could lead to a better informed alloy design process in order to best utilize magnesium's osteogenic inducing capabilities.

- Andrew Brown (Pitt)

Thrust 4: Medical Devices & Applications

At the Musculoskeletal Research Center, research in Dr. Savio Woo's laboratory focuses on developing magnesium devices to solve two significant problems with current orthopedic surgical procedures: soft tissue fixation and the long-term risk of developing osteoarthritis. Today, materials for orthopedic devices include inert metals (namely titanium and stainless steel) or degradable polymers, both with notable advantages and disadvantages. However, the properties of Mg make it well-suited to be an advantageous alternative to these materials as it is bioresorbable, has good mechanical properties, does not cause interference with MRI scans, and may promote bone regeneration.

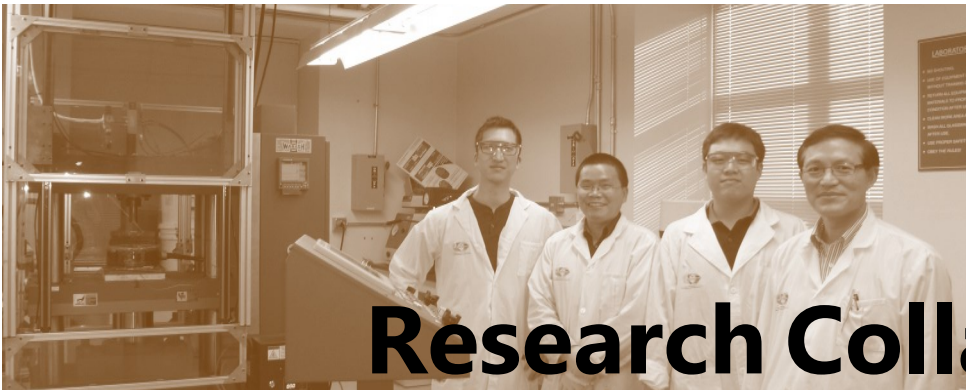
Thus, to address the aforementioned complications of orthopedic surgery, three devices: A) Mg-based interference screw anterior cruciate ligament (ACL) reconstruction, B) suture anchor for rotator cuff and acetabular labrum repair, and C) "ring" device for ACL healing have been developed (photographs below). *In vitro* work

in a cadaveric goat model has demonstrated the time zero efficacy of both the ACL screw and ring in restoring knee joint stability and function immediately after surgery, and ongoing *in vivo* work in a live goat model shows the potential of these devices to improve the healing outcome. With the success of the ACL screw for fixation of an ACL replacement graft, the suture anchor has recently been designed for other applications of soft tissue fixation. This work has recently been highlighted in the *Journal of Biomechanics'* Special Issue on Functional Tissue Engineering in an article titled, "Revolutionizing Orthopedic Biomaterials: The Potential of Biodegradable and Bioresorbable Magnesium-Based Biomaterials for Functional Tissue Engineering," written by ERC-RMB students and faculty, Kathryn Farraro, Kwang Kim, Dr. Savio Woo, Jonquil Flowers, and Dr. Matthew McCullough.

-by Kathryn Farraro (Pitt)

Mg-based devices for orthopedic surgery being developed by Dr. Woo's group: (A) the ACL screw, (B) ring device, and (C) suture anchor.





Research Collaborations

Within the Center & Abroad

Leon White Works with UC Researchers to Develop Nerve Regeneration Technology

Leon White, a PhD candidate in Dr. Yeohung Yun's lab at NC A&T visited Dr. Sarah Pixley's lab at UC in January, 2014 to increase collaboration between UC and NC A&T on a project that is focused on peripheral nerve repair in small animals. Currently, the only method to repair nerve injuries in long gaps (>1.5 cm in humans) is the autograft, however due its low success rate, new strategies are needed to bridge the gap between the two nerve stumps to facilitate nerve regeneration. Researchers at UC and NC A&T are now attempting to use Mg to provide contact guidance between the two nerve stumps to provide a means for nerve regeneration. Leon is interested in developing biocompatible coatings that will slow the corrosion rate of these Mg implants which will allow time for full recovery. Leon's coating (described in Thrust 2, page 2) successfully slowed corrosion *in vitro*, demonstrating that the technology is ready to move into *in vivo* testing.

While at UC, Leon was able to spend two days learning about and observing a series of experiments that will help bring knowledge to his research from the biological side. Leon was able to learn about basic sterile cell culture technique while observing Kolade Ojo (graduate Student with Dr. Heineman) and Tracy Hopkins (lab technician in Dr. Pixley's lab). Also, Leon was able to look on as the first set of animals were sacrificed as part of an experiment that involved implanting Mg to repair nerves. He was able to visit the lab of Dr. John Lorenz (an electrophysiologist at UC) where he observed students testing nerve-muscle connections in rats.

Leon also had the opportunity to visit the lab of Kati LaSance, Director of the Vontz Core Imaging Lab (VCIL) where he was able to gain valuable knowledge about the capabilities of the powerful imaging tools and methods available at UC. The university's expertise in biological and cytocompatibility testing allowed Leon to identify steps



From right to left: Tracy Hopkins, Dr. Sarah Pixley, and Leon White during his visit to UC.

that would need to be taken to enable successful implementation of the coated Mg in animal models. From discussions with Dr. Pixley, he is working to perfect measures to analyze cell attachment to the Mg wires that will be implanted and methods of working with Mg wire for cell culture. In addition to collaborative discussions with

the Pixley Lab, Leon was provided a tour of other parts of the campus where he got a sense of other research being performed at UC. This visit laid the groundwork for what is sure to be an impactful collaboration between ERC-RMB thrusts.

