NSF Engineering Research Center for Revolutionizing Metallic Biomaterials (ERC-RMB)

North Carolina A&T State University (lead institution)

Transformational therapies through materials and sensing innovations

A National Science Foundation Engineering Research Center since 2008

Partner Institutions:

- *University of Pittsburgh (Pitt)*
- *University of Cincinnati (UC)*
- *Hannover Medical School (MHH)- Germany*

Outreach Institutions:

- *California State University Los Angeles (CSULA)*
- *Edmonds Community College (EDCC)*
- *Guilford Technical Community College (GTCC)*
- *Indian Institute of Technology Madras (IITM)*
- *selected K-12 institutions*

The Engineering Research Center for Revolutionizing Metallic Biomaterials (ERC-RMB) will pursue revolutionary advances in metallic biomaterials and the underlying sciences and technologies, leading to engineered systems that will interface with the human body to prolong and improve quality of life. This research effort is coupled with the development of a vibrant, diverse workforce well-prepared for the global challenges and opportunities of the 21st century.

The ERC proposes to develop the fundamental knowledge and technology needed to advance biocompatible and biodegradable metal-based, implantable systems with feedback control for reconstruction and regeneration. The research and technology development will be aided by industrial input and clinical assessments. The ERC's education program is designed to develop innovative and adaptive engineers. Seamlessly integrated undergraduate and graduate bioengineering programs will be established at North Carolina A&T State University (NCAT) to support this goal.

Major goals of the ERC-RMB are:

- Establish a new generation of revolutionary biological interface materials.
- Generate revolutionary technologies via sharing of resources and the ERC-generated knowledge base to extend and improve the quality of life.
- Achieve excellence through a true interdisciplinary and inter-institutional approach.
- Facilitate economic and healthcare development in the U.S. and strengthen the global position of the U.S. healthcare system.
- Prepare the STEM workforce (pre-college and college) for 21st-century careers in advanced processing, bioengineering, and materials.
- Improve Ph.D. graduation rates in nano/bioengineering areas, especially among African-American students, women, and other underrepresented minority groups.

Research

Carefully planned, cutting-edge research coupled with education and economic development activities on a global scale will be used to create engineered systems (ESs) for: (I) Craniofacial and Orthopedic Applications, (II) Cardiovascular Devices and (III) Responsive Biosensors for Implants. These ESs will arise out of four cross-cutting enabling technology thrusts (ETTs): Biodegradable Metals, Biofunctional Surface Modification, Sensors and Controlled Degradation, and Controlled Release. The fundamental research areas of multi-scale materials synthesis, bio-interfacial science, biomechanics, and clinical pathophysiology will be performed in the ETTs. These ETTs, in turn, are based on strong cross-cutting research in the fundamental sciences across all dimensional scales.

ES-I: Craniofacial and Orthopedic Applications — This systems area focuses on identifying, designing, and fabricating materials systems based on biocompatible and biodegradable metallic systems for craniofacial and orthopedic applications. The goal is to identify and develop metallic systems that are biocompatible and/or exhibit controlled resorption characteristics without any toxic response. Fundamental science issues to be tackled include *ab-initio* calculations, processing of non-porous and porous metal alloy structures, surface engineering of functional coatings, biocompatibility, toxicity controlled release, etc.

ES-II: Cardiovascular Devices — This area is focused on identifying, designing, and fabricating materials systems based on biocompatible metallic systems, mechanical properties, and performance for cardiovascular applications. Fundamental research challenges include making non- and anti-thrombogenic surface coatings that allow the reduction in anticoagulation requirements with metallic, blood-contacting medical devices. For pediatric devices, this is especially important given the very small size of these devices (versus adult-use devices).

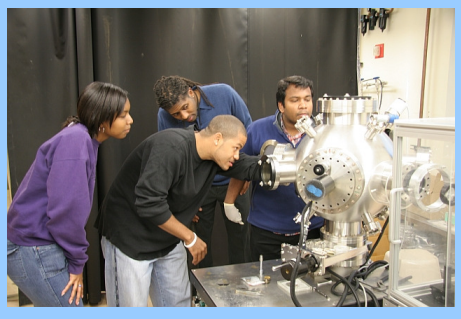
ES-III: Responsive Biosensors — This area will develop responsive biosensors to regulate processes and will aid in the design of metal-based implants. Fundamental research challenges include developing responsive biosensors and making the sensor small so that it can monitor “what is happening” at the interface between the implant and tissue for in vitro studies; and later, making the sensor wireless and resistant to biofouling so that it can monitor “what is happening” at the implant for in vivo animal studies and possibly (eventually) for temporary use in patients.

Education

Through its education programs, this ERC will prepare a highly diverse, globally experienced, and innovative engineering workforce for the U.S. biomedical implant industry and for academia in the fields of engineering and medicine. The ERC will train engineers in a unique, multidisciplinary, innovation-oriented environment. The approach to education integrates traditional and emerging engineering disciplines with industrial and clinical experiences along with exposure to social, regulatory, ethical, and entrepreneurial issues from a global perspective. The ERC’s educational materials will be research-based but will also build on existing best-practice bioengineering model curricular materials and innovative teaching/learning software systems. A Department of Bioengineering at NCAT will offer undergraduate and graduate programs that will be strengthened by the ERC’s curricular materials.

Engineering- and science-oriented undergraduate students will be recruited as REU participants, with a preference for students from our outreach partners: CSULA, EDCC, and GTCC. The intent is to steer them towards STEM skills that will enable them to enter, explore, and succeed in future STEM-related careers with no boundaries. Faculty and students from the affiliated institutions will initiate activities related to the ERC’s testbeds and ETTs and will become an integral part of the REU activities.

