opportunity...
The Medical University of South Carolina would like to convey its deepest appreciation to the faculty, staff and students as well as the many other dedicated individuals and organizations in the city and across the state of South Carolina that are responsible for generating such a rich ecosystem for biomedical research, development and knowledge application as delineated in this publication.

Dr. Lanier would like to acknowledge the entire team in the Office of the Associate Provost and many, many others across campus for their valuable contributions in the development of the “Opportunity” publication. Dr. Lanier also acknowledges the early contributions by Shelia Watson and he would like to particularly recognize Wanda Hutto and Thomas L. Hamm II for their tireless commitment and creative thought with this project and publication.
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## MEDICAL UNIVERSITY OF SOUTH CAROLINA

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PERSPECTIVE

This brochure provides an introduction to the Medical University of South Carolina (MUSC) and is meant to serve as a primer and entry platform for interested partners with respect to targeted research and clinical trials as well as the development of new therapies, diagnostics and advanced technologies.

MUSC was founded as a freestanding medical school in 1824, and as such is one of the oldest continuously operating medical schools in the USA. The institution has now grown to include six colleges - Medicine, Health Professions, Dental Medicine, Nursing, Pharmacy, and Graduate Studies.

We have several nationally top ranked clinic care and research programs and teams of committed and dedicated faculty and staff across a number of different areas. MUSC has a robust basic, clinical and translational research program with total extramural funding of over $230M for each of the last four years.

MUSC has developed a broad innovation ecosystem to accelerate the movement of discoveries in this area for further development and commercialization for the benefit of the global community. This ecosystem includes creative research teams at the top of their field, advanced technologies for discovery and knowledge application, two new research buildings and a new hospital, regional partnerships for business development and an organizational infrastructure that nurtures the forward movement of ideas.

With its unique mix of culture, business and research and as one of the top places in the world to live and visit, Charleston has quickly become a hub for biomedical innovators, creative thinkers, artists, scientists, students and entrepreneurs. MUSC is a leading factor in the rapid regional development and a great platform for strategic partnering in biomedical sciences and healthcare technologies.

Stephen M. Lanier, PhD
Chief Scientific Officer and Associate Provost for Research
Medical University of South Carolina
BIOMEDICAL RESEARCH INFRASTRUCTURE
ABOUT THE MEDICAL UNIVERSITY OF SOUTH CAROLINA

The Medical University of South Carolina (MUSC), a freestanding academic medical center, is at the forefront of the latest advances in the health sciences and healthcare delivery. MUSC consists of six colleges (Dentistry, Graduate Studies, Health Professions, Medicine, Nursing, Pharmacy) for the education of a broad range of healthcare professionals, a hospital (Medical University Hospital Authority), affiliated foundations (MUSC Foundation, MUSC Foundation for Research Development), a physician practice plan (MUSC Physicians), and over 1,000 faculty.

Among the state’s largest and most innovative health systems, the Medical University Hospital Authority (MUHA) includes the Medical University Hospital, the Storm Eye Institute, the Children’s Hospital, the Institute of Psychiatry, the Hollings Cancer Center, the Rutledge Tower Outpatient Center, and the Ashley River Tower.

The FY2014 operating budget of MUSC, with its nearly 13,000 employees, approached $2B: University - $633M; Medical University Hospital - $1B; MUSC Physicians practice plan - $281M; Foundation for Research Development - $1.2M; SC Area Health Education Consortium - $12M; MUSC Foundation - $1.6M.

MUSC has been affiliated with the Ralph H. Johnson Veterans Administration Medical Center (VAMC) for over fifty years and the two institutions share a research building.

The 2004 integration of the Colleges of Pharmacy at MUSC and the University of South Carolina in Columbia (USC) established the South Carolina College of Pharmacy (SCCP), a statewide education; research and service institution that combines these institutions’ nationally recognized faculty/staff and resources.

With 93 buildings (including two new research buildings for Drug Discovery and Bioengineering) on a 76-acre campus, MUSC is well positioned for strategic partnerships and technology development in the biomedical sector.
RESEARCH AND DEVELOPMENT INFRASTRUCTURE

MUSC’s breakthrough research leads to new cures, new standards of care, and a better understanding of the basic science that drives biomedical discovery. With a true sense of commitment, MUSC research teams push the frontiers of basic, clinical, and applied research. What sets MUSC apart from other institutions is the array of multidisciplinary approaches, the breadth of intellectual and technical skills, and advanced technologies to support research and development.

In FY2013, MUSC faculty received 1,139 extramural awards totaling $232 million. Federal funding constitutes about 67% of extramural research funding at MUSC with the National Institutes of Health (NIH) as the primary funding agency representing 71% of the total federal research funds awarded to MUSC in FY2013.

MUSC’s collaborative funding with other universities and research entities increased by 13% in FY2013. In FY13, MUSC also experienced a marked increase in research funding from foundations and the corporate sector.

BIOMEDICAL RESEARCH FUNDING

Figure 1: Extramural research funding to MUSC. ARRA - American Recovery and Reinvestment Act. NIH – National Institutes of Health. Other - funding from various sources including foundations, the state of South Carolina and federal funding from agencies other than the NIH.
RESEARCH ACCOMPLISHMENTS

• Hollings Cancer Center (HCC) is South Carolina’s only National Cancer Institute-designated cancer center and one of fewer than 70 such centers in the US.

• MUSC’s $20 million NIH Clinical and Translational Science Award, one of only 62 awarded nationally and the only one awarded in South Carolina, is housed in the South Carolina Clinical and Translational Research (SCTR) Institute.

• MUSC is the lead institution for a $20 million award from the National Science Foundation (NSF). Granted July 2009, the award is supporting development of an advanced Tissue Biofabrication Center, part of a statewide alliance of ten institutions.

• MUSC has a rapidly growing technology transfer and commercialization ecosystem with several startup companies formed by faculty already acquired by corporate partners with significant investment. MUSC technologies have led to the creation of 39 startup companies 900 invention disclosures, 560 patent filings, 55 issued patents and 39 startup companies. MUSC has entered into 85 license and option agreements based upon campus research.

• MUSC is now home to five NIH Centers of Biomedical Research Excellence (COBRE) awards with total funding over $27 million. MUSC was recognized for its research achievements with unprecedented, simultaneous COBRE renewals for three centers – cardiovascular, oral health, and lipidomics research. The fourth award, a partnership between the Colleges of Medicine and Pharmacy, established a Center in Oxidants, Redox Balance, and Stress Signaling. The fifth award established a Center for Stroke Recovery.

• The SmartState® Centers of Economic Excellence program supports research in areas that will help South Carolina companies grow, attract new business to the state and build a technology-rich economy. Each Center is awarded between two million and five million in state funds with matching funds provided from non-state funds, investors, donors and/or corporate partners. There are currently 27 such centers with a biomedical focus supporting 58 endowed chairs.

• MUSC’s research infrastructure includes a broad-based administrative support platform for sponsored programs, research technology, and research regulatory support with full accreditation for animal (AAALAC) and human research programs (AAHRPP).

• The establishment of SCresearch.org, a directory of ongoing clinical studies, provides the opportunity to access and engage potential study participants and to facilitate their recruitment into trials across the state.

• A web-based eIRB platform connects MUSC and major research and healthcare institutions across the state, providing a robust regional platform for clinical trials.
RESEARCH AND DEVELOPMENT LABORATORIES

MUSC’s James E. Clyburn Research Center includes the interconnected research buildings for Drug Discovery and Bioengineering, offering more than 200,000 ft$^2$ of laboratory space, conference facilities and advanced core technologies. Home to a range of programs including cancer drug discovery, neuroscience, regenerative medicine, chemical and structural biology programs, and biomedical imaging, these interdisciplinary facilities house research teams from MUSC as well as Clemson University and the University of South Carolina (USC).

Much more than two state-of-the-art buildings, the Clyburn Research Center provides a collaborative research environment, drawing investigators from MUSC, Clemson and USC and reflects a special approach to biomedical investigation – people from different backgrounds, disciplines, and institutions working together to solve our most vexing health problems in a place where the state’s best mathematical, scientific, engineering, industrial and medical minds can coordinate their work and dramatically accelerate the rate of discovery, development and application.

These new facilities, which include embedded technology transfer staff, are home base for MUSC endowed chairs in the SmartState$^\circledR$ Centers of Economic Excellence in Brain Imaging, Cancer Drug Discovery, Regenerative Medicine, and Translational Cancer Therapeutics. The buildings also include our Cancer Genomics program, the Center for Biomedical Imaging, the Clemson-MUSC Bioengineering Program, the SC Bioengineering Alliance and the Ralph Hirschman Laboratory for Structural Biology.

The Darby Children’s Research Institute (DCRI), the most comprehensive pediatric research facility in the Carolinas, provides 122,000 ft$^2$ of wet laboratory research space. The Institute is home to research teams in eleven multidisciplinary programs that represent cardiobiology, neurosciences, cancer biology, pharmacogenetics, addiction research, pulmonary biology, proteomics, vitamin D metabolism, osteoclast biology, autoimmune and rheumatic diseases, and renal biology.

The Gazes Cardiac Research Institute (GCRI) and the Strom Thurmond Research Building provides 113,416 ft$^2$ of research space and is a joint research building with the Ralph H. Johnson Veterans Administration Medical Center. The GCRI brings together a multidisciplinary group of investigators dedicated to understanding the biology of heart disease at the molecular level in order to promote the successful development of new therapies for heart disease. The shared facility houses a range of talented physician scientists and translational investigators conducting a wide spectrum of research that includes cellular and molecular investigation, physiological studies in model systems, investigator-initiated clinical research, population studies and large corporate and NIH multicenter clinical trials.
MUSC MEDICAL CENTER

The MUSC Medical Center is South Carolina’s only tertiary/quaternary care referral center for a statewide population of about 5 million people. The Center, which has 709 beds in five inpatient facilities and will increase to 751 beds in the near future, has an operating budget of $1B. MUSC clinicians provide outstanding care, nationally recognized for its quality. The Medical Center at MUSC has a comprehensive range of specialized care centers, including the Hollings Cancer Center, the Transplant Center, the Center for Alcohol and Drug Programs, the Heart Value Center, the Digestive Disease Center and a Level I Trauma Center.

Medical Center Recognition by U.S. NEWS & WORLD REPORT

• Best Hospitals 2013
• Best Hospital in SC & Top 25% in 13 out of 16 nationally-ranked clinical areas
• MUSC Children’s Hospital one of America’s Best Children’s Hospitals

An integral part of MUSC, the Children’s Hospital is dedicated to enhancing the health of children throughout South Carolina and to providing an environment that supports excellence in pediatric patient care, teaching and research. The U.S. News & World Report of America’s Best Children’s Hospitals ranks MUSC Children’s Hospital among the top 50 programs for three specialties (heart and heart surgery, gastroenterology, and nephrology). The MUSC Children’s Hospitals offers a full range of care to children of all ages, from the tiniest of newborns to teenagers.

The Ashley River Tower (ART) Hospital features 156 beds and includes an intensive care unit, nine operating rooms, laboratories, interventional radiology and endoscopy suites and a specialized chest pain center. Specializing in Heart & Vascular Disease, Digestive Disease, and Cancer Care, this facility offers the latest technologies and the expertise of world-renowned physicians while providing patients a wellness atmosphere including commissioned contributions from South Carolina artists.

The Ralph H. Johnson Veterans Affairs Medical Center provides primary, secondary, and tertiary care. It operates approximately 145 inpatient beds and is closely affiliated with MUSC. The research service at the VAMC broad-based: 98 investigators are conducting more than 260 active research studies. A unique VAMC-MUSC partnership maintains the nation’s mutually supported stand-alone research facility, housing collaborative biomedical research.
PARTNERSHIP PLATFORMS IN BASIC AND CLINICAL RESEARCH
RESEARCH PLATFORMS

With MUSC’s vast array of multidisciplinary centers and statewide collaborations, our scientists and clinicians strive to solve complex problems in human health with a broad range of expertise in a number of areas including cancer, cardiovascular disease and stroke, drug discovery, health information technology, neurosciences, inflammation, oral health, and sensory sciences.

The Hollings Cancer Center (HCC), South Carolina’s only center with National Cancer Institute designation, and the South Carolina Clinical & Translational Research Institute serve as cornerstone programs for basic and clinical research. They provide a robust platform to support and facilitate both early-stage development and clinical trials.

Bioengineering initiatives such as the Bioengineering Alliance – a collaboration between MUSC, the University of South Carolina (USC), and Clemson University – form the core of our commitment to translational research in the development of pharmaceuticals, medical devices, and diagnostics.

Health Sciences South Carolina (HSSC), a collaborative effort connecting the largest healthcare organizations in the state, develops and deploys health information management tools in conjunction with SCTR that improve the efficiency and effectiveness of its members’ research processes and healthcare delivery.