- Leon White (NC A&T)



Leon with Dr. LaSance using a MicroCT imaging system.

Collaboration Across Continents: Avinash Patil Teams-up with German Lab

In November 2013-February 2014, Avinash Patil, a bioengineering graduate student in Dr. Beniash's lab at Pitt, visited the Underwater Technology Hannover (UWTH) Institute of Leibniz University in Hannover, Germany. Avinash spent three months working on a collaborative project in the laboratory of Dr.-Ing. Thomas Hassel. Dr. Hassel is division head of the UWTH and his research focuses is on water jet technology, underwater cutting, and welding.

Avinash's research aims to address the rapid corrosion and formation of hydrogen gas pockets at implantation sites of magnesium. He and Dr. Beniash established a collaboration with Dr. Hassel and the UWTH which has a long history of Mg research, especially with MgF_2 conversion coatings. The goal of the multinational project was to test how the combination of the MgF_2 coating and self-assembled Organosilane coating will affect the corrosion rate of several Mg alloys. New alloys with the novel coating method demonstrated that the addition of the self-assembled Organosilane coating on

top of the MgF_2 significantly slows down the rate of corrosion. The data generated from this collaboration has been submitted as an abstract to the 6th Symposium on Biodegradable Metals in Maratea, Italy. Finally, Avinash presented his work at the UWTH and received feedbacks from scientists working at the Institute. These suggestions motivated him to further explore the project in different avenues.

Overall, the exchange program was a wonderful experience for Mr. Patel. Avinash built a strong friendship with Michal Bauer and Inder Sarpal, members of Dr. Hassel's lab, who helped in day-to-day activities during his stay in Hannover. In addition to working in lab, he had the opportunity to travel to Berlin and Munich where he was exposed to German culture,

food, and different varieties of beer. Avinash's fruitful visit to Germany shows the potential for students to explore international collaboration to further progress research in degradable Mg alloys.

- Avinash Patel (Pitt)



Avinash Patil setting up equipment to measure corrosion of his test samples.

Students From Around the ERC-RMB Converge at NC A&T to Perform Research

In December 2013, Da-Tren Chou, Daeho Hong and Jingyao Wu, graduate students from Dr. Prashant Kumta's lab at Pitt, and Madhura Joshi, Pravahan Salunke, and Guangqi Zhang from Dr. Shanov's lab at UC, visited NC A&T to further inter-ERC collaborations.

The Pitt students visited Dr. Zhigang Xu's lab at NC A&T to initiate collaboration on magnesium alloy extrusion. Due to the existence of defects and non-homogeneity, as-cast materials usually exhibit insufficient mechanical properties and corrosion resistance. Performing material post-processing such as extrusion is extremely important to gain better material performance. The extrusion machine in Dr. Xu's

lab enables improvement of novel ERC-RMB alloys which will translate to improved function of medical devices developed within the ERC.

At NCA&T, Pitt ERC students learned the procedure of extrusion as well as the operation of extrusion machine. With the help from Dr. Xu and Dr. Chen, a post-doc in Dr. Xu's lab, the students successfully extruded all of the Mg alloy ingots they brought from Pittsburgh.

During the trip, Dr. Yarmolenko invited the students on a tour of his lab and mechanical testing facilities at NCA&T. Dr. Yarmolenko explained the key points of mechanical testing and offered suggestions based on his experience. He also provided insight into

maximizing the capabilities of data management and presentation available in the ERC-RMB Materials Database which he developed. Jingyao Wu also engaged in a fruitful discussion with Dr. Waterman on *in vitro* testing for the magnesium tracheal stent project which was extremely beneficial for Jingyao moving forward in his studies.

Madhura, Paravahan, and Guanqi worked with Dr. Yarmolenko and Dr. Fialkova during their stay in NC A&T, working to better understand properties of their novel magnesium single crystals. Through pole figure analysis, they determined that the orientation of the single crystals is close to the basal plane.

- Jingyao Wu (Pitt)



Dr. Zhigang Xu watches as Daeho Hong sets up equipment for extrusion.



From left to right: Paul McGhee, Madhura Joshi, Pravahan Salunke, and Dr. Sergey Yarmolenko discussing results from their visit.

AWARDS & RECOGNITION

White House Selects Leon White as Part of its First Class of HBCU All-Stars

The ERC-RMB had one of its proudest moments as Leon White, a doctoral student from NC A&T, was selected to be part of the inaugural class of Historically Black Colleges and Universities (HBCU) All-Stars. Leon is one of just 75 undergraduate, graduate, and professional students making up the All-Star class selected by the White House Initiative on HBCUs (WHIHBCU) based on their accomplishments in academics, leadership and civic engagement.

White, a recipient of a Title III, PhD Fellowship funded by a grant from the U.S. Department of Education, is a doctoral student majoring in mechanical engineering, and is also co-president of the ERC-RMB student committee.

Currently enrolled at 62 HBCUs, the All-Stars were selected from 445 students who submitted completed applications that included a transcript, resume, essay, and recommendation. The All-Stars will serve as ambassadors of the White House Initiative by providing outreach and communication with their fellow students about the value of education and the Initiative as a networking resource.

