

NSF EPSCOR RII TRACK-1 PROJECT SUMMARY

The South Carolina 2009 NSF EPSCoR RII Track-1 proposal presents an integrated plan to implement a statewide vision that will give South Carolina a competitive edge in the field of biofabrication — an emerging *‘transforming’* technology — operationally defined as computer-aided, layer-by-layer deposition of biologically-relevant material with the purpose of engineering functional 3D tissues and organs. Challenges lie on both the engineering and biological sides. Biology-based questions relate to identifying cell sources, optimizing hydrogels for cell growth and differentiation, and designing “blueprints” for computer-aided printing of functional tissues. A major challenge remains in achieving *vascularization* and maintaining viability of the printed construct. Without a vascular supply, thickness of tissue constructs is limited to four cell layers or less. To proceed to true organ level, one must successfully engineer a vascular supply, which requires creating a branching 3D tree-like construct. This challenge is the subject of the South Carolina Project and the research theme of the 2009 NSF EPSCoR RII Track-1 proposal.

The proposed Research Plan to engineer a 3D vascular tree is divided into five scientific “thrust” areas. All require enabling infrastructure in terms of content expertise and technology systems. Thrust I focuses on analysis of structural-functional properties of an authentic (natural) branched vascular tree. Anticipated research milestones include a computer-aided design or simulation of a natural branched vascular tree based on the acquisition of detailed data inputs from histological, morphometric and immunohistochemical analyses of sequential segments, and biomechanical testing of sequential segments from a natural branched vascular tree. Thrust II focuses on directed differentiation of adult stem cells into monomer units of vascular cell types, specifically to induce stem cells isolated from fat tissue to enter a smooth muscle cell lineage. Thrust III requires functional biomechanical testing of engineered, sequential segments and comparison to naturally occurring (authentic) branched vascular trees. This requires an enabling technology for the scalable production of standard sized, vascular tissue spheroids having a single lumen surrounded by endothelial cells and smooth muscle cells. Thrust IV is biofabrication of a branched vascular tree, or creating linear 3-D, hollow tubular segments representing branches that can be transformed into branched “Y” or “T” vascular units. Thrust V focuses on accelerated tissue maturation of bioprinted, branched vascular tubes. This requires clever design and fabrication of a perfusion bioreactor, as well as evidence that one or more candidate maturogens can accelerate tissue maturation (e.g. growth factors, extracellular matrix or cytokines). Thus, the scientific theme of the RII is broadly based and includes stem cell biology, cell and developmental biology, molecular biology, tissue engineering, extracellular matrix, biomathematics, chemical and mechanical engineering.

The 2009 SC NSF EPSCoR RII focuses on a diverse subset of institutions including 3 research intensive institutions, 3 HBCUs (1 public and 2 private) and 2 other PUIs (1 private and 1 public), with outreach to 2 technical colleges. Together this will form an alliance for tissue biofabrication. The research infrastructure improvement strategies include: (1) engaging a diverse group of institutions that bring complementary approaches to research, education, training and production of South Carolina’s future STEM workforce; (2) recruiting 22 new tenure-track faculty at Claflin, Furman, MUSC, USC and USC-Beaufort, and Voorhees with interests and expertise in one or more of the enabling biofabrication technologies; (3) identifying and mentoring “target” junior faculty who can enhance the potential to successfully implement the SC Project; (4) creating a local and global virtual e-community that will facilitate and hasten the development of sophisticated databases on the vascular tree; (5) creating academic-industrial collaborations needed to overcome the major challenges of biofabrication; (6) integrating statewide initiatives for education, outreach, and communication to the general public; and (7) expanding a current bioprinting program at MUSC into an Advanced Tissue Biofabrication Center that will serve as the S&T hub and sustainable center.

Efforts directed towards strengthening STEM research and education in SC’s graduate and undergraduate institutions and technical colleges, and interfacing with K-12/pre-college level programs, are critical for building SC’s workforce and economy. Proposed RII activities support postdoctoral and graduate research training at Claflin, Clemson, Furman, MUSC, and USC. A new Masters program in Biorobotics and Biofabrication is in development at SC State University. Two 2+2 degree programs between Claflin and Greenville Technical College, and Voorhees and Denmark Technical College, will be supported with appropriate outreach to the K-12 sector.

The integrated 2009 RII plan includes diversity, cyberinfrastructure improvements, outreach and communication, sustainability, management, accountability and evaluation. The South Carolina Light Rail will be expanded to provide statewide high speed, high capacity linkage to regional, national and international cyber-networks and support collaborative e-communities in S&T and education. An Innovative Integration Board will advise, design, implement and review activities that bridge SC’s minority serving programs and integrate with the science, education, communication and sustainability programs of the RII. Educational innovations include development of e-textbooks and new curricula to recruit and train a diverse 21st century workforce. A novel outreach activity will expand the capacity of South Carolina’s reporters, journalists and journalism students to understand and report complex S&T developments and enhance science literacy statewide. The sustainability plan outlines specific approaches to obtain mainstream grants for research, training and technology development, as well as activities for mentoring, career development and technology transfer. An integrated, multi-year evaluation approach will measure progress towards goals, document outcomes and transformative results, and identify areas for improvement. An RII management team and External Advisory and Review Board will ensure implementation of the South Carolina Project and assist the South Carolina EPSCoR/IDeA Committee and its staff in meeting the overarching requirements for accountability and substantive impact.