MUSC is at the forefront as the biomedical partner for two additional statewide platforms – the SC Centers of Biomedical Research Excellence (COBRE) supported by NIH and the SC SmartState® Centers of Economic Excellence. The COBRE programs build research infrastructure in Cardiovascular Disease, Lipidomics and Pathology, Oral Health, Oxidative Stress and Stroke Recovery. MUSC has 20 SmartState® Centers with a total of 43 endowed chairs to lead a knowledge-based economy in the biomedical sector.
The MUSC Hollings Cancer Center (HCC) is South Carolina’s only National Cancer Institute–designated cancer center. Under the leadership of Dr. Andrew Kraft, HCC serves the state as a leader in cancer research, patient care and public and professional education. Since its opening, the Center has experienced significant growth in its clinical and research facilities, patient care volume, research funding and clinical trials portfolio and accrual. Last year, HCC diagnosed and/or treated more than 3,000 new cancer patients. With more than $40M in extramural funding supports cancer research and over 120 nationally-recognized scientists, the Hollings Cancer Center enrolled more than 900 individuals in clinical research studies.

Organized as a matrix cancer center, HCC’s 120 affiliated faculty research teams represent 23 departments in six MUSC colleges. Members are organized into four formal research programs – Cancer Genes & Molecular Regulation, Developmental Cancer Therapeutics, Cancer Immunology, and Cancer Control. These highly interactive research programs provide fertile ground for collaborative initiatives. In fact, 45% of all MUSC-based cancer research publications during the past few years involved interdisciplinary collaborations.

HCC facilitates and supports interactions between clinical teams, community-based organizations and research programs to ensure the latest discoveries and newest approaches to prevention, diagnosis, and treatment are being transferred to the clinics, yielding the most advanced patient care.

Establishing a Phase I clinical trial division propelled the launch of HCC’s first-in-human, Phase I clinical trial, using a novel drug developed by an MUSC/HCC scientist. Partnering with in-house drug development experts and with pharmaceutical partners, the HCC now has more than 25 actively enrolling Phase I trials. These trials are offering patients with advanced cancers the very latest in therapeutic options.
SHARED RESOURCES
HCC supports an array of shared research resources, including:

- Biorepository & Tissue Analysis
- Biostatistics
- Cell Evaluation & Therapy
- Cell & Molecular Imaging
- Drug Discovery & Screening
- Drug Metabolism & Clinical Pharmacology
- Gene Targeting & Knockout
- Genomics
- Lipidomics
- Translational Research

FACILITIES
The HCC completed a major expansion in 2006 – a seven-story tower adjacent to the original building. A significant 2007 renovation of the original building provided a platform to consolidate adult outpatient cancer services and associated clinical trial operations.

More recently, MUSC completed two new laboratory research buildings – the Drug Discovery Building and the Bioengineering Building – collectively named the James E. Clyburn Research Center. Nearly half of the research space in these two buildings has been allocated for cancer research. With much of the new laboratory research space designated for cancer research, it has been possible to organize it programmatically, promoting multidisciplinary collaborations.
The South Carolina Centers of Economic Excellence (SmartState®) program provides funding for the recruitment of highly talented scientists as endowed chairs and serves as a nucleus for university-based research centers to cultivate public-private industrial partnerships. Cancer-related SmartState® Centers include the following:

**CANCER DRUG DISCOVERY CENTER**
The Cancer Drug Discovery Center provides support and expertise for new target identification and the generation of lead compounds in the drug discovery process. The goal is increasing the productivity of collaborative academic and biotechnology/pharmaceutical industry research. This Center also offers expertise in structural biology for target analysis, medicinal chemistry, computational platforms for designing drug candidates, and advanced compound screening technologies. The endowed chairs and investigators in this center have complementary expertise in drug discovery and development and have been involved in multiple startup companies, some of which have proprietary compounds in early-stage clinical trials.

The success of the SmartState® Centers is built upon the expertise and resources of its endowed chairs. Dr. John Lemasters, Endowed Chair, has expertise in advanced cellular technologies. His projects focus on the role of mitochondria in cell injury in cancer, heart, and liver cells. He has identified a potential new therapy for the treatment of hemorrhagic injury. Dr. Patrick Woster is a medicinal chemist focusing on the development of drugs that turn specific genes in tumor cells on or off, a process known as epigenetic modulation that can make anti-tumor medications more effective.

**CANCER STEM CELL BIOLOGY AND THERAPY CENTER**
The Cancer Stem Cell Biology and Therapy Center develops new technologies for isolating, growing, and manipulating cancer stem cells. The Center will also explore the use of adult stem cells from bone marrow or organs to treat cancer. This research is generating further understanding of cancer stem cells and ways to eradicate them without harming healthy cells. This research could lead to the “engineering” of healthy adult stem cells to replace cancerous stem cells in the body. MUSC recruited Dr. Zihai Li, an expert in stem cell-based cancer vaccine development. A cancer immunology expert, Dr. Li is finding ways to help the body’s immune system recognize and fight cancer cells and control tumor growth. Types of immunotherapy, such as cancer vaccines and antibody treatment, have the potential to be more effective, more targeted, and less toxic than traditional cancer treatments.

One of the country’s leading investigators in hematopoietic stem cell therapy, Xue-Zhong Yu, MD, holds the second chair within the SmartState® Center for Cancer Stem Cell Biology and Therapy. Dr. Yu is a Professor in the Department of Microbiology and Immunology and Department of Medicine.
The focus of Dr. Yu’s research is the biology of graft-versus-host disease and graft-versus-leukemia after allogeneic hematopoietic stem cell transplantation. The ultimate goal of these studies is to prevent or treat graft-versus-host disease while preserving the graft-versus-leukemia effect, which could greatly enhance the therapeutic potential of hematopoietic stem cell transplantation.

**CENTER FOR CANCER DISPARITIES**

The Center for Cancer Disparities is accelerating cancer screening and early detection among African American populations and training students and junior faculty to conduct prostate cancer research in South Carolina. Dr. Chanita Hughes-Halbert, a leading health disparities researcher, is the first of three endowed chairs in the Center. Dr. Hughes-Halbert is incorporating basic behavioral sciences in exploring how patients make treatment decisions, developing statewide partnerships to increase minority access to care, improving access to technology that enhances care delivery, and raising health literacy across all populations.

**GASTROINTESTINAL CANCER DIAGNOSTICS CENTER**

The Gastrointestinal Cancer Diagnostics Center focuses on fostering basic research and expanded clinical trial infrastructure in GI cancers. Research areas include molecular profiling, therapeutic targets and strategies, screening technologies, environmental impacts and population studies with a particular interest in esophageal cancer. Co-leading this Center is Dr. Melanie Thomas, an internationally recognized hepatobiliary cancer expert. Dr. Thomas also serves as the Hollings Cancer Center’s Associate Director of Clinical Investigations.

Dr. Carolyn Britten, the second SmartState® Endowed Chair in this center, is the Director of the Phase I clinical trials program within the Hollings Cancer Center Clinical Trials program and Associate Professor in Hematology/Oncology.

In Phase I trials, research teams test an experimental drug or treatment for the first time in a small group of patients (20-80) to evaluate its safety, determine a safe dosage range, and identify adverse effects. Dr. Britten’s appointment will accelerate Phase I trials at HCC and increase the availability of the latest therapies to cancer patients in South Carolina and neighboring states.

**LIPIDOMICS, PATHOBIOLOGY AND THERAPY CENTER**

The Lipidomics, Pathobiology and Therapy Center leverages MUSC’s strength in the area of lipidomics – both synthetic and analytical – with its translational teams focused on lipid biology in cancer, inflammation and diabetes. Research teams will identify new targets for diagnostics or treatments.

The Center’s Endowed Chair, Dr. J. Alan Diehl, was recruited from the University of Pennsylvania and his research focuses on the molecular mechanisms that contribute to uncontrolled cell proliferation and decreased cell death, which are collectively associated with neoplastic growth. Dr. Diehl is a faculty member in the Department of Biochemistry & Molecular Biology and serves as the Associate Director of Basic Sciences in the Hollings Cancer Center.
This Center is home to an internationally recognized Lipidomics Shared Resource providing qualitative and quantitative analysis of lipid composition from biological materials with a current listing of more than 300 distinct molecular species. It also provides the most advanced synthetic molecular tools to study the role of bioactive lipids as new potential drug agents. It also has established an animal pathobiology core for the facilitation of preclinical studies that is focused on generating, acquiring, and using genetically modified mice with emphasis on enzymes of sphingolipid metabolism, targets of bioactive lipids, and genetically interacting components.

TRANSLATIONAL CANCER THERAPEUTICS CENTER

The Translational Cancer Therapeutics Center builds on existing MUSC and University of South Carolina strengths in pharmacology. The SmartState® Endowed Chair Dr. Kenneth Tew, whose earlier research was pivotal in designing treatments for hormone-refractory prostate cancer, has more recently been instrumental in the late-stage clinical testing of three novel drugs; one that shows promise in treating ovarian and lung cancer, and another exhibiting potential as a modifier of bone marrow-mediated immune function.

Dr. Igor Roninson, SmartState® Endowed Chair, is a leading investigator in cancer therapeutics whose work in pharmacogenomics—the study of how an individual’s genes affect the body’s response to drugs—could be particularly important to minority populations understudied in clinical trials. His principal research interests include developing personalized cancer therapy based on target and drug discovery through functional and chemical genomics.
SC CLINICAL AND TRANSLATIONAL RESEARCH INSTITUTE

The Medical University is one of 62 national centers in the Clinical and Translational Sciences Award (CTSA) Consortium located in 28 states and the District of Columbia. Launched in 2006, the CTSA program creates academic homes for clinical and translational science at research institutions across the country. This CTSA Consortium works to build national clinical and translational research capability.

The CTSA is a component of the South Carolina Clinical and Translational Research Center (SCTR), which serves as a catalyst for research partnership development across the state and region by facilitating interdisciplinary, multi-institutional collaborations spanning the full translational spectrum from drug discovery and target identification through pre-clinical studies, clinical trials, community-based participatory research, and startup company initiatives. Kathleen T. Brady, MD, PhD, serves as the Director of the South Carolina Clinical and Translational Research Institute, Distinguished University Professor, and Associate Provost, Clinical and Translational Research.

SCTR works to facilitate sharing of resources and expertise and to streamline research-related processes to assist large-scale clinical and translational research efforts in South Carolina. SCTR’s statewide affiliates include USC, HSSC, Clemson, South Carolina State University, Claflin University, Greenwood Genetics Center, South Carolina Research Authority, and VA Medical Centers.

BY THE NUMBERS (2009-2013)

• $175 Million in grant funding facilitated by SCTR services
• $306 Million in total economic impact (2009-2011)
• 3,500+ consultations/requests
• 5,000+ patients enrolled in the Clinical and Translational Research Center
• 752 scientific retreat attendees
• 626 studies on statewide clinical trials listing (SCresearch.org)
PROGRAMS

The SUCCESS Center (Support Center for Clinical & Translational Science) is a consolidated entry point for SCTR programs, research support services, and research navigation support. SUCCESS spans the entire research spectrum from idea inception through technology transfer and the dissemination of best practice models. SUCCESS links investigators and research team members to SCTR and other research services and cores using certified research professionals. SCTR also offers other services for research teams. These include budget development, database development, regulatory submissions, study coordinator services, patient care, and laboratory services.

The SCTR Pilot Project Program & Scientific Retreats serves as a forum to bring together SC research teams, funders, and national leaders to catalyze scientific collaboration building and to provide seed funding.

The MUSC Center for Community Health Partnerships, based in the College of Nursing, exists to lead an innovative, system-wide effort to strengthen capacity for collaborative research relationships among academic investigators and community members, community-based clinicians, and local healthcare organizations. It is dedicated to engaging community members and academic partners in all aspects of the research process to promote health, reduce the risk of illness and disease, and build community resilience to help transform healthcare and eliminate health disparities.

Resources include:
- Community Advisory Board
- Community Research Readiness toolkit translated into Spanish and Korean
- Community-Engaged Scholars Program – the first in the nation to simultaneously train research teams and community leaders in the principles of community-based participatory research in the same classroom
- Team Science & Implementation Science Core
TECHNOLOGY TRANSFER, INNOVATION & ENTREPRENEURSHIP
Resources aimed at catalyzing technology transfer and facilitating research with industry.

• The Center for Innovation & Entrepreneurship, whose purpose is to provide resources and expertise for technology commercialization to the MUSC community

• The Research Opportunities Core (partnering with Quintiles), whose purpose is to pair industry trial opportunities with MUSC investigators and provide the resources and facilities necessary to successfully conduct Phase 0–IV studies.

ENABLING SOFTWARE & TOOLKITS
• REDCap is a secure, Web-based application supporting research data acquisition and databases.

• SPARC (Services, Pricing, & Applications for Research Center) is a Web-based research management system at MUSC providing a one-stop shop to research teams and their study teams to browse services and submit service and pricing requests to research service providers across the MUSC campus. The system focuses on billing compliance and proposal and budget development.

• MUSC Approval Plans for Research tool (MAP-R) guides users through the MUSC research approval process.

• Research Toolkit addresses submitting, conducting, closing and disseminating results of a research study, and includes links to institutional, state, and federal resources and regulations.

• Palmetto Profiles allows users to identify research expertise across the state, creating new opportunities for collaboration among research teams and with industry partners.