"Engaging with the next generation of leaders who will graduate from HBCUs and go on to make meaningful contributions to society is crucial to the success of our community, our country and our global competitiveness," said George Cooper, executive director of the WHIHBCU. "It is a privilege to announce



Leon White, HBCU All-Star ambassador of its inaugural class.

these 75 students who have demonstrated a commitment to both their own academic achievement and making a difference in their communities, and we look forward to working with them as partners in advancing President Obama's college completion goal."

Over the course of the next year — through social media and their relationships with community-based organizations — Leon and the other All-Stars will share promising and proven practices that support opportunities for all young people to achieve their educational and career potential. In addition, they will participate in regional events and web chats with Ivory Toldson, deputy director of the WHIHBCU, other Initiative staff, and professionals from a wide range of disciplines. They also will have opportunities to engage with other scholars to showcase individual and collective talent across the HBCU community.

"This latest distinction is one of many in Leon's graduate career here at North Carolina A&T State University. We are extremely proud of him," said Dr. Robin Coger, Dean of the College of Engineering. "Leon's research, his leadership and commitment to academic excellence, exemplifies the well-rounded, high-achieving engineers that our College is dedicated to producing."

-Terri Godwin (NC A&T COE Director of Communications)

Kathryn Farraro Awarded \$27,500 From Victories in Innovation Competitions

With the translational nature of the research done in ERC-RMB, one of its greatest themes is entrepreneurship. Laboratories are encouraged to work with the Office of Technology Management on protection of intellectual property related to their ERC projects, with hopes of spinning out a start-up company or finding a potential licensor or industry partner. Additionally, students are encouraged to get involved with various innovation-themed events and competitions to showcase their work and generate publicity to attract investors or industry partners. Indeed, many of the students in ERC RMB have achieved success in entrepreneurial events and competitions both at the university level as well as ERC-wide, with numerous top finishes over the past 3 years.



Kathryn Farraro (right) and Danielle Martin, winners of the University of Pittsburgh's Randall Family Big Idea Competition.

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Within the past year, the ERC-RMB has continued this success in entrepreneurship with two awards won by Kathryn Farraro, a 4th year PhD student in Dr. Savio Woo's lab at the Musculoskeletal Research Center at the University of Pittsburgh. Katie's work focuses of the use of a bioresorbable Mg "ring" device to assist in the repair and regeneration of the anterior cruciate ligament (ACL). This device could serve as a future alternative treatment option to the current gold standard of ACL reconstruction, where the

injured ACL is removed and replaced with a soft tissue graft.

In March of 2013, Katie won first place in the McGowan Institute's elevator pitch competition, with a \$7,500 research grant for her 90-second pitch of this novel technology. Then, in April of 2014, working with dual MS/MBA student Danielle Martin, Katie and the "Mg Ring" team won first place in the Randall Family Big Idea Competition. Sponsored by the university's Innovation Institute, this prestigious competition is held annually at the University of Pittsburgh to

help launch new and promising technologies in 4 major sectors: energy/sustainability, general/IT, healthcare/life sciences, and social innovation. The first place award included a \$20,000 prize, as well as commercialization workshops and valuable networking opportunities.

The ERC-RMB is proud of the entrepreneurial efforts and successes of its students and hopes to foster this spirit moving forward.

- Kathryn Farraro (Pitt)

ERC-RMB Students Win 2nd Place in Pittsburgh Health Innovation Case Competition

Three University of Pittsburgh Bioengineering graduate students and researchers in the ERC-RMB were on a team which placed second in the inaugural Pittsburgh Health Innovation Case Competition (PHICC), taking home a \$1000 prize. SLC members Andrew Brown, Amy Chaya, and Da-Tren Chou, and Katz MBA/Industrial Engineering student Emily Basara participated in the student-driven event founded and organized by Saik Kia Goh, a bioengineering graduate student at Pitt.

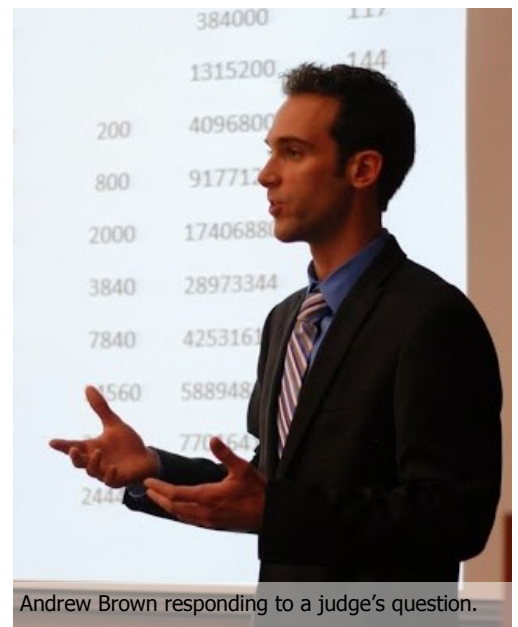
The PHICC, held on April 11, 2013, was distinct from usual innovation and business plan competitions where entrants pitch their own ideas and projects, in that the PHICC challenged all teams to build a consulting recommendation regarding the same technology. This format levels the playing field, giving the students the same starting point and pushing them to develop and leverage their analytical skills to make and support their recommendation. Because of the focus on consulting, the competition shed light on a career that many graduate students were otherwise not familiar with.