The K-12 part of the pre-college program will be built on partnerships in the communities served by NCAT, Pitt, and UC. The program will integrate experiences for students in Grades 6-12 by providing curricular materials that include a "palette" of devices that engagingly demonstrate bioengineering applications and principles. Workshops will be conducted for guidance counselors, parents, and students. The Research Experiences for Teachers (RET) program will develop standards-based materials related to bioengineering. The RET participants, along with talented high school students (Young Scholars), will receive guidance in developing lab experiments, course modules, and other multimedia materials. Geographical reach of these initiatives will be extended through a traveling display and use of the cyberinfrastructure. The ERC will work closely with EDCC and GTCC to develop special workforce training programs in nano-bioengineering for non-traditional students, providing exciting career opportunities.



Industrial Collaboration/Technology Transfer

The ERC team includes industrial partners with expertise in the regulatory process as well as innovation, and government agency partners to achieve its mission.

Attention will be paid to integration of existing clinical/industrial knowledge to define the tasks and goals – i.e., by involving clinical, academic, and industrial partners at all stages to achieve the greatest economic impact.

The ERC has formulated a comprehensive plan that includes a Scientific Advisory Board (SAB) and Industrial Advisory Board (IAB) for guidance of the science and commercialization activities. The annual meetings of these boards will produce Strengths-Weaknesses-Opportunities-Threats analyses to guide the ERC. ERC partners have crafted a Memorandum of Understanding that addresses Governance, Financial, Intellectual Property, and Commercial issues.

Facilities

NCAT facilities:
NCAT facilities of the ERC currently occupy 10,000 sq. ft. of the Fort Interdisciplinary Research Center (IRC), with plans for expansion. Twelve existing labs and facilities are interconnected and span three of the five floors of this building, providing a seamless state of-the-art materials research infrastructure valued at over $6M (http://camss.ncat.edu). The IRC supports a highly advanced cyber-infrastructure, including laboratories for Materials Processing and Sample Preparation, Electron Microscopy, Bio-Polymeric Smart Materials, Surface Engineering and Characterization, Micro-Raman Spectroscopy and various Microstructural Techniques, XRD, Physical Property Measurement, and Mechanical Testing. The interconnectedness and open-door nature of this state of-the-art research facility create a hub for interdisciplinary knowledge sharing.

Pitt Facilities:

- McGowan Institute for Regenerative Medicine (MIRM) – The MIRM includes ~80,000 sq. ft. of clinical labs, a large animal surgery suite, non-human primate suite, and a small-animal facility (www.mirm.pitt.edu), which includes the Center for Craniofacial Regeneration (CCR), with ~10,000 sq. ft, materials synthesis, characterization, and processing facilities (www.mirm.pitt.edu/ccr/)
- Musculoskeletal Research Center (MSRC) – The MSRC includes ~5000 sq. ft. of labs for mechanobiology, tissue mechanics, shoulder, and ACL/ robotics (www.pitt.edu/~msrc/).
- Swanson School of Engineering (SSoE) – SSoE is housed in the 12-story Benedum Engineering Hall, which is undergoing extensive renovation to include state-of-the art research floors for Bioengineering and Nanoengineering (http://www.engr.pitt.edu/transformation/index.html)

UC Facilities:

- Materials Research Center, Institute for Nanoscale Science and Engineering, Smart Structures Bio-nanotechnology Lab, Biochemistry Lab, Microscopy Lab, Cell Culture Laboratory, Noyes Tissue Engineering and Biomechanics Lab, 3-D Motion Simulation Lab, Center for Chemical Sensors and Biosensors, and NanoWorld
- At the College of Medicine, the Vontz Molecular Study Center has an Animal Resource Area, as well as cell and cancer test facilities.

Center Configuration, Leadership, Team Structure

The Leadership Team consists of the Director (NCAT), Deputy Director (Pitt), Deputy Director (UC), Education and Outreach Director (NCAT), and Executive Director (Pitt/NCAT). Each Engineered System has a principal lead and sub-project leads. Faculty, staff, and students from multiple disciplines cross institutional boundaries to form research as well as education/outreach project teams. The ERC receives assessment and guidance from the Deans Council, Scientific Advisory Board, Industrial Advisory Board, an Educational Assessment Team, and the Student Leadership Council (SLC).

Center Headquarters

NSF ERC for Revolutionizing Metallic Biomaterials
North Carolina A&T State University
Fort Interdisciplinary Research Center
Suite 201
Greensboro, NC 27411
Tel (336) 256-2680 · Fax (336) 256-2683
Homepage: http://erc.ncat.edu/

Center Director: Jagannathan Sankar
(336) 256-2680 x2282 · sankar@ncat.edu

Deputy Director: William Wagner
(412) 624-5324
wagnerwr@msx.upmc.edu

Deputy Director: Mark Schulz
(513) 556-4132 · Mark.J.Schulz@uc.edu

Education & Outreach Director: Devdas Pai
(336) 256-2680 x2106 · pai@ncat.edu

Executive Director: Harvey Borovetz
(412) 624-4725 · borovetzhs@upmc.edu

Administrative Officer: Lois Dalton Deve
(336) 256-2680 x2006 · lddeve@ncat.edu

Industrial Liaison Officer: Nicholas Bentley
(336) 256-2680 x2252 · nbentley@ncat.edu