Additional software and branching logic tools for research support are described in the Clinical & Trials Development section and include SCresearch.org (statewide clinical trials listing), Study Tracker (designed to track and bill clinical trials through a Web-available portal), Research Nexus (comprehensive clinical research service line) and the Research Permissions Management System (mechanism for electronically capturing and managing informed consents, research authorizations and patient permissions).
BIOENGINEERING INITIATIVES

Bioengineering applies principles and methods from the physical, engineering, and computational sciences to improve healthcare and enable understanding of biological and disease processes. At MUSC, bioengineering involves bridging disciplines, distances, and organizations to coalesce scientific and clinical resources from across the state and encompasses all aspects of the discovery-to-translation-to-delivery biomedical research and development paradigm.

The scope of bioengineering at MUSC spans the cellular/molecular to whole body and encompasses advanced biomaterials, nanotechnology, tissue engineering, regenerative medicine, computer modeling and simulation, biotransport, and imaging. Current clinical applications include cardiovascular, orthopaedics, ophthalmology, dental and craniofacial, neuroscience, cancer, pharmacology, surgery, and biomechanics/rehabilitation.

CLEMSON-MUSC BIOENGINEERING PROGRAM

The Clemson/MUSC Bioengineering Program is a partnership between two major research universities – one known for the engineering, physical, and computational sciences and the other recognized for biomedicine and healthcare – that provides unique multi-disciplinary and translational research and education opportunities that neither would have on its own. The program involves locating Clemson Bioengineering faculty and students full-time at MUSC to enable clinical research and training opportunities for bioengineers and access to engineering and physical science resources for MUSC clinicians and research teams.

After more than ten years, the joint program has produced valuable multi-disciplinary research collaborations between Clemson Bioengineering and more than ten medical departments and colleges at MUSC. The most productive partnerships have occurred in regenerative medicine and biofabrication, orthopaedic and craniofacial biomaterials, ophthalmology, neuroscience, cardiovascular, and biomechanics and rehabilitation sciences.
SC BIOENGINEERING ALLIANCE

The SC Bioengineering Alliance (SCBA) was established over twenty years ago through the SC Commission on Higher Education as a collaborative initiative among the state’s three graduate research universities – Clemson, MUSC, and USC. SCBA’s mission is to capitalize on bioengineering partnerships as a platform to promote, strengthen, and develop multi-disciplinary biomedical research, education, and technology transfer in South Carolina and to integrate academic, business, healthcare, and government resources to support the regional economy.

To accomplish this, the Alliance identifies opportunities, develops agreements, and implements programs to share personnel, facilities, and other resources among state organizations. It also seeks to expand funding from all sources for research and education; facilitates communication and collaboration among the clinical, basic science, and business communities; and provides consultation and advice to state government, medical and basic science professionals, and the biomedical industry.

In support of this initiative, a Bioengineering Building was constructed and dedicated in 2011 on the MUSC campus to provide approximately 100,000 ft² of laboratory, office, conference, and classroom facilities for collaborative research and educational opportunities involving all three Alliance universities.

MEDICAL TRANSLATIONAL TECHNOLOGY PROGRAM

The SC Medical Translational Technology (SC MedTransTech) Program is a partnership of academic, healthcare, and industry organizations aimed at supporting teams of bioengineering and clinical investigators to conduct high-impact, clinically relevant research and to accelerate the transfer of resulting advances to the patient community.

Current partners include the three South Carolina research universities (MUSC, Clemson, and USC), six South Carolina hospitals and surgery/diagnostic centers (Anderson Medical Health System, Bon Secours St. Francis Health System, Greenville Hospital System, Medical University Hospital Authority (MUHA), Oconee Medical Center, and Palmetto Health) and Stryker Corporation – a leading international medical technology and device manufacturer.

The program is coordinated and administered by the SCBA, overseen by Advisory Council that includes representatives from all participating organizations, and implemented by a Steering Committee, which consists of representatives of the Alliance universities, and Stryker Corporation.
The primary objectives of research projects funded by the SC MedTransTech Program are to:

- Develop novel medical advances that will address clinical needs and improve healthcare delivery
- Demonstrate technical feasibility and potential for commercialization
- Accelerate the transfer of advances to the patient community through interactions with industry and technology transfer offices

Research projects focus on devices, processes, materials, procedures, or approaches that are innovative, clinically driven, scientifically feasible, collaborative, and high potential for rapid transfer to the patient community. The program supports one-year grants for up to $100,000 direct costs and six-month fast, track grants for up to $50,000 direct costs for projects that are close to proof of feasibility and have a high potential for short-term commercialization. The MedTransTech Program is in its third year and has funded five research projects to date. These are associated with cancer therapy, advanced imaging systems, spinal cord disorders, rapid orthotic manufacturing, and surgical assist devices.

**SMARTSTATE® CENTERS OF ECONOMIC EXCELLENCE**

The South Carolina Centers of Economic Excellence (SmartState™) program enables MUSC to recruit top scientists to lead the SmartState™ Centers of Economic Excellence. These scientists, Endowed Chairs, serve as the nucleus for university-based research centers to cultivate public-private industrial partnerships. The bioengineering-related SmartState™ Centers include:

**CENTER FOR ADVANCED TISSUE BIOFABRICATION**

The long-term goal of the SmartState® Center for Advanced Tissue Biofabrication is to facilitate industrial-scale production of complex tissues and organs for the repair, replacement, or restoration of diseased cells, tissues, and organs. Work on this goal is primarily conducted at a tissue biofabrication laboratory at MUSC that houses state-of-the-art equipment for assembling and testing tissue constructs, tissue culture suites for autologous cell production, and bioreactors for maintaining engineered constructs. The Center is one component of South Carolina’s broader bioengineering program, which includes the Center for Regenerative Medicine and the SC Bioengineering Alliance.

The Advanced Tissue Biofabrication Center played a major role in the statewide $20 million organ bioprinting project supported by the National Science Foundation in 2009. Bioprinting involves assembling human tissues and organs by layering living cells and a hydrogel using a three-dimensional computer-driven approach. Previously, production of bioprinted tissue has been limited to cartilage and similar structures that do not require blood flow. Center research teams aim to generate a vascular supply for bioprinted tissue that would allow a larger variety of structures and organs to be created in this manner.
The Center for Regenerative Medicine is a collaborative initiative involving Clemson, MUSC, and USC including expertise in developmental biology, stem cell technology, and tissue engineering. A major focus of the center is to enable the in vivo regeneration of damaged tissues to return them to full functionality and the in vitro production of tissues for transplantation when regeneration is not possible.

Dr. Martin Morad, one of three endowed chairs for this SmartState® Center, is an internationally recognized scientist in the field of cardiac electrophysiology and calcium signaling, specifically in the area of calcium-binding proteins.

Dr. Morad seeks to discover what causes these calcium-signaling mechanisms to stop working properly as this can lead to congestive heart failure. His research is ultimately aimed at developing a biological pacemaker using regenerative medicine approaches.
MUSC has the only comprehensive cardiovascular center in the state, offering the latest advances in pediatric and adult cardiology, interventional radiology, cardiovascular surgery, and heart transplantation. The center includes programs in disease prevention, research, teaching, public health and community education. Its work in cerebrovascular disease includes a highly recognized stroke management program. MUSC is home to some of the world’s best cardiovascular specialists and services.

MUSC is recognized for global leadership in research on cardiovascular developmental biology, and adult and pediatric cardiovascular disease. Research programs focused on cardiovascular research include the Gazes Cardiac Research Institute, the Center for Biomedical Research Excellence for Developmentally Based Cardiovascular Disease, Regenerative Medicine and Cell Biology, Cardiothoracic Surgery and Pediatric and Adult Cardiology.

The diversity of the cardiovascular research faculty and its collaborative culture fosters a multidisciplinary approach to research problems and provides an important bridge between clinical and basic science departments at MUSC. Research efforts include the study of gene regulation in heart development and cardiac disease; cardiovascular function and metabolism, muscle contraction and protein turnover, and signal transduction pathways in development and disease.

Given MUSC’s traditional strengths in adult cardiovascular disease and cardiac developmental biology, and in collaboration with the MUSC-Clemson Bioengineering program, and MUSC Drug Discovery Center we are well positioned to compete effectively in the area of stem cell-based cardiovascular regenerative medicine. Our discoveries are contributing to new paradigms in understanding molecular mechanisms involved in heart development and disease and are translating into new diagnostic strategies and novel therapies in the treatment of heart disease.

In addition to the cardiovascular research programs, clinical medicine offers advanced technologies in our Heart and Vascular Center. These include: the Seinsheimer Cardiovascular Health Program, offering one-step access to a full range of preventative cardiology services, and the SC Heart Valve Center (HVC), the first center in South Carolina – and among the first in the nation – to perform Transcatheter Aortic Valve Replacement (TAVR).
This is a new treatment option for severe narrowing of the aorta in patients determined to be inoperable or at high risk for open-chest surgery to replace their diseased aortic heart valve.

The MUSC Children’s Heart Center provides comprehensive cardiac care with inpatient and outpatient services for patients of any age with congenital heart disease and children with acquired heart disease. This comprehensive center has consistently been named one of the top pediatric heart centers in the country by *U.S. News and World Report*.

**COMPREHENSIVE STROKE AND CEREBROVASCULAR CENTER**

Highly coordinated expertise at every level of care — prevention, diagnosis and treatment — makes our Comprehensive Stroke and Cerebrovascular Center unique in South Carolina and distinguishes us in the Southeast. With one of the nation’s largest team of top stroke and cerebrovascular specialists supported by a full range of leading-edge technology and facilities, our patients receive care available only at the most elite neuroscience medical centers in the country.

The MUSC Comprehensive Stroke and Cerebrovascular Center is one of the leading certified stroke centers and has received many awards and recognitions including Advanced Certification as a Primary Stroke Center from the Joint Commission and the Stroke Gold Plus Quality Achievement Award from the American Heart Association/ American Stroke Association’s Get With The Guidelines®.

In addition, the Stroke Research and Education Center serves as a dedicated resource to enhance stroke education and research activities conducted at MUSC. Specifically, the Center facilitates the productivity of investigators and educators focused on stroke by enhancing collaborations both domestically and globally. The faculty and staff are involved in many NIH-funded research studies focused on treating and preventing stroke more effectively. The stroke research faculty includes not only neurologists, but also epidemiologists and emergency medicine physicians.

**REACH TELE-STROKE NETWORK**

MUSC’s stroke team provides urgent consultations at select hospitals in South Carolina through a web-based outreach initiative called REACH. “REACH” stands for Remote Evaluation of Acute ischemic Stroke.

This potentially life-saving network connects partnering hospitals with immediate, round-the-clock access to MUSC’s stroke care experts,
who can remotely provide urgent consultations after virtually examining patients and brain imaging studies. Many rural, community medical centers have stroke patients arrive in their emergency department, but don’t have a neurologist on staff or do not have enough neurologists provide an around-the-clock stroke team capable of rapid stroke evaluation and treatment.

There are twelve partner hospitals across the state, soon to expand to 20 sites — the REACH Stroke Network has doubled access to expert stroke care in South Carolina and resulted in many more safe and effective treatments with tPA, the only FDA approved drug for stroke. With the activation of the REACH Network, more than 56% of the South Carolina population is now within a 60-minute drive of tPA treatment compared with only 38% prior. As of March 1, 2011 the MUSC REACH program had provided expert consultative care to more than 1,000 stroke patients in South Carolina.

SOUTH CAROLINA COLLABORATIVE ALLIANCE FOR STROKE TRIALS (SC-COAST)

In September of 2013, MUSC was selected as 1 of 25 Regional Coordinating Centers to participate in a Stroke Trials Network funded by the National Institutes of Neurological Diseases and Stroke (NINDS). The primary goal of the network is to maximize efficiencies leading to the development, promotion and conduct of high-quality, multi-site clinical trials focused on key interventions in stroke prevention, treatment, and recovery. Exploratory phase I, II and confirmatory phase III clinical trials as well as biomarker-validation studies that are immediately preparatory to trials will be coordinated through the network.

Clinical and basic scientists at MUSC are contributing to the development of network-based clinical trials and will execute NINDS-funded stroke clinical trials from outside of the network, including trials that result from Collaborative Research and Development Agreements between the NINDS and industry partners. The Network will also be uniquely poised to rapidly collaborate with other existing networks, such as the NINDS Neurological Emergencies Treatment Trials Network and international consortia to conduct larger, definitive trials of promising interventions for the treatment of stroke. MUSC was chosen to participate in this network because of its excellence in clinical science, its specialized expertise in stroke management, its strong background in stroke research, and its proven ability to recruit stroke patients.
MOLECULAR PROTEOMICS IN CARDIOVASCULAR DISEASE AND PREVENTION CENTER

The Molecular Proteomics in Cardiovascular Disease and Prevention Center will advance cardiovascular prevention and treatment by accelerating the translation of bench science and advanced diagnostics into clinical bedside care. This SmartState® Center maintains a statewide network of five primary locations, all linked by a central bioinformatics core.

This core will allow patients from across the state that are currently suffering or at risk for cardiovascular disease to be screened for specific biomarkers to aid in the diagnosis and prediction of left ventricular hypertrophy and diastolic heart failure. Center objectives include the development of measurement systems to detect early heart failure indicators relating diagnostic protein signatures to clinical outcomes and creating a statewide network to develop and improve clinical care of heart failure.