In this unique health care-focused case competition, the 12 student teams from universities throughout Pittsburgh were given a week to provide a solution to a business case in the healthcare arena. On the day of the competition, teams presented to a panel of judges comprised of specialists in innovation, entrepreneurship, consulting, and commercialization, coming from organizations including McKinsey and Company, SDLC Partners, Akamas Consulting, CE City, Innovation Works, and the University of Pittsburgh. With the esteemed group of judges and sponsoring companies from around Pittsburgh, the

case competition provided networking and recruiting opportunities for the companies and students involved.

The PHICC was a resounding success, attracting an audience that filled the engineering school hall to hear vibrant talks by invited speakers and the final round of presentations and judging. The success of the ERC-RMB students involved highlights the entrepreneurial spirit and interest in translating technology from benchtop to bedside which the center has imparted on its members.

- Da-Tren Chou (Pitt)



Andrew Brown responding to a judge's question.



From left to right: Amy Chaya, Da-Tren Chou, Andrew Brown, and Emily Basara presented with a check by head judge Jon Kowalski and PHICC organizer Saik Kia Goh.

Conferences

ERC-RMB travels the world to present its discoveries

Leaders in Biodegradable Metals Gather for Annual Meeting in Indonesia

Approximately 80 scientists representing universities and companies from all over the world gathered on the tropical getaway of Umang Island, Indonesia from August 26-31, 2013 to participate in the 5th Symposium on Biodegradable Metals. The focus of the symposium was the development of novel biodegradable metals for biomedical applications. Over the past five years, the symposium has provided a distinguished yet open forum for students, professors, industry, and researchers around the world. The organizers, which include Dr. Frank Witte, ERC-RMB international partner and principle investigator at the Julius Wolff Institut, part of the Charité medical school in Berlin, Germany, have always aimed to maintain a friendly atmosphere where junior and senior scientists have the chance to exchange, discuss, and mutually benefit from the shared knowledge and curiosity in the field of biodegradable metals.

Dr. Frank Witte gave the keynote address in the session on *in vivo* assessment discussing his research on "MRI based perfusion measurements in bone after implantation of biodegradable magnesium rods". Joint-training Ph.D. student Juan Wang from NC A&T and Southwest Jiaotong University in Chengdu, China presented her work entitled "Biodegradation behavior of magnesium alloy under flow-induced shear stress". Accepted abstracts were published in a special issue of European Cells & Materials Journal.

The attendees came to an understanding that the biodegradable metals community has in place necessary key resources and actions to meet new challenges in the field. The interdisciplinary group is committed to exploring new frontiers and spreading news of their research into their scientific societies back at home. Since the conception of the symposium, active exchange with regulatory agencies and standardization organizations has been encouraged. It is this continuous dialogue that has led to workshops with the FDA and ASTM and which are now extending to workshops including notified bodies in Europe and standardization organizations (ISO, DIN). The ERC-RMB will continue to contribute in this field and we hope even more of us can make it next year's symposium when it returns to the beautiful Mediterranean shores of Maratea, Italy!

- Juan Wang
(NC A&T and Southwest Jiaotong University)



Dr. Frank Witte preparing to kick off the symposium.



Juan Wang (left) fielding a question after her talk at the 5th Symposium on Biodegradable Metals.

ERC-RMB Members Attend Society For Biomaterials Annual Meeting in Boston

The Society for Biomaterials (SFB) 2013 Annual Meeting and Exposition was held at the John B. Hynes Veterans Memorial Convention Center in downtown Boston, MA from April 10-13, 2013. The conference hosted more than 1,000 biomaterials experts from academia, industry, and government. The SFB annual meeting offers a snapshot of cutting-edge research and technology in the field of biomaterials.

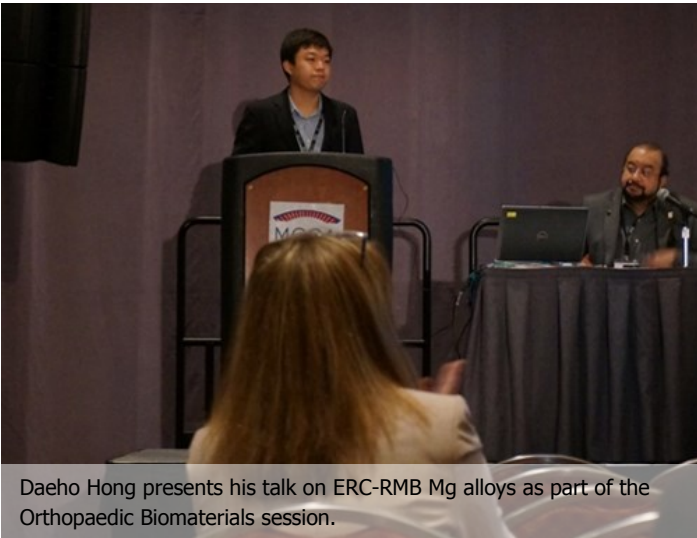
As the ERC-RMB's work focuses on biomaterials research, this conference was a great opportunity to find out how biodegradable metals perform compared to other

biomaterials based on their relevant applications. The ERC-RMB represented the biodegradable metals community, with graduate students Daeho Hong, Da-Tren Chou and Satish Singh, as well as Dr. Sang-Ho Ye, and Dr. William R. Wagner from the University of Pittsburgh attending the conference to present the ERC-RMB's research accomplishments in the orthopedic, craniofacial, and cardiovascular device sessions.