STROKE CENTER

Although no region of the country is immune to stroke, people in South Carolina – in the middle of an eleven-state region known as the stroke belt – are particularly susceptible to the disease, with death rates twice the national average. The Stroke Center is focused on reducing the incidence of stroke and improving the delivery of acute stroke care in South Carolina. Advances in stroke treatment are most effective when patients are seen within the first three hours after symptoms develop. This time factor is crucial for any recovery.

This collaborative effort enhances the research programs of MUSC, USC, Greenville Health System, and the Greenwood Genetics Center, while it strengthens clinical and basic stroke research in South Carolina. The Center’s three endowed chairs are increasing access to expert stroke care across the state, building a dynamic translational stroke research program, and stimulating development of new treatment paradigms.
Dr. Robert J. Adams is the SmartState® Endowed Chair in Stroke at MUSC. His research is in clinical neurology with a focus on preventing strokes and developing new ways to deliver stroke care to patients. He serves as principal investigator for two multisite projects in stroke prevention in children with sickle cell disease and one Department of Defense (DoD)-funded project on access to care and addressing disparities in stroke care.

Dr. Adams is a founder and Director of the MUSC REACH Telesstroke Network, a statewide program connecting outside hospitals (large and small) with stroke neurologists at MUSC via the Internet to provide round-the-clock stroke care that can save stroke victims’ lives and improve post-event quality of life.

Dr. Marc Chimowitz, also a SmartState® Endowed Chair in the Stroke Center, received NIH funding for a $20 million, 50-center nationwide clinical trial “Stenting vs. Aggressive Medical Management for Preventing Recurrent Stroke in Intracranial Stenosis (SAMMPRIS)”, which he led from MUSC (one of the largest extramural research grants in South Carolina history).

The study showed that aggressive medical management alone is superior to aggressive medical management combined with a specific type of brain stent for patients at high risk for stroke. Dr. Chimowitz and the team of investigators published the results from this trial in The New England Journal of Medicine. The trial studied the value of using stents to prevent strokes in patients whose brain arteries have hardened and narrowed due to plaque buildup. The findings of this study have had a huge impact on stroke care around the world.

Drs. Adams and Chimowitz, working in complementary areas of stroke prevention, have each designed and executed two large multicenter clinical trials, which resulted in changes in clinical practice. The SmartState® Stroke Center represents an uncommonly strong clinical trial design resource.

Dr. Souvik Sen is the SmartState® Endowed Chair in Stroke Neurology at USC. His research focuses on understanding stroke risk factors and developing new approaches for treatment and prevention. His specific interests include acute stroke treatment and cardio-embolic strokes caused by blood clots that develop in the heart and travel to the brain. In 2011, Dr. Sen succeeded in establishing the first Joint Commission–certified stroke center in the South Carolina Midlands at Palmetto Health, one of the state’s largest health systems.
Clinical trials are a key research tool for advancing medical knowledge and patient care. Funded by government entities such as the NIH and the Department of Defense, along with pharmaceutical and medical device companies, these research studies address nearly every disease process from cancer, heart disease, and diabetes to digestive disease disorders, adolescent obesity, autoimmune diseases, addiction, neurodegeneration and sickle cell disease. Clinical trials offer hope to patients and families and also provide tremendous opportunities for research collaboration and investment.

SCresearch.org is the South Carolina Research Studies Directory. It enables South Carolinians to participate in research opportunities and novel treatment options available at MUSC and across the region. MUSC participates in a large number of clinical research studies and provides support through the HCC and the SCTR clinical trials office along with electronic platforms for administration and review.

HOLLINGS CANCER CENTER (HCC)
CLINICAL TRIALS OFFICE

- Personnel: 48 staff and support personnel
- Assists HCC investigators in the initiation and administration of studies
- Centralized support for scientific, ethical, financial and operational reviews and ongoing management
- Provides training and education relevant to all aspects of study management to staff, and new investigators
- Communicates the availability of clinical studies to HCC physicians, referring physicians and the public
- Prepares records for internal and external quality and compliance audits
- Assist clinicians in screening and enrolling patients for clinical research studies
- Coordinates and ensures the completion of patient-specific study requirements
- Provides data management support for clinical research studies
- Provides multi-center management support services for investigator-initiated trials
SCTR RESEARCH NEXUS

• The Research Center is a 9,200 ft² outpatient facility with eight examination rooms, three procedure rooms and one dental suite.

• Clinical nursing & nutrition services include research nurses & staff that conduct protocols, secure specimens, administer medications, gather critical data at the bedside of hospitalized patients and evaluate nutritional dynamics.

• Resources include the Body Composition Suite with precision image quality at low radiation exposure and pulmonary function testing equipment that measures static and dynamic lung functions.

• Research coordinators provide assistance with management of multi-site trials or day-to-day oversight of research programs.

• Processing of biological specimens and nucleic acid extraction services

• Processing and storage samples in the Biorepository Laboratory

• The Research Opportunities & Collaboration Program assists in establishing industry-sponsored research providing a single service approach.

ADDITIONAL SUPPORT AND ENABLING PLATFORMS

• The Research Permissions Management System, a collaborative project with Health Sciences South Carolina, enables users to manage their own data on the Internet in a significant advance in consumer choice and facilitates South Carolina patients’ participation in clinical trials by enabling them to quickly identify and volunteer for clinical research trials and receive notifications of future research trials related to their condition.

• The eIRB, web-based shared platform for Institutional Review Boards, also a collaborative project with Health Sciences South Carolina (HSSC), allows research teams to complete critical paperwork for clinical trials online. This platform streamlines the administrative aspects of protocol review and supports collaborative research among HSSC member organizations. South Carolina is among the first states to implement such a system, now operational at all six HSSC-supporting organizations.

• A Study Tracker platform tool allows for the tracking of individual research assessments/procedures at the patient level at any time throughout the research study. Study summary reports display all patients in a particular study, the status of each patient within the study, and research charges related to each participant visit to facilitate tracking of ongoing study progress.

• MUSC investigators have access to ResearchMatch, the first national registry of research volunteers, designed to bring together two groups of people who are looking for one another: (1) individuals trying to find research studies, and (2) research teams who are looking for individuals to participate in their studies.
DRUG DISCOVERY AND THERAPEUTICS

Along with strong basic science and clinical research, MUSC maintains drug discovery programs in multiple therapeutic areas including cancer, infectious diseases, neurosciences, cardiovascular sciences, pulmonary medicine, and rheumatology/immunology. Moreover, MUSC offers uncommon capability to generate small molecule leads for validated targets identified by scientists in other basic and clinical science departments. This has led to a number of NIH-funded research programs, industry partnerships, clinical trials, and startup companies.

The Drug Discovery Center is under the direction of Karen Lackey whom was appointed in February 2014 after serving as Vice President and Head of Medicinal Chemistry at Roche. At Hoffman-La Roche she was responsible for small molecule drug discovery in oncology, virology, and inflammation while chairing the Global Chemical Biology Initiative. Prior to joining Hoffman-La Roche, Ms. Lackey served as Vice President, Discovery Medicine Chemistry at GlaxoSmithKline with responsibility for the early-stage research portfolio. During her 22-year career at GlaxoSmithKline, Karen held a variety of positions and contributed to small molecule research, development of new technologies, and systems-based research with an active role in the discovery of the dual erbB2/EGFR tyrosine kinase inhibitor, lapatinib, currently marketed as Tykerb®.

BASIC RESEARCH

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CLINICAL RESEARCH

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PRECLINICAL DISCOVERY

Preclinical discovery encompasses target identification and validation, computational chemistry and structure-based design, high throughput screening to identify “hits” from chemical libraries, medicinal chemistry (hit-to-lead studies and lead optimization) and scale-up synthesis coupled with animal efficacy models and pharmacokinetic characterization. Affiliated complementary core facilities at MUSC include proteomics, monoclonal antibody generation, lipidomics, genomics, biomarker identification and a Biorepository. The Center for Biomedical Imaging provides a spectrum of services ranging from cell and molecular imaging through research human imaging. The Cellular Evaluation & Therapy Shared Resource Laboratory provides tissue processing and cell generation in compliance with Good Manufacturing Practice and Good Tissue Practices standards. These resources are available to multiple research and development programs across campus and through industry partnerships.

As part of its drug discovery platform, the MUSC Drug Discovery Center provides technical and intellectual expertise for identification of new drugs and compounds targeting biological events across a range of disease focus areas. The shared resource provides expertise for handling compound libraries and assay development as well as instrumentation and technical support for high-throughput screening. Compound libraries include the DIVERSet™ collection (ChemBridge Corporation) of 50,000 compounds, which defines novel subsets of drug-like, small molecules with a broad range of pharmacophore diversity. The DIVERSet library provides the entry point to the entire 500,000 compound ChemBridge collection for compound optimization and expanded screening initiatives.

As sufficient data become available from the screening efforts, hits are compiled and structurally analyzed. The shared resource also utilizes computational modeling to derive quantitative structure-activity relationships for each target studied.
If the three-dimensional structure of the target is known, virtual screening can be used to rapidly select compounds for testing. Also, docking analyses and virtual screening provide important information about how compounds interact with their target facilitating the design of new analogs. Additional related resources (NMR and X-ray crystallography) for structural analysis of drug-target interactions are available through the Molecular Structure Laboratories (See Advanced Technologies).

These resources provide a platform for strategic partnerships and commercialization in targeted therapeutic areas.

CHEMINFORMATICS
• Molecular Operations Environment: A cheminformatics software suite
• Protein Structure/Activity Relationships (X-Ray Crystallography, NMR)
• Ligand 3D Pharmacophore Modeling
• Ligand 2D/3D QSAR Modeling (Quantitative Structure Activity Relationships)
• Ligand Docking Simulations
• Rational Drug Design
• Virtual Screening
• Drug Cross Reactions
• Scaffold Hopping and Peptidomimetic Leapfrog

DRUG DISCOVERY & SCREENING RESOURCE INSTRUMENTATION
• Multifunctional Molecular Devices Spectramax M5 and Perkin Elmer EnVision microplate readers capable of quantifying absorbance, luminescence, fluorescence intensity, time-resolved fluorescence and fluorescence polarization.
• Seahorse XF96 – real-time cellular oxygen and pH meter in microplate platform
• Caliper SciClone ALH 3000 automated liquid-handling workstation
• Molecular Devices AquaMax microplate washer
• IN Cell Analyzer and Hermes WiScan imaging systems for cell-based high-content screens

DRUG METABOLISM & CLINICAL PHARMACOKINETICS
• Preclinical/clinical trial design and analysis
• Drug metabolite identification (in vivo, in vitro and ex vivo)
• Drug level quantification (serum/plasma, tissue or cell/media)
• Pharmacokinetic and Pharmacodynamic studies
• Evaluation of human safety pharmacology using normal target cells from dose-limiting tissues
• LC-MS/MS facilities include a 96-well plate automated liquid-handling system and a triple quad LC-MS/MS Micromass Quattro Premier XE with multimode ionization for applications in protein and peptide analysis, small molecule analysis in drug metabolism and pharmacokinetic studies
• LC-MS autopurification units capable of medium-throughput purification and identification of chemical entities
• Abaxis VetScan and Beckman Coulter DU800 spectrophotometer for hematologic and toxicology assays
MEDICINAL CHEMISTRY
- Development of synthetic methodology
- Hit-to-lead and lead optimization studies
- Medium-throughput synthesis of analogues and chemical library development
- Microwave-assisted chemical synthesis
- Scale-up synthesis of desirable intermediates up to the kilogram scale
- Enzymology and enzyme kinetic analysis
- Analytical services
- Peptide and peptidomimetic synthesis
- Structure-based drug design
- Virtual screening

EARLY CLINICAL RESEARCH
MUSC has a dedicated Phase I oncology unit and the SCTR Research Nexus that is used by a variety of clinical research disciplines. In addition, a well-funded addiction biology unit performs specialty studies in a range of addiction states. Many of the studies are designed or co-authored by MUSC investigators working collaboratively with industry sponsors.

LATER-STAGE CLINICAL TRIALS
MUSC faculty members are or have been investigators in large multi-center trials encompassing virtually every therapeutic condition. Some examples by therapeutic area include the following.
- **Cardiovascular**: heart failure, atrial fibrillation, hypertension, coronary artery disease, venous thromboembolism, stroke, peripheral artery disease
- **Neurosciences and Psychiatry**: major depressive disorder, schizophrenia, bipolar disorder, addiction disorders, alcoholism, epilepsy, multiple sclerosis, Alzheimer’s disease, Parkinson’s disease, fibromyalgia
- **Virology**: HIV, hepatitis C virus
- **Metabolism**: carcinoid syndrome, diabetes mellitus, Cushing’s syndrome, polycystic ovarian disease, acromegaly, hypoparathyroidism
- **Oncology**: acute myeloid leukemia, lymphoma, breast, brain, renal cell, hepatocellular, prostate, lung, melanoma, myeloma, myelodysplastic syndrome, ovarian, colorectal, head and neck, pancreatic, bladder
- **Pulmonary**: asthma, COPD, pulmonary hypertension, bronchiectasis, sarcoidosis
- **Fibrosis and Inflammation**: interstitial pulmonary fibrosis, Crohn’s disease, psoriasis, rheumatoid arthritis, scleroderma, angioedema, Raynaud’s Phenomenon, lupus, osteoarthritis
- **Renal**: acute kidney disease, chronic renal failure, renal transplant
The drug discovery-related SmartState® Centers include those centers described under the Hollings Cancer Center (Cancer Drug Discovery; Cancer Stem Cell Biology and Therapy; Gastrointestinal Cancer Diagnostics; Lipidomics, Pathobiology and Therapy; and Translational Cancer Therapeutics) as well as the SmartState® Center for Medication Safety and Efficacy.

**MEDICATION SAFETY AND EFFICACY CENTER**

The SmartState® Medication Safety and Efficacy Center focuses on increasing drug safety and effectiveness, as well as decreasing medication errors by identifying the incidence and significance of adverse drug events that occur with prescription and non-prescription drugs.

These data are provided to hospitals, pharmaceutical companies, insurance companies, and governmental agencies such as Medicaid and Medicare for use in epidemiological and economic studies and will help lead to fewer adverse drug reactions and improved drug effectiveness.

The SmartState® Endowed Chair Dr. Charles Bennett focuses on preventing adverse drug events, improving drug safety, making drug information more consumer-friendly, and developing new training tools for healthcare providers.
MUSC has fully implemented an electronic health record (EHR) – EpicCare. This platform is a structured combination of tightly integrated clinical functions – electronic orders, online nursing documentation, medication administration, automated care tracks, physician order entry, and clinical database/viewer. EHR captures relevant patient information at the point of care in an electronic format that then can be managed, analyzed, and transferred across and accessed throughout MUSC and beyond, quickly, effectively, and securely.

Mobile health and telehealth activities at MUSC are directed at reducing the continued escalation of healthcare costs associated with a high prevalence of chronic diseases. Additionally, they increase access to care and timely expert diagnostics and treatment, especially to rural and underserved populations. These telehealth initiatives include programs in diabetes, stroke, emergency room operations, health disparities, and posttraumatic stress disorder. The State of South Carolina recently awarded MUSC substantial funding for further expansion of these initiatives.
REMOTE EVALUATION OF ACUTE ISCHEMIC STROKE (REACH)

The REACH Stroke network connects twelve hospitals across South Carolina to experts in the MUSC Stroke Center 24 hours a day, seven days a week, 365 days a year. Using a computerized cart with audio-visual capability and a secure Internet connection, staff in the hospital emergency departments (and the patient’s family) can see and talk to a MUSC stroke expert, who can review the brain scan in real time and recommend a course of action.

CAROLINA EHEALTH ALLIANCE (CEHA)

The Carolina eHealth Alliance was established to develop and augment health information exchange platforms to improve care and cost savings. Through CEHA, eleven emergency departments of all the major Charleston-area hospitals are now connected through patient health information exchange that links electronic medical records, saving critical time and reducing costs.

TELEMENTAL HEALTH

Telemental health, or the delivery of psychotherapeutic and psychiatric services via telehealth, brings treatment right into patients’ homes or into the community (rape crisis center, police department, community center, or women’s shelter) where help is most needed. MUSC’s telemental health program offers evidence-based treatment for posttraumatic stress disorders.
The Technology Applications Center for Healthful Lifestyles (TACHL) is a SmartState® Center of Economic Excellence launched by USC and MUSC in August 2010 with the recruitment of Dr. Frank Treiber as the institute’s director at MUSC. The Center provides an outstanding environment for multi-disciplinary research in this sector by investigators from MUSC, USC and Clemson University.

TACHL has the infrastructure to develop hardware and software as well as implement and maintain applications in a secure encrypted environment. The programming paradigm involves development of software systems based on n-tier architecture, where the presentation layer and the business logic and data layer are created separately to minimize maintenance and offer a robust scalable model for future growth and interaction using a unified modeling language.

Through multi-institutional collaborations the Center develops, evaluates and commercializes mobile health technology for individuals, worksites, community groups, and healthcare provider networks. This allows fostering of efficacious health promotion, disease prevention and healthcare management.

Products include software and information systems for mobile smart phones, personal digital assistants, iPad®/tablet technologies, and Web-based computer-assisted programs with support for interactive call centers. Applications developed to date target physical activity, diet, stress reduction, smoking prevention/cessation, biomarker monitoring, and medication adherence.

Product development is guided by the preferences of various users. For example, youth may prefer interactive game-based computer technology applications for health behavior change, young adults may prefer smart phone-delivered interventions, and seniors and others may prefer direct contact with healthcare call centers.

Recent partnerships with MUSC’s Center for Health Disparities Research and Transplant Center resulted in a project to develop and test a Mobile Health iPad®-delivered video program for potential organ donors and recipients across the state.
CLINICAL EFFECTIVENESS AND PATIENT SAFETY CENTER

The Clinical Effectiveness and Patient Safety Center has established a vehicle for clinical education and enhanced patient safety through the use of simulation technology. Dr. John Schaefer, SmartState® Endowed Chair, is an international expert in healthcare simulation that is transforming the way clinicians are taught, and in the process, reducing patient injury and improving medical outcomes. Dr. Schaefer has led the effort to establish a statewide network of simulation centers, collaborating with diverse partners to open or improve centers at the Clemson College of Nursing, Greenville Hospital System, Greenville Technical College, MUSC, Palmetto Health, the USC College of Nursing, and Trident Technical College.

These SmartState® Program–funded simulation centers provide training for medical, nursing and allied health students, and advanced continuing education to hospital employees and physicians while allowing healthcare providers to practice their skills in a controlled, risk-free environment. This innovative training method results in better healthcare outcomes and increased patient safety. Dr. Jihad Obeid, SmartState® Endowed Chair in Biomedical Informatics, serves as an expert in clinical and translational research informatics systems. Dr. Obeid is the Associate Director of the Biomedical Informatics Center at MUSC and is involved in major informatics initiatives across campus and the state including the Clinical Data Warehouses and interoperability across different electronic medical record systems. The third endowed chair, Dr. Rita Snyder at USC, focuses on Health Informatics Quality and Safety Evaluation.

HEALTH CARE QUALITY CENTER

The Center for Healthcare Quality is working to improve the safety, efficiency, effectiveness, and affordability of healthcare in South Carolina through applied medical research and state-of-the-art information technology. This has paved the way for many organizations and individuals to develop a single, unified plan for securing federal funding for, and implementing, a statewide health information technology strategy. Recently, this Center played an instrumental role in establishing the SC Healthcare Quality Trust, a partnership between the Center, the Health Sciences South Carolina consortium, the South Carolina Hospital Association, and Premier, Inc.

Dr. Leslie Lenert was appointed as the Center’s Endowed Chair in Medical Bioinformatics and the first Chief Research Information Officer at MUSC. Dr. Lenert’s research approach is to enable and enhance patient centric healthcare platforms through the application of cognitive modeling and predictive analytics.

TRANSLATIONAL BIOMEDICAL INFORMATICS CENTER

The Center, established in 2013 will provide an additional critical mass of informatics experts to expand the Biomedical Informatics research hub in South Carolina. In collaboration with USC, Clemson, and HSSC, the center will integrate information technology platforms across the state to facilitate regional clinical trials, healthcare quality improvement and discovery-driven research initiatives. This center will support one endowed chair.
HEALTH IT PLATFORMS

Additional resources in this area are described earlier under the sections entitled Platforms in Basic and Clinical Research: Clinical Trials Development and Support - REDCap, SPARC Request, MAP-R, Palmetto Profiles, SCresearch.org, Study Tracker, Research Nexus, Research Permissions Management System, ResearchMatch, and the statewide electronic Institutional Review Board, eIRB.

- **Outpatient Quality Improvement Network (OQUIN)** - Research teams at MUSC developed OQUIN, a multi-state system encompassing approximately 2 million patients from 197 clinics in the southeastern US. OQUIN represents a full spectrum of clinical settings: rural, suburban, and urban sites; federally qualified health centers; solo, small and large group practices (independent or part of larger management groups); university clinics; and, free clinics. A common database from multiple electronic medical records enables identification of management challenges, several of which are now topics involved in mHealth research projects.

- **PPRNet** - A practice-based research network established in 1995 as a collaborative effort between MUSC, Practice Partner/McKesson, and participating practices, this network has 224 physician practices representing over 1,219 healthcare providers, approximately two million patients located in 44 states. Members receive quarterly performance reports on nearly 100 clinical measures. PPRNet also develops mechanisms for conveying and implementing best practices and captures information through electronic medical records.

- **Enterprise Data Warehouse (EDW)** – This platform provides a wealth of data for clinicians, research teams, analysts, etc., to extract current, accurate, and secure information relevant to a particular patient, subject or business unit. The EDW is the “Gold Standard” for MUSC data and is fed from multiple information streams and formatted in a data structure/schema that is naturally aligned with the work processes, work environment, and information access preferences of individual users. It includes the Clinical Data Warehouse, which is used for research and healthcare quality initiatives, allowing exploration of massive amounts of electronic health record data while protecting patient confidentiality and data security, using IRB approved methodologies and research protocols.

- **The Health Sciences South Carolina (HSSC) Clinical Data Warehouse (CDW) and i2b2** is provided via the statewide research collaborative of HSSC. Real-time clinical data from multiple HSSC-supported health systems around the state are aggregated into a comprehensive data set. The initiative leverages the excellence of the nationally recognized open-source analytic toolkit, i2b2 (or Informatics for Integrating Biology and the Bedside) to provide a dedicated Web-based system for de-identified research.

- **The Center for Information Technology Implementation Assistance (CITIA)** is South Carolina’s regional extension center for health information technology. CITIA is part of a national effort to increase the use of Electronic Health Records by healthcare providers.
INFLAMMATION AND FIBROSIS RESEARCH

MUSC has a longstanding interest in the clinical treatment of and research in understanding the natural history and mechanistic aspects of the development of autoimmune disorders and fibrotic diseases. The highly regarded interdisciplinary programs in Inflammation and Fibrosis multidisciplinary at MUSC encompass clinical, translational and basic research. The clinical research program provides patients with opportunities to participate in disease registries and novel clinical trials, including both early studies of new therapies and large-scale trials. Investigators in basic research focus on disease mechanisms, diagnostics and the development of new therapies.

Dr. Richard Silver is Professor of Medicine and Pediatrics and serves as Director of the Division of Rheumatology and Immunology. Dr. Silver’s research interests center on scleroderma and, in particular, scleroderma lung disease, now the leading cause of death among patients with scleroderma. He was one of the first to utilize bronchoalveolar lavage (BAL) to characterize scleroderma lung disease. He played an instrumental role in the design and development of the Scleroderma Lung Study (SLS) and continues to serve as principal investigator for the SLS’s Biological Samples Repository.

Dr. Silver’s clinical interests include scleroderma and scleroderma-related conditions, as well as childhood rheumatic diseases. MUSC is one of the world’s leaders in clinical care and investigation of systemic sclerosis (scleroderma) and scleroderma-like conditions, e.g. eosinophilic fasciitis and the eosinophilia-myalgia syndrome. MUSC also serves as the state of South Carolina’s only referral center for childhood rheumatic diseases. Dr. Silver has led the efforts to coordinate care for children in South Carolina with rheumatic diseases for the past 25 years, and he continues to provide clinical care and conduct clinical research.

Dr. Gary Gilkeson, Professor in the College of Medicine, serves as the Director of a NIH-funded Multidisciplinary Clinical Research Center (MCRC) for Rheumatic Diseases in African Americans. A goal of MCRC is to advance our understanding of the causes of rheumatic diseases such as systemic lupus erythematosus (SLE), systemic sclerosis (scleroderma), and other debilitating diseases that disproportionally affect African Americans.

Dr. Don Rockey, Professor and Chair in the Department of Medicine, laboratory has demonstrated that the hepatic stellate cell is a key player in liver fibrosis. This cell, which normally functions in the storage of vitamin A,
undergoes a transformation when the liver is injured. This transformation causes stellate cells to become myofibroblasts, a cell type with smooth muscle–like features that contracts and additionally produces extracellular matrix proteins involved in fibrosis.

Dr. Diane Kamen, Associate Professor of Medicine and Director of the Clinical Research Division, spearheads several large observational investigations, including studies of the prevalence, characteristics, and genetics of SLE within the Sea Island African American Gullah population. The SLEIGH (Systemic Lupus Erythematosus in Gullah Health) cohort continues to grow and has led to many important collaborations and discoveries regarding the contributions of genetic and environmental contributions to the development of autoimmunity and autoimmune diseases.

Dr. Lynn Schnapp is the Chief of the Division of Pulmonary Critical Care, Allergy, & Sleep Medicine in the Department of Medicine. Dr. Schnapp leads an active research program focused on lung injury and repair with a special interest in the role of lung pericytes and other stromal cells in the pathogenesis of fibrosis. Her work also involves the proteomic analysis of bronchoalveolar lavage fluid from patients with different lung diseases to identify new biomarkers and causative pathways.

Dr. Carol Feghali-Bostwick, the Kitty Trask Holt Endowed Chair in the SmartState® Center for Inflammation and Fibrosis, studies scleroderma, a disease in which fibrosis develops in multiple organs, especially the skin. This fibrosis is also associated with aberrant myofibroblast activity and Dr. Feghali-Bostwick’s laboratory is developing drugs that are expected to interrupt the signaling pathways involved in the aberrant fibrosis.