The invited talks at the plenary session were remarkable, including an inspiring presentation by MIT professor and entrepreneur Dr. Robert Langer, a true leader in

the fields of drug delivery and tissue engineering. A highlight of the annual meeting was the Biomaterials Bash at Sheraton Boston Hotel where attendees enjoyed live music and an opportunity to network and foster relationships with peers. The SFB Annual Meeting was a rewarding experience for the students who attended and the SLC hopes to see more members attend this wonderful conference in the years to come.

- Daeho Hong (Pitt)



Daeho Hong presents his talk on ERC-RMB Mg alloys as part of the Orthopaedic Biomaterials session.



From left to right: Da-Tren Chou, Daeho Hong, and Satish Singh at Fenway Park after enjoying a day of stimulating research at the SFB Annual Meeting.

ERC-RMB Represented at the BMES Conference in Seattle

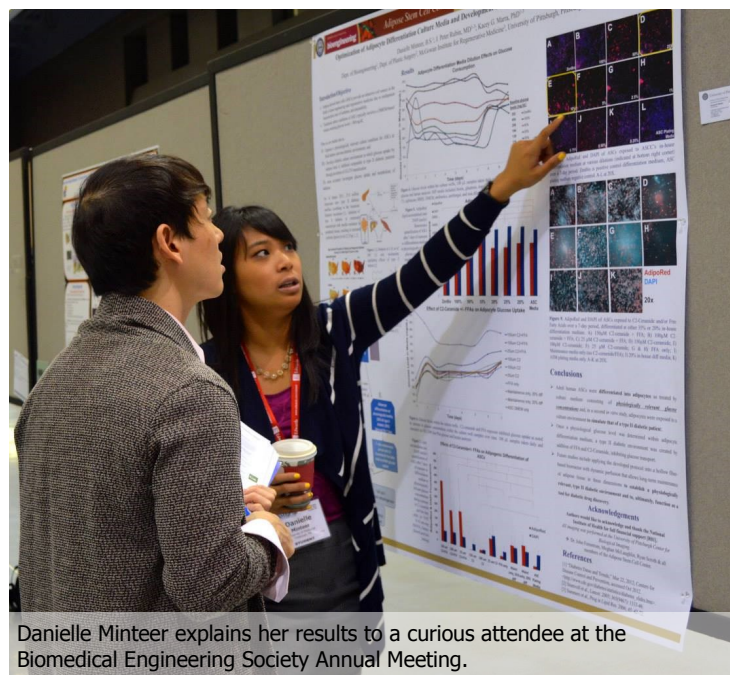
The 2013 Biomedical Engineering Society (BMES) Annual Meeting took place on September 25-28 in Seattle, Washington. The conference brought together scientists from across the country to share their research and form new collaborations. Just a stone's throw from Seattle's famous Public Market, the Washington State Convention center hosted nearly 4,000 professional scientists, engineers, professors, researchers, academics, students, and health care providers.

University of Pittsburgh's Dr. William Wagner, Deputy Director of the ERC-RMB, served as the overall conference chair. The ERC-RMB made a strong showing, with over 20 students and faculty represented by work presented at the conference. Kathryn Farraro from Dr. Savio Woo's lab was awarded a

BMES travel grant to attend the meeting. The conference lasted 4 days, with numerous academic and social events. Most notable, a reception was held to honor Dr. Harvey Borovetz, ERC-RMB Executive Director, for his years of service as the University of Pittsburgh Bioengineering department chair.

The conference concluded as it always has, with a BMES bash, held in Seattle's iconic EMP museum near the Space Needle. We hope that our students will continue to spread the word on research of the ERC-RMB at this seminal bioengineering conference next year in San Antonio, Texas.

- Adapted from article by Collin Edington (Pitt)



Danielle Minter explains her results to a curious attendee at the Biomedical Engineering Society Annual Meeting.



Student Retreat Provides Glimpse into a Variety of Career Opportunities

The 2014 ERC-RMB Student Retreat was held at the University of Cincinnati on Feb 28-Mar 1. Dr. Mark Schulz, director of RMB programs at UC welcomed the students and introduced the purpose of the retreat: helping students' plan their future careers. In addition to research updates and a poster session driven by ERC-RMB students, four speakers from industry addressed the students, providing insight on their career paths.

First, Joe Sprengard spoke about his career as CEO and co-founder of General Nano, a specialty manufacturer of carbon nanotube materials for aerospace and defense applications. Mr. Sprengard spoke about how he addressed challenges of keeping the company moving forward and growing. His experience of making decisions in difficult situations and understanding of the principles of running a company enlightened the students and will influence them when choosing a career. Many of ERC-RMB students are considering joining a start-up after graduation or starting up their own business with technologies they have developed and benefited greatly from hearing

Joe's story.

Staying in the medical device space, the next speaker, Mary Beth Privitera, Director



Joe Sprengard, CEO of General Nano.

of the Medical Device Engine at UC, highlighted the importance of design and innovation in the medical device arena. To design a successful medical product, innovation and thoughtful consideration from a human user point of view is critical. Mary Beth drew on her long history in the medical device industry and as co-director of the Medical Device

Innovation and Entrepreneurship Program (MDIEP) at the University of Cincinnati. This successful program partners student teams from the Schools of Design, Biomedical Engineering, and Business with physicians at UC Medical Center and innovators at corporate design firms and medical device manufacturers to translate research efforts into viable product development opportunities. Her lecture provided examples of how designers concoct ideas and evaluate whether the ideas will become successful medical devices from history and her own experiences.

Finally, the attendees were treated to a presentation by Jan Shilling, Chief Engineer of GE Aviation and member of the National Academy of Engineers. Mr. Schilling gave a lecture highlighting engineering design elements which he emphasized while leading his team working on the design of airplane engines for GE. He included examples from his productive career in numerous engineering leadership roles within GE's esteemed Engineering Division, including leading the technical team that brought the GE90-115B – the biggest and most powerful jet engine on the face of the planet – through the design, development and certification process.

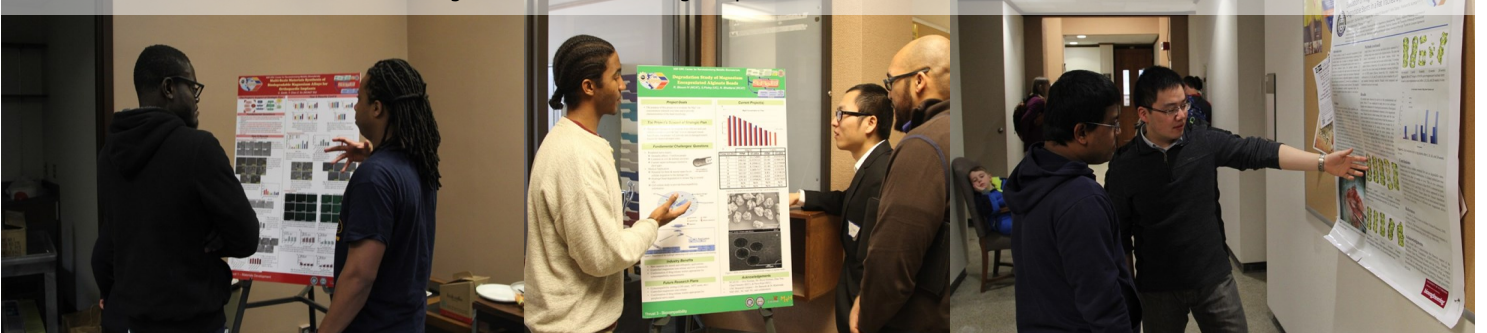
The student retreat was a success in highlighting various career paths students can pursue after graduating the ERC, and also advice as to how get into these exciting fields. After the speaker sessions had concluded, the students had a chance to bond further while exploring different neighborhoods of Cincinnati.



Mary Beth Privitera, Director of the MDIEP, UC.

- Yonghai Zhang (UC)

ERC-RMB students discuss their research findings with each other during the poster session.



Students Introduced to Career Opportunities in the World of Patents

On November 18, 2013 the ERC-RMB student association held a webinar that focused on careers in intellectual property. This webinar was conducted by Dr. Laura Collins, Director of Intellectual Property at NC A&T and a U.S. Patent Agent. All three universities (Pitt, UC, and NC A&T) were able to participate in this very informative and interactive webinar. Dr. Collins discussed the path to becoming a patent attorney, patent agent, or patent examiner and places that an individual could potentially work. This discussion also included information on how to train for those separate career paths while in graduate school now and what could be done to enhance skills that would be needed for those roles. Finally, Dr. Collins was able to provide feedback on some good practices for keeping one's first job in the intellectual property world. Students were actively engaged in the conversation and were able to leave with a better understanding of an alternative career path outside of industry or academia.

- Leon White (NC A&T)



Dr. Laura Collins presents her careers in intellectual property at NCA&T.



ERC-RMB alumnus, Dr. Matt Fisher.

ERC-RMB Alumnus Matt Fisher Describes his Successful Path to Professorship

In a true display of ERC-RMB alumni giving back to the center, former SLC president Dr. Matthew Fisher presented to current RMB students on his path in academia. After graduating from Dr. Savio Woo's lab at the University of Pittsburgh with a PhD in Bioengineering, Dr. Fisher worked as a post-doctoral fellow in the Department of Orthopedic Surgery at the University of Pennsylvania, and has recently been appointed as an Assistant Professor in the Joint Department of Biomedical Engineering at North Carolina State University and University of North Carolina – Chapel Hill. Dr. Fisher gave a light-hearted and informative presentation on his experience in his academic career, including why he chose his career path, insight into the techniques he used to obtain and select his positions, advice on preparing documents for applications, and what to ask for upon receiving an offer. His success story will certainly serve as an inspiration to current students in the ERC-RMB who are interested in following in Dr. Fisher's footsteps and pursuing a career in academia.

- Da-Tren Chou (Pitt)

ERC-RMB Alumnus John Vennemeyer Shares his Story of Transition from Graduate to Industry

During the students retreat at UC, the SLC welcomed back a familiar face to UC, recent UC and ERC-RMB graduate Dr. John Vennemeyer! Completing a graduate degree is a major accomplishment. For many students though, the greater challenge is launching their career with a top-notch job afterwards. In this talk, Dr. Vennemeyer shared professional development insight and advice that he picked up over the last year during his transition from graduate school in Biomedical Engineering at UC to a management role at a medical technology company. Finding a job after graduation is not an easy task, thus Dr. Vennemeyer's step-by-step advice of what to say and how to behave when building connections during interviews and personal meetings was something that all the students drew lessons from.