SMARTSTATE® CENTERS OF ECONOMIC EXCELLENCE RELATED TO INFLAMMATION AND FIBROSIS

The SmartState® Inflammation and Fibrosis Center, which supports two endowed chairs provides an umbrella for research teams focused on the development of anti-inflammatory and anti-fibrotic drug therapies as well as the alignment of clinical and basic science investigators in this area. Both endowed chairs reside at MUSC and Dr. Carol Feghali-Bostwick was recently appointed as the Endowed Chair in Scleroderma Research in this center.
NEUROSCIENCE, PSYCHIATRY & BEHAVIORAL SCIENCES

Disorders of the brain, nerves and spine are among the most complex in medicine. MUSC has one of the nation’s largest teams of top specialists in neurology, neurosurgery, neurovascular intervention, neuroradiation oncology, neuromodulation, psychiatry, rehabilitation, neurologic nursing and related fields. Using the most advanced technologies, this team pools their expertise to provide a collaborative approach to each patient’s diagnosis, treatment plan and care.

Our programs in Neuroscience and Psychiatry & Behavioral Sciences are consistently nationally ranked among the top ten for research funding by the National Institutes of Health. In 2013, the Departments of Neurosciences and of Psychiatry & Behavioral Sciences were ranked 6th and 7th, respectively, in NIH funding among academic departments of neuroscience and psychiatry. Notably, the number of Psychiatry and Neurosciences faculty with career commitments to research in addiction and substance use disorders has tripled in the last 15 years representing one of the world’s most well-funded, cohesive, and prolific multidisciplinary addiction research groups.

The MUSC Institute of Psychiatry, a 90-bed inpatient hospital located in the middle of campus, houses five inpatient treatment units for acute and general care. The Institute is also home to a variety of day treatment programs, plus the Center for Drug and Alcohol Programs, the Brain Stimulation Laboratory, and other research programs focused on the understanding of psychiatric illness.

Within neurosciences and psychiatry, clinical and translational research teams work collaboratively to investigate mechanisms, causes, and treatments for a number of psychiatric disorders – especially drug abuse and addiction – that frequently co-occur with these conditions. MUSC programs include research on marijuana, cocaine, opiate, alcohol and nicotine dependence, as well as schizophrenia, bipolar disorder, attention deficit hyperactivity disorder, and post-traumatic stress disorder.

Strong emphasis is placed on new combinations of ideas and techniques including the application of new developments in basic neuroscience to clinical problems, the use of molecular techniques to solve cellular and integrative neuroscience problems, and the development of novel cellular and animal models of neurological and psychiatric illness.
BROAD RESEARCH THEMES

- Addiction
- Alzheimer’s disease
- Behavioral management
- Cortical physiology/cognitive disorders
- Deep brain stimulation for treatment of depression and other mood and behavioral disorders
- Demyelinating disorders (multiple sclerosis)
- Movement disorders (Parkinson’s disease)
- Neurovascular devices for stroke management and neurointervention
- Neuroimaging modalities
- Neurodegeneration
- Posttraumatic stress disorder
- Sleep and anxiety disorder
- Stroke

Cerebrovascular research teams in neurosurgery include a team of leading investigators and surgeons focused on the development of new neurosurgical devices and technologies. The team is involved in both the development and evaluation of such devices in concert with industry partners.

Industry partnerships cover the spectrum from target identification and validation to development of new technologies and treatment strategies with a broad range of clinical trials. Initiatives in this area led to the establishment of the MUSC Institute for Applied Neurosciences, which provides a technology development and commercialization platform linking basic, clinical, and applied research in focused areas of neurointervention and neurosurgery.
NEUROBIOLOGY OF ADDICTION RESEARCH CENTER

The primary goal of the Neurobiology of Addiction Research Center (NARC), led by Dr. Peter Kalivas, is to determine the neurobiological basis of an addict’s overriding motivation to obtain cocaine and the related inability to develop behaviors that compete with drug use. To accomplish this goal, NARC research teams have brought together cell biologists, behavioral neuroscientists and clinicians whose careers are devoted to finding new and effective cures for addiction.

By probing the molecular basis of how cocaine changes the brain, investigators are determining which of the proteins that regulate communication between nerve cells are most greatly affected in rats trained to self-administer cocaine. This involves measuring the influence of cocaine treatment and withdrawal on the changes in the expression and processing of proteins and gene transcripts as well as changes in the structure of the nerve cells and physiological responses in the nerve cells. This range of measurements provides a first step towards effective treatment strategies. Not only does it tell us which parts of the brain are most affected, but also which molecules are the most eligible candidates to target in treating addiction. Once a viable compound has been identified, the team has the ability to initiate pilot clinical trials with addicted subjects.

BRAIN STIMULATION LABORATORY

The Brain Stimulation Laboratory led by Dr. Mark George encompasses a number of studies and technology development initiatives related to electromagnetic approaches as research tools investigating neuroscience questions and as investigational or FDA-approved treatments for brain diseases. MUSC is a world leader in transcranial magnetic stimulation research, including clinical trials for depression and pain management, and in determining other applications of the technology, e.g. behavioral modification and stroke. MUSC research teams were among the first in the world to implant vagus nerve stimulation devices in patients with major depression who had not adequately responded to traditional antidepressants and are recognized leaders in the application of functional magnetic resonance imaging (fMRI) to monitor brain activity.

Specialized techniques include: transcranial magnetic stimulation (a non-invasive technique for treating neuropsychiatric disorders, Parkinson’s disease, chronic pain and depression); vagus nerve stimulation; transcranial direct current stimulation; electroconvulsive therapy; deep brain stimulation; and epidural cortical stimulation. In some instances, brain stimulation techniques are delivered in conjunction with fMRI to examine relevant circuitry.

INSTRUMENTATION

- NeoPulse Neotonus® Model 3600 stimulators
- Magstim® Rapid, Super-Rapid and Bistim2 machines
- Brainsway Deep transcranial magnetic stimulation H-coil device
- Neuronetics Neurostar Deep transcranial magnetic stimulation
- Two MECTA spECTrum 5000Q® machines and a Thymotron® System IV
- Frameless stereotaxy for image-guided targeted transcranial magnetic stimulation.
NEUROIMAGING

The neuroimaging research team, led by Dr. Jane Joseph, in coordination with the Center for Biomedical Imaging offers image analysis support and study design consultation for basic, translational and clinical research teams. In addition, MUSC research teams are at the forefront of applying new multiphoton imaging systems to visualize changes in brain structure and function at a molecular level.

The Brain, Cognition and Development Laboratory focuses on the neural basis of various cognitive and affective behaviors throughout the human lifespan fMRI and network analysis techniques to discover how different brain components communicate. The Translational Research of Addiction and Integrative Neurosciences (TRAIN) Laboratory investigates the neural basis of drug addiction (e.g. smoking, psychostimulant abuse) and psychiatric illness using cognitive and affective neuroscience theory and methods.

CENTER FOR DRUG AND ALCOHOL PROGRAMS

The Center for Drug and Alcohol Programs (CDAP) is one of the nation’s premier academic centers for the study and treatment of alcohol and substance abuse. Nationally and internationally known scientists are advancing current knowledge about alcohol and substance abuse through basic, translational, and clinical research.

CDAP’s members utilize brain imaging technologies, genetics, behavioral pharmacology and therapies to provide better treatments for alcohol and substance abuse. Located within the Institute of Psychiatry with 33,000 ft$^2$ of dedicated space for research, clinical treatment and education, CDAP encompasses nine basic science laboratories, a 23 bed inpatient unit for treatment of severe addictions, interview rooms, and offices. All CDAP treating physicians have passed Addiction Medicine specialty boards as well as General Psychiatry/Neurology boards.

A cornerstone of CDAP is the Alcohol Research Center supported by a National Institute of Alcohol Abuse and Alcoholism P50 grant. One of 15 such centers in the nation, the Alcohol Research Center focuses on pharmacotherapy and comorbidity for alcohol abuse and alcoholism.

The Center views alcoholism as having a biological basis, with neuroanatomical, neurochemical, genetic, and behavioral underpinnings. The Center’s research components are tied together by a focus on neuroanatomical and/or neurochemical adaptations that accompany the transition from controlled to uncontrolled drinking, the neurocircuitry underlying reward processes, and trait personality factors that may mediate the risk for development of alcohol dependence or the response to pharmacotherapy.
The Center for Rehabilitation Research in Neurological Conditions, housed within the College of Health Professions’ Department of Health Science and Research, is a world-class rehabilitation research program. Dr. James Krause, Director, and Dr. Steven Kautz, Associate Director, serve as the scientific leadership for the center.

The Center’s collaborative partnerships include the SmartState® Center for Stroke, MUSC’s Department of Neurosciences and Center for Advanced Imaging Research, the Clemson-MUSC bioengineering program, the College of Charleston’s Department of Health and Human Performance, and the Ralph H. Johnson VA Medical Center. It also has formal collaborative relationships with the Minnesota Department of Public Health and several internationally renowned rehabilitation centers, including the Shepherd Ctr., Craig Hospital, and Rancho Los Amigos National Rehabilitation Center.

The Center’s research is designed to provide physicians and therapists a theoretical framework and a measurements toolbox necessary to guide the most effective custom-tailored treatment for a patient’s specific impairment. It is also designed to develop and analyze large data sets to guide epidemiologic studies and public health interventions designed to decrease morbidity and mortality after neurologic injury and disease. The interdisciplinary research center includes seven high-tech laboratories in the areas of locomotor energetics and assessment, locomotor rehabilitation, upper extremity motion function, functional neurostimulation, neuromuscular assessment, voice and swallowing, and neurological conditions research. It is one of only five other centers in the nation with this range of capabilities.

The laboratories feature an instrumented split-belt treadmill that can measure 3D ground reaction forces; a motion-capture system that allows human movement data to be collected at up to 242 frames per second; a one-of-a-kind perturbation system for investigating balance during walking; and, a high-tech, computer-controlled body-weight support system that assists in walking over ground or on a treadmill.

INSTRUMENTATION

- ZeroG mobile body weight support system
- Bertec instrumented split-belt treadmill
- Three PhaseSpace active marker based motion capture systems
- Newest line of Magstim magnetic stimulators and magnetic coils and Brainsight-2 Neuronavigation System
- GE LOGIQ i ultrasound machine
- Biodex System 4Pro isokinetic dynamometer
- Three Motion Laboratory Systems 16-Channel EMG system
This environment also allows investigators to more accurately challenge an individual’s speed and endurance than in a traditional rehabilitation laboratory. Detailed biomechanical analyses allow the therapists to understand specific deficits, critical for choosing the most effective interventions. The result is a critical mass of people conducting rehabilitation research, with an international reputation for neuro-rehabilitation research excellence. Center research teams also focus on behavioral measurement techniques, detailed engineering analyses, and novel explorations into nervous system function and plasticity to help individuals with neurological injury and disorders – the key concept being that no one therapy fits all.

SMARTSTATE® CENTERS OF ECONOMIC EXCELLENCE IN NEUROSCIENCES AND PSYCHIATRY & BEHAVIORAL SCIENCES-RELATED AREAS

CENTER FOR BRAIN IMAGING

The Center for Brain Imaging leverages MUSC’s international reputation in brain imaging and brain therapies with the expertise in cognitive neuroscience, computer science, engineering and public health at USC and MUSC to provide an exceptional platform for synergistic collaborative initiatives. The Center is developing new technologies in the areas of deception detection and minimally invasive brain diagnostic and stimulation.

The Center’s MUSC Endowed Chair Dr. Joseph A. Helpern is leading a new biomedical imaging initiative at MUSC while also continuing his personal research activities, which focus mainly on using magnetic resonance imaging to investigate brain function and mechanisms involved with neurodegenerative diseases such as Alzheimer’s, epilepsy, stroke and attention deficit hyperactivity disorder. He has developed new brain imaging technology called Diffusional Kurtosis Imaging (DKI) to study the micro-architecture of the brain. Using DKI, disorders such as Alzheimer’s disease and epilepsy may be diagnosed at earlier stages of disease development. Siemens Medical has licensed Dr. Helpern’s DKI technology. Dr. Helpern holds several patents related to imaging technologies.

NEUROSCIENCE CENTER

The Neuroscience Center focuses on age-related neurodegenerative problems, including dementia, Alzheimer’s, Parkinson’s, and stroke. The Center is a strong component of our established Neuroscience Institute and also works in collaboration with the MUSC Center on Aging. SmartState® Endowed Chair Dr. Gary Aston-Jones and his research team have focused on such subjects as neuronal mechanisms involved in drug addiction, a new animal model of depression, and the brain circuits involved in circadian regulation of behavioral processes.
ORAL HEALTH

The Center for Oral Health Research (COHR) provides support to stimulate campus-wide oral and craniofacial research and interdisciplinary integration of the contemporary sciences in oral health. COHR director Dr. Keith Kirkwood serves as the Associate Dean for Research and as Chair of the Department of Craniofacial Biology. This center is integrated with a new, state-of-the-art dental education and treatment facility. A primary research focus for the oral health program is related to head and neck cancer and it is fully integrated with research and treatment programs in the MUSC Hollings Cancer Center.