-Yonghai Zhang (UC)



ERC-RMB alumnus, Dr. John Vennemeyer presents at the UC students retreat.



Education & Outreach

North Carolina A&T

This academic year has been filled with outreach opportunities aimed at increasing the exposure of elementary, middle school, and high school students to the STEM fields. The first outreach project of the year involved talking with students at MALE Club at the Academy of Lincoln Middle School. The group consists of male volunteers working to encourage male middle schoolers to excel in academics and pursue higher education. Both students and professors from NC A&T spoke about various fields of engineering with special focus on biomedical engineering and the ERC-RMB's contribution. This discussion stimulated many positive responses from the middle schoolers and even included a clip of two familiar engineering superheroes: Iron Man and Batman.

NC A&T SLC members also helped at the Science Extravaganza at Claxton Elementary school on April 21, 2014, an event supported

by representatives from Caterpillar and ASME (including alumni of NC A&T). The focus of this year's Science Extravaganza was "Marvelous Marble Contraptions" and involved the students utilizing teamwork to make original designs. This outreach project was aimed at providing the students with exposure to using scientific methods, designing blueprints, and pondering how their starting materials could work together to accomplish their goals. Volunteers from the NC A&T SLC worked to provide the students with support and guidance while encouraging the teams to think like engineers to meet their objectives. The students were encouraged to problem solve and consider design flaws as they worked to get a marble to progress to a catching tray. These examples are but a small fraction of the outreach done by the NC A&T SLC with the overall goal of increasing youth interest in the STEM fields.

- Roman Blount, IV (NC A&T)



Paul McGhee (left) and Zhao Nan working with students to design their "marvelous marble contraption".



Dr. Narayan Bhattarai (right) and Udhav Adhikari working with a design group.

University of Cincinnati

Over the past year, graduate students and faculty from UC engaged Mt. Healthy Junior/Senior High School to directly impact the lives of the students there by stimulating these young minds to think creatively and expose them to interesting science and engineering concepts.

Students Chenhao Xu, Tingting Wang, Kolade Ojo, and Yonghai Zhang, as well as Dr. Sarah Pixley volunteered at the "Invention Convention" for seventh grade students of Mt. Healthy Junior/Senior High School. The students were challenged to invent or improve on an existing design of a tool or instrument that would help law enforcement agencies, fire departments or first responders to make their job easier and safer. Graduate students from UC program helped the students think analytically us-

ing their science and engineering backgrounds to improve on their designs.

Students from UC were also invited by Ms. Roni Dean, a science teacher at Mt. Healthy, to lead a class of seventh graders on research done at the University. The UC representatives also taught the concept of pH, using an experiment where students tested orange juice, coffee, milk, and soft drinks with pH test papers to illustrate the concept in real everyday life liquids.

- Yonghai Zhang



Tingting Wang (left) Yonghai Zhang (right) helping students to make their invention with a real-world connection.

University of Pittsburgh

ERC-RMB students at the University of Pittsburgh volunteered in a variety of local education and outreach events, many in tandem with the Pitt chapter of the Biomedical Engineering Society (BMES). Jonquil Flowers, a graduate student from Dr. Savio Woo's lab who received her M.S. from NC A&T advised by Dr. McCullough, served as Outreach Chair, fostering relationships with the local outreach organizations and creating volunteer opportunities for students.

Every month students hosted ice cream socials at the University Place Family House, a "home away from home" for patients and their families who traveled to Pittsburgh for treatment of serious or life threatening illnesses. For these patients going through difficult times in an unfamiliar city, having a chance to socialize and enjoy ice cream sundaes served by volunteers provides an uplifting experience.

Students also volunteered with the Greater Pittsburgh Community Food Bank whose mission is to feed the hungry in Southwestern PA. Pitt students worked at the Repack Center to sort and package donated groceries for distribution as well as taking part in direct distribution of food to families in need.

Pitt BMES President, Danielle Minter, who is a graduate student in

Dr. Kacey Marra's lab, led fundraising for the BMES Relay for Life team, raising \$2,252 for the American Cancer Society. A portion of the fundraising was collected through a cookout at the engineering school organized by Danielle and other Pitt Bioengineering students.

Many ERC-RMB students also served as judges for the 75th annual Pittsburgh Regional Science and Engineering Fair (PRSEF) on March 27-28th, 2014. PRSEF connects over 1,000 students in grades 6-12 with area scientists and engineers, giving a chance for ERC-RMB students to share their knowledge on pursuing an education and career in STEM fields, while taking part in a rewarding experience in hearing from bright young minds.

Lastly, for the third year in a row, three RMB students, Andrew Brown, Amy Chaya, and Da-Tren Chou gave interactive seminars for over a hundred high school students at the University of Pittsburgh Health Career Scholars Academy. They provided a background of bioengineering and discussed the research taking place at the ERC-RMB. Their presentation captured the high schoolers' attention and imagination with some showing interest in conducting research in our labs.

-Jonquil Flowers, Andrew Brown, Da-Tren Chou (Pitt)

FACULTY ACHIEVEMENT CORNER

The SLC would like to acknowledge some of the accomplishments of our outstanding faculty. It is through their leadership, encouragement, and guidance that we as a student body are able to always perform to our greatest potential.