COHR supports faculty members across campus and around the country through the Clinical Core, the Gnotobiotic Animal Research Core for germ free preclinical studies, the Laboratory Core, and a Training Core.

- The Clinical Core facilitates sharing of resources and expertise to provide outpatient dental clinical research capacity to support all industry and university projects on site or in the community.

- The Laboratory Core provides a range of services, including histology, oral cancer mouse models, digital imaging, microCT, mineralized tissue analysis and laser capture microdissection.

- The COHR provides mentored research training opportunities at the interface of oral health, craniofacial biology, and bioengineering.

The COHR has over 60 investigators across campus focused on understanding molecular mechanisms underlying oral cancer and periodontal disease progression, along with oral infectious diseases, including candidiasis.

COHR investigators are actively developing novel strategies to manage oral mucositis and periodontitis as well as in the development of new dental materials such as a recently development antimicrobial adhesive with special bond durability characteristics that prevent enzyme degradation of the hybrid layer.
SENSORY SCIENCES

MUSC has strong programs in the sensory sciences, including hearing and vision. These collaborative programs involve interdisciplinary research teams in multiple clinical and basic science departments in the College of Medicine (Otolaryngology-Head and Neck Surgery, Pathology and Laboratory Medicine, Ophthalmology, and the Neuroscience Institute).

HEARING RESEARCH

Auditory neuroscience is the central theme and research focus for the Hearing Research Program, with an emphasis on the aging auditory system. The mission of the Hearing Research Program is to advance our understanding of the mechanisms and effects of hearing loss and improve diagnostic methods, intervention procedures, and prevention strategies. NIH-funded research includes studies of mechanisms that result in inner ear and auditory nerve damage; studies with adult bone marrow stem cells to replace or regenerate damaged cochlear cells, and the use of brain imaging technologies to study the human auditory system. A Clinical Research Center grant, led by Dr. Judy Dubno, from NIH also supports a large number of clinical studies focusing on declines in hearing due to aging. Its database of measures of hearing function includes more than 1,000 participants from the Charleston area and spans more than 25 years. This is a longitudinal study of hearing, where the same measures are obtained from participants every couple years to better understand how hearing and related health conditions change over time. Research efforts also focus on understanding why people do not achieve maximum benefit from hearing aids and how speech perception training may serve as a supplement to aided listening, so that better technology can be developed and better rehabilitation programs can be designed.

SMARTSTATE® CENTER FOR ECONOMIC EXCELLENCE IN VISION SCIENCE

The Vision Science SmartState® Center at MUSC will focus on research in new gene and pharmaceutical-based treatments for retinal degenerative diseases such as macular degeneration and glaucoma as well as bioengineering and material science techniques to develop novel products for improving surgical outcomes and drug delivery.

VISION SCIENCE

The Storm Eye Institute (SEI) is the only comprehensive eye center in South Carolina providing a full range of educational, clinical, and research services related to eye care. SEI serves as a major educational support unit for MUSC students and for specialty training of interns, residents, and fellows in ophthalmology, and as a major eye research center. Research foci include retinal cell biology, degenerative diseases of the retina, cataract and intraocular lens, glaucoma, infectious diseases, and refractive-surgery. The impact of these studies will improve vision loss predictions in individuals, and identify new therapies for the treatment of macular degeneration and other retinal diseases. The SEI has recently purchased the Spectralis HRT+OCT instrumentation, which will facilitate the translation of basic research findings into new therapies.
Established in 2004 as the nation’s first statewide biomedical research collaborative, the members of Health Sciences South Carolina (HSSC) include the state’s largest research-intensive universities (MUSC, Clemson, and USC) and the state’s largest health systems (Greenville Hospital System University Medical Center, Palmetto Health, Spartanburg Regional Healthcare System, McLeod Health, AnMed Health, and Self Regional Healthcare).

The objective of the collaborative is to transform the state’s public health and economic well-being through research and to educate and train the healthcare workforce. Toward this end, HSSC received $21 million from the Duke Endowment in 2006 to launch this initiative and was awarded $11.25 million in 2011 from the Duke Endowment for the next phase of program development. As a result of The Duke Endowment grants, HSSC has brought another $50 million into South Carolina through research grants and proposals.

HSSC is an active participant in the South Carolina SmartState® Program, which creates Centers of Economic Excellence in research areas that will advance the state’s economy. HSSC currently supports twelve Centers of Economic Excellence that are addressing a wide range of issues, including healthcare quality, clinical re-engineering, healthcare facilities design/testing, cancer, heart disease, and medication safety.

Among HSSC’s initiatives is Health IT, a statewide information technology infrastructure to support research and clinical trials and link HSSC member organization. Partnering with various entities including IBM, Siemens, Sun Microsystems, and Recombinant Data Corporation on strategy and implementation, HSSC’S Health IT is designed to promote and accelerate research, facilitate data collection and analysis, and enable expanded clinical trials across the region.

The NIH-supported Centers of Biomedical Research Excellence (COBRE) program develops research teams and specialized core technologies in targeted areas.

DEVELOPMENTALLY BASED CARDIOVASCULAR DISEASES
The SC COBRE for Cardiovascular Disease conducts research and training in the mechanisms of normal and abnormal heart development, the developmental basis of adult cardiovascular diseases, and the application of the principles of normal development to guide stem cell based, tissue regeneration or replacement. The Center, directed by Dr. Roger Markwald, a Professor and Chair of the Department of Regenerative Medicine and Cell Biology in the College of Medicine, supports a Morphology, Imaging and Instrumentation Core, Proteogenomics Core, and Gene Function Core. This program integrates with the SmartState® Center for Regenerative Medicine.
LIPIDOMICS AND PATHOBIOLOGY
The COBRE for Lipidomics and Pathobiology supports several unique core resources that significantly enhance research on novel bioactive lipids that are involved in many important diseases including cancer, neurodegeneration, diabetes and cardiovascular disease. The Center, coordinated by Dr. Besim Ogretman, a Professor in the Department of Biochemistry and Molecular Biology, supports an Animal Pathobiology Core, Lipidomics Shared Resource, and Protein Science Core. This program integrates with the SmartState® Center for Lipidomics, Pathobiology and Therapy.

CENTER FOR ORAL HEALTH RESEARCH
The MUSC Center for Oral Health Research (COHR) has provided a major impetus for developing a sustainable oral/craniofacial research center based in the College of Dental Medicine. The COHR is directed by Dr. Keith Kirkwood, Associate Dean for Research and Professor and Chair in the Department of Craniofacial Biology and Professor in the Department of Microbiology and Immunology. MUSC’s COHR has supported and stimulated oral and craniofacial research campus wide and fostered the interdisciplinary integration of contemporary science in the oral health and dental education environment. The Center supports a Clinical Core, Laboratory Core, and a Training Core as well as providing a platform for germ-free animal models for preclinical studies.

OXIDATIVE STRESS
The COBRE in Oxidants, Redox Balance and Stress Signaling has established essential research cores and programs with specialization in redox biology. Biological changes induced by oxidative stress are associated with numerous human pathologies. A better understanding of how such stresses impact cells through macromolecular damage and signaling pathways will provide insight to the etiology of and therapeutic management of a number of diseases including cancer, diabetes, neurodegenerative and cardiovascular disorders as well as pathologies linked with aging. The program is co-directed by Dr. Kenneth Tew, Professor and Chair of the Department of Pharmacology in the College of Medicine and Dr. Rick Schnellmann, Professor and Chair of the Department of Drug Discovery and Biomedical Sciences in the South Carolina College of Pharmacy. The Center supports a Cell and Molecular Imaging Core, Mass Spectrometry Core, and Metabolomics Core.

RECOVERY FROM STROKE CENTER
The purpose of the South Carolina Research Center for Recovery from Stroke is to improve the recovery of those who have suffered a stroke. The Center’s concept is that better understanding of the experience-dependent nature of neural plasticity will allow us to investigate and exploit inherent neural recovery processes, develop and translate novel mechanism-based interventional strategies, and ultimately improve the function and quality of life of individuals recovering from stroke. This groundbreaking program will be directed by Steven A. Kautz, PhD, professor in the College of Health Professions and co-directed by Robert J. Adams, MD, a professor of Neurology in the College of Medicine and SmartState® Endowed Chair in Stroke. The Center supports the following cores: Quantitative Behavioral Assessment and Rehabilitation Core, Brain Stimulation Core, Neuroimaging Core and Clinical & Translational Tools and Resources Core.
SMARTSTATE® CENTERS OF ECONOMIC EXCELLENCE

The SmartState® Centers of Economic Excellence program was established by the SC legislature in 2002 with funding through the South Carolina Education Lottery to support the development and commercialization of new ideas and technologies from the three SC research universities - MUSC, Clemson and USC. To date, 51 Centers have been created and 44 SmartState® endowed chairs have been appointed to lead the centers.

The SmartState® Program is responsible for $1.4 billion in external investment in the state economy and is responsible for the creation of more than 8,000 jobs. This program has established 27 SmartState® Centers in biomedical sciences and healthcare technologies. MUSC has a total of 43 endowed chairs through this program.

ROBERT J. ADAMS, MS, MD
Stroke Center
Research Focus: Clinical neurology with a focus on stroke prevention and care

GARY ASTON-JONES, PhD
Neuroscience Center
Research Focus: Brain mechanisms of motivation and cognitive processes

CHARLES L. BENNETT, MD, PhD, MPP
Medication Safety and Efficacy Center
Research Focus: Preventing adverse drug events, improving drug safety, and making drug information more consumer-friendly

CAROLYN D. BRITTEN, MD
Gastrointestinal Cancer Diagnostics Center
Research Focus: Drug development related to gastrointestinal oncology and Phase I clinical trials

MARC I. CHIMOWITZ, MBChB
Stroke Center
Research Focus: Clinical trial design and strategies to prevent and treat stroke.

RICHARD DRAKE, PhD
Proteomics Center
Research Focus: Analysis of the proteome in clinical tissue and fluid samples related to prostate, kidney, colon, and breast cancers

J. ALAN DIEHL, PhD
Lipidomics, Pathobiology and Therapy Center
Research Focus: Molecular mechanisms that contribute to uncontrolled cell proliferation and decreased cell death
<table>
<thead>
<tr>
<th>Name</th>
<th>PhD/M.D.</th>
<th>Center</th>
<th>Research Focus</th>
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</thead>
<tbody>
<tr>
<td>CAROL FEGHALI-BOSTWICK</td>
<td>PhD</td>
<td>Inflammation and Fibrosis Center</td>
<td><em>Research Focus: Novel targets for anti-fibrotic strategies for scleroderma and other fibrosing conditions</em></td>
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<tr>
<td>LOUIS J. GUILLETTE, JR.</td>
<td>PhD</td>
<td>Marine Genomics Center</td>
<td><em>Research Focus: Development of new procedures that identify, prevent or treat health problems caused by environmental factors</em></td>
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<tr>
<td>JOSEPH A. HELPERN</td>
<td>PhD</td>
<td>Brain Imaging Center</td>
<td><em>Research Focus: Magnetic resonance imaging in Alzheimer’s, epilepsy, stroke, and attention deficit hyperactivity disorder; Development of new imaging modalities</em></td>
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<tr>
<td>CHANITA HUGHES-HALBERT</td>
<td>PhD</td>
<td>Prostate Cancer Therapeutics</td>
<td><em>Research Focus: Development of tailored and targeted assessments and interventions to improve health outcomes in racial and ethnic minorities and other medically underserved populations</em></td>
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<td>JOHN J. LEMASTERS</td>
<td>MD, PhD</td>
<td>Cancer Drug Discovery Center</td>
<td><em>Research Focus: Pioneer of techniques to image events in individual cells during re-oxygenation</em></td>
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<td>LESLIE A. LENERT</td>
<td>MS, MD, FACMI</td>
<td>Health Care Quality Center</td>
<td><em>Research Focus: Application of cognitive modeling and predictive analytics for improved patient-centric healthcare delivery.</em></td>
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<tr>
<td>ZIHAI LI</td>
<td>MD, PhD</td>
<td>Cancer Stem Cell Biology and Therapy Center</td>
<td><em>Research Focus: Cancer immunology</em></td>
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<tr>
<td>MARTIN MORAD</td>
<td>PhD</td>
<td>Regenerative Medicine Center</td>
<td><em>Research Focus: Cardiac electrophysiology and calcium signaling; use of stem cells for pacemaker generation</em></td>
</tr>
<tr>
<td>GAVIN J. P. NAYLOR</td>
<td>PhD</td>
<td>Marine Genomics Center</td>
<td><em>Research Focus: Leveraging observed patterns in molecular evolution to better understand the forces that shape and constrain the diversity of life from protein structures to organismal designs</em></td>
</tr>
</tbody>
</table>


JIHAD OBEID, MD
Clinical Effectiveness & Patient Safety Center
Research Focus: Research databases and Web-based clinical research systems

IGOR RONINSON, PhD
Translational Cancer Therapeutics Center
Research Focus: Mechanisms of multidrug resistance in cancer and chemotherapy-induced senescence in tumor cells

JOHN SCHAEFER, MD
Clinical Effectiveness & Patient Safety Center
Research Focus: Healthcare simulation design and platforms for education, research and certification

KENNETH D. TEW, PhD, DSc
Translational Cancer Therapeutics Center
Research Focus: Targeting redox systems for cancer therapeutics.