Dr. Jagannathan Sankar

- Elected to the American Institute for Medical and Biological Engineering (AIMBE) College of Fellows on March 24, 2014
- Featured as one of the Most Influential Persons of 2014 in the Business Journal – Piedmont Triad of NC
- 3 keynote addresses globally

Dr. Salil Desai

Received the Best Paper Award (Manufacturing & Design) at the 2014 Industrial and Systems Engineering Research Conference (ISERC) for his work—'Amorphous Calcium Phosphate Blended Polymer Coatings for Biomedical Implants'

Dr. William Wagner

- Served as Chairman, 2013 Annual Meeting, Biomedical Engineering Society (BMES)
- Received the Senior Scientist Award at the 2013 Tissue Engineering Regenerative Medicine International Society (TERMIS-AM)
- 2 Keynote addresses globally

Dr. Mark Schulz

Held the 2014 Nanotechnology Materials and Devices (NMD) Workshop sponsored by the University of Cincinnati, the Air Force Research Laboratory, and the University of Dayton Research Institute

Dr. Peter Seoane

Instrumental in forming partnerships between ERC-RMB, InCube Labs and Coulter Translational Research Partners Program and signing an option-to-license agreement with InCube Labs for orthopedic applications of ERC-RMB alloys

Dr. Harvey Borovetz

Instrumental in Pitt's Department of Bioengineering receiving the 2013 Chancellor's Affirmative Action Award

Our faculty has played a leading role in research efforts which have led to the development of **11** different classes of novel patent pending alloys based on Mg and **three** different classes of novel patent pending Fe based alloys that exhibit controlled degradation. Also they have been involved with numerous journal publications, book chapters and books!

Our entire faculty and staff have helped to present and promote ERC-RMB activities to visitors and at various technical gatherings and conferences held locally, nationally, and globally! We'd like to acknowledge everyone for their dedication in making the ERC-RMB a success.

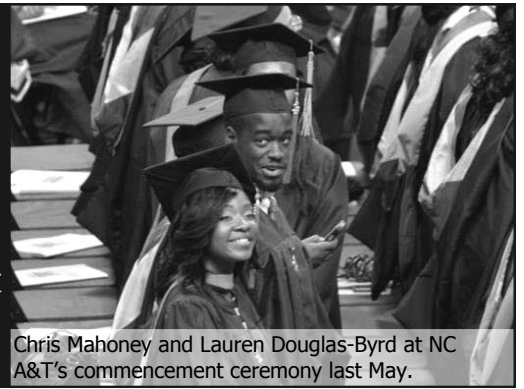


The ERC-RMB faculty, staff, and SLC members who make the center a success.

ERC-RMB

Graduating students & alumni

Bright young scientists move on to the next saga of their promising careers



Chris Mahoney and Lauren Douglas-Byrd at NC A&T's commencement ceremony last May.

What did you take out of your experience being a part of the ERC-RMB?

John Vennemeyer (UC)

John graduated with a Ph.D. in Tissue Engineering from Dr. Sarah Pixley's lab at the University of Cincinnati in 2013. He is now a Project Manager for a biotechnology company based in Cincinnati, OH, coordinating medical imaging sharing for national and international clinical trials.

"Being a part of the RMB-ERC was an integral part of my professional development during graduate school. In addition to the opportunity to work with great people, the RMB-ERC gave me exposure to the leading edge of biomedical technology, access to top-notch facilities and, through the student leadership program, a chance to develop skills managing people and large-scale projects."

I still smile when I think of the fun I had as part of the student group, the satisfaction of working toward a larger goal and the many inspirational speeches from Dr. Sankar...One Team, One Dream!"

Kwang Kim (Pitt)

Kwang graduated with a Ph.D. in Bioengineering from Dr. Savio Woo's lab and the Musculoskeletal Research Center at the University of Pittsburgh in 2014.

"The ERC-RMB has given me exceptional opportunities to experience translation of pure scientific findings to commercializable medical technologies that can make a direct and profound impact on patient care. This experience has prepared me well for my next step in a career in the medical device field."

Christopher Mahoney (NC A&T)

Chris graduated with a master's degree in Bioengineering under the direction of Dr. Narayan Bhattarai from North Carolina A&T State University in 2013 and is now pursuing a Ph.D. at the University of Pittsburgh.

"While a part of the ERC-RMB, I was able to gain experience in scientific writing, dissecting peer-reviewed journal articles, and the development of competent investigative research. These skills have been helpful at the University of Pittsburgh where I am

currently pursuing my PhD in Bioengineering and preparing for the preliminary qualifying exam. The ERC is where I gained my passion for biomedical research!"

Nevija Watson (NC A&T)

Nevija Watson, received her M.S. in Bioengineering in May 2013 under the direction of Dr. Donghui Zhu at North Carolina A&T State University. After graduation she began her career at Genentech Inc. as an analyst in the Operations Rotation Development Program (ORDP).

"My time with the ERC helped to prepare me for a career by exposing me to the various areas of bioengineering research and working on multidisciplinary teams. Attending ERC activities such as the FDA Think Tank Workshop provided the premise for understanding FDA requirements and interactions with current related bioengineering research in academia. Through these various experiences I have been able to gain unique understanding of the bioengineering field that I have been able to apply to my career today."



VISIT US ON THE WEB!

<http://erc.ncat.edu>
<http://erc-rmb.org>



Group photo of ERC-RMB students at the UC Students Retreat.