MELANIE B. THOMAS, MD
Gastrointestinal Cancer Diagnostics Center
Research Focus: Clinical trial development, GI cancer treatment and screening

FRANK A. TREIBER, PhD
Technology Center to Advance Healthful Lifestyles
Research Focus: Development of information systems for mobile phones and other digital devices (e.g., iPad®) and Web-based personalized programs for patients to support lifestyle changes

PATRICK M. WOSTER, PhD
Cancer Drug Discovery Center
Research Focus: Developing epigenetic modulators as cancer drugs

XUE-ZHONG YU, MD
Cancer Stem Cell Biology and Therapy
Research Focus: T-cell response to transplantation antigens and tumors
To be at the leading edge in biomedical research requires access to new and diverse technologies that are often difficult to obtain within the resources of a single laboratory. MUSC has invested in a number of advanced technologies to meet this challenge. These advanced technologies provide opportunities for research teams to collaborate and discover new ways to study, diagnose and treat diseases. In some cases, these technologies improve the quality of delivered care, promote patient safety, advance the practice and training efficiency of a critically understaffed workforce, and serve as a focal point for health sciences education and innovative research.
CELL AND MOLECULAR IMAGING

The Cell and Molecular Imaging shared resource provides instrumentation, technical support, and expert intellectual resources for examining living cells, tissues, and animals with submicron 3-dimensional resolution. The core is housed in the new Drug Discovery Building and the Hollings Cancer Center. Dr. John Lemasters, SmartState® Endowed Chair and in the Departments of Drug Discovery and Biomedical Sciences and Biochemistry and Molecular Biology, directs the facility.

The shared resource houses six confocal/multiphoton microscopes, each having its own unique capabilities – two are configured for intravital (in vivo) multiphoton microscopy. In addition to specialized instrumentation, the resource provides consultation and assistance in experimental design, sample preparation, probe selection and work stations for data analysis for both basic confocal/multiphoton applications and complex experiments using high-end imaging techniques.

- Access to state-of-the-art confocal microscopy for imaging living cells in culture to monitor ions, electrical potentials, oxygen, and nitrogen radical generation, NADPH, mitochondrial and plasmalemmal membrane permeability, cell viability, fluorescent protein biosensors, and other parameters
- Intravital multophoton microscopy for imaging in live tissue and animals to monitor microcirculation, leukocyte margination, invadopodia formation, mitochondrial polarization and permeability, radical generation, gene expression, detection of collagen fibers, and other factors
- In-depth training in multiple imaging modalities, including microscopic techniques, live cell-imaging confocal/multiphoton imaging, fluorescence resonance energy transfer and fluorescence recovery after photobleaching techniques
- High-resolution imaging of tissue sections for immunocytochemistry and fluorescent protein distribution
- Consultation and assistance concerning experimental design, sample preparation, probe selection and data analysis for imaging applications
- Education in the fundamentals of imaging technology and its application

INSTRUMENTATION

- Zeiss LSM 510 NLO multi-photon laser scanning confocal microscope system
- Zeiss LSM 510 META confocal microscope
- Olympus FV1200MPE intravital microscope
- BD CARV II disk-scanning confocal microscope
- Leica TCS SP5 confocal microscope
- Olympus FV10i–LIV live cell imaging system
CELLULAR THERAPY

The Cellular Therapy Shared Resource is an interdepartmental initiative to facilitate a variety of cell-based therapies requiring cell and tissue processing in a clean room environment. The cell-processing facility operates in accordance with Good Manufacturing Practice and Good Tissue Practice standards. It supports multiple research projects and investigator-initiated, industry-sponsored New Drug/Investigational Device Exemption Studies as well as a variety of standard clinical care protocols.

- Processing autologous and allogeneic pancreatic islet cells for transplantation
- Processing and isolating hepatocytes
- Generation of dendritic cells for cancer vaccines
- Hematopoietic stem cell expansion protocols
- Gene transduction into dendritic or stem cell populations
- Tumor cell and T-cell purging protocols using human hematopoietic stem cells
- Cell-based immune therapy protocols involving plasmid/viral transduced human cells
- Cell processing to facilitate the fabrication of engineered tissues

INSTRUMENTATION

The facility consists of three annually certified ISO 14644-1 compliant Class 6 processing rooms, with monthly in-house testing placing them at or below Class 5. Each of these rooms is a fully functional processing laboratory containing well-maintained, high quality laboratory equipment. Each room contains at least one Class 5 Biological Safety Cabinet for performing open system sterile processing.

Additional processing equipment provided includes COBE® 2991 automatic cell processors and various types of centrifuges enabling all types of cell separation. Multiple CO2 incubators and inverted phase microscopes allow all phases of cellular isolation, culture, differentiation, and packaging of the final product to be performed inside the clean room environment. In addition, a highly-skilled team of laboratory professionals is available to provide whatever assistance is needed, from startup to project completion.

The Flow Cytometry and Cell Sorting Shared Resource provides a range of services and support with the following core equipment platforms.

- BD FACSVerse™ flow cytometer
- BD FACSCalibur Analytical Flow Cytometer
- BD LSRFortessa Analytical Flow Cytometer
- FACSAria IIu Cell Sorter
- MoFlo Cell Sorter
The MUSC Center for Biomedical Imaging (CBI) provides advanced imaging resources to train and mentor young scientists, and provide collaborative opportunities for basic and clinical faculty to discover new ways to study diseases and disease processes. The goal is to apply this knowledge to clinically relevant situations and translate these advances to improve healthcare. Dr. Joseph Helpern, SmartState® Endowed Chair, Director of the CBI, and Vice Chairman for Research in the Department of Radiology and Radiological Sciences, is a highly regarded investigator with a record of developing and applying new and advanced physics techniques in magnetic resonance imaging (MRI).

With approximately 13,000 ft² of dedicated space, the CBI provides opportunities for technology development and strategic partnering to discover advanced diagnostic tools, identify new ways to study disease processes, and develop image-based disease treatment and management paradigms. The mission of the human imaging shared resource is to speed multidisciplinary adoption of imaging methodologies in clinical research and their translation to improved clinical diagnostics. It also develops imaging methodologies or research protocols and provides assistance interpreting complex data. Although open to investigators from any field of research, the human imaging shared resource has special interest and expertise in imaging technologies that study addiction, neurodevelopmental or neurodegenerative diseases, and cardiovascular disorders.

Facilities include a human imaging research center housing a Siemens 3T TIM Trio MRI scanner fully dedicated to research and development and equipped with an integrated fMRI paradigm presentation equipment. The site includes subject interview and changing rooms as well as an image analysis laboratory. CBI also provides coordinated access to Siemens 1.5T and 3T clinical MR scanners located in the hospital for human subjects. A significant CBI component is the informatics management system, consisting of an integrated system of Linux workstations surrounding a central core of Linux servers and a growing cluster facility. This allows network access for data retrieval and image analysis both locally and to CBI faculty working remotely. A full-time informatics person manages the system, providing system design, troubleshooting, data export, software maintenance, and systematic backup. Software maintained for CBI research teams covers a wide range of commonly used contemporary applications for medical image analysis.

The small animal imaging shared resource provides state-of-the-art in vivo imaging capabilities to MUSC research teams. Housed within the CBI, preclinical imaging needs are addressed through this shared resource. In vivo serial imaging of animal models of disease can provide information not easily obtained by other methods. The advent of commercially available imaging devices capable of interrogating small animals is revolutionizing biomedical research and has rapidly expanded molecular imaging.

**INSTRUMENTATION**

- **IVIS 200 Preclinical In-Vivo Imaging System**
- **Siemens Inveon Micro-CT/PET**
- **BioSpec 70/30 Preclinical MRI scanner**
LABORATORY ANIMAL RESOURCES

Laboratory Animal Resources (LAR) provides care for all laboratory animals at MUSC in approximately 110,000 ft² of animal research space. There are two surgical suites with a capability of operating four tables at a time. The program has been fully accredited by the Association for Assessment and Accreditation of Laboratory Animal Care (AAALAC) International since 1987, with a perfect record of compliance with regulatory inspections by the US Department of Agriculture.

The LAR group has partnered with a number of companies for the testing and evaluation of biomedical devices subsequently advanced into clinical trials. Imaging modalities available in the facilities include x-ray, echocardiography, ultrasound, and fluoroscopy. Laparoscopic and endoscopic units are also available.

The LAR can provide direct service to companies following specific discussions of their needs and can support other investigators on campus with projects they are proposing to industry partners.

Staff includes four attending veterinarians, three board-certified experts in lab animal medicine, and a board-certified veterinary pathologist with experience in translational research. Additional support staff includes well-trained, experienced American Association for Laboratory Science-certified veterinary technicians. Surgical specialties include gastrointestinal, cardiovascular, and interventional catheterization. In addition to these specialties, a broad range of experience is available in other organ systems and models.
MUSC established core facilities in X-Ray Crystallography and Nuclear Magnetic Resonance (NMR) organized within the Molecular Structure Laboratories. Most of these resources are housed on the second floor of the Drug Discovery Building. Both facilities provide the means to obtain high-resolution structures of biological macromolecules and to probe biomolecular interactions. Supporting these facilities are a Protein Science Laboratory for large-scale production of proteins and instrumentation for biophysical measurements of proteins, including circular dichroism, fluorescence spectroscopy, dynamic light scattering and isothermal calorimetry.

The X-Ray Crystallography facility enables MUSC research teams to obtain high-resolution structures of biological macromolecules in order to understand biological function at the molecular level and for drug discovery. The facility comprises resources for crystallization, X-ray diffraction and computational analysis. In addition, MUSC’s membership in SER-CAT, a consortium of mostly Southeast institutions, affords guaranteed and regular access to two-synchrotron beam lines at the Advanced Photon Source, Argonne National Laboratory near Chicago.

INSTRUMENTATION

- A dedicated crystallization laboratory contains an Art-Robbins Gryphon nanoliter-dispensing robot for high-throughput screening of crystallization conditions, a Rigaku Minstrel crystal imaging system, two stereomicroscopes and six incubators operating across a range of incubation temperatures.
- The X-ray diffraction laboratory is equipped with a Rigaku X-ray generator fitted with Osmic Confocal mirror optics, a RAXIS-IV++ Image plate detector, and an X-stream cryo-cooling device.
- The molecular graphics laboratory contains Linux workstations, providing access to crystallographic and molecular modeling software. In addition, the MUSC cluster provides high-performance computing for molecular modeling and in silico drug discovery.

The Nuclear Magnetic Resonance Facility in the Drug Discovery building is designed to the strict stability criteria required for the very highest quality environment for NMR instruments. NMR spectroscopy is a powerful technique that can provide detailed information on the three-dimensional structure of biological molecules in solution, protein dynamics, protein-ligand interactions and the metabolite composition of biofluids. The Protein Science Laboratory can purify isotope-labeled proteins for multidimensional NMR experiments.
INSTRUMENTATION

• Bruker 400: A NanoBay Avance III 400, equipped with a 5 mm dual resonance, broadband inverse probe with an actively shielded single-axis gradient. A complementary Multinuclear Broadband Fluorine Observe probe exists for exotic X-nuclei observation. The current configuration allows operation in a two-channel setup.

• Bruker 600: Equipped with Quadruple Resonance-Cryoprobe (H/C, N, P), room temperature 5 mm triple (H/C, N) and a quadruple (H,F/C,P) resonance inverse probes with actively shielded single- and triple-axis gradients exist as backups. Four-channel setup and equipped with a CASE sample changer for automated analysis of up to 24 samples. 1H and 19F can be pulsed independently using two separate, high-band RF-channels.

• Bruker 850: Equipped with a TCI-cryoprobe triple resonance inverse probe and a room temperature Quadruple Resonance-RT probe. Five-channel setup and equipped with a CASE sample changer for automated analysis of up to 24 samples. 1H and 19F can be pulsed independently using two separate, high-band RF-channels.
PROTEOMICS, GENOMICS, LIPIDOMICS, AND FUNCTIONAL GENOMICS

MUSC research teams study integrative personal “omics” profiling. This technique is a stepping-stone to personalized healthcare and may improve disease risk assessment, accuracy of diagnosis, disease monitoring, targeted treatments, and the understanding of the biological processes of disease states.

PROTEOMICS

Dr. Richard Drake, Professor of Cell and Molecular Pharmacology and Experimental Therapeutics, leads MUSC Proteomic initiatives. The research team develops and utilizes mass spectrometry approaches for proteomic, glycomic, and tissue imaging for cancer biomarker discovery and diagnostic assay development. Whereas the specific components of any individual genome may be somewhat fixed, protein expression and behavior is remarkably dynamic in reflecting the biology of cells and tissue.

Research and technology development projects include:

• Identification of glycan structures on prostate-specific antigen and prostatic acid phosphatase isolated from prostatic fluids reflective of prostatic disease state.

• Analysis of exosome proteins associated with prostatic fluids and serum from prostate cancer samples. Metabolic labeling of tumor cell lines with modified sugar residues to identify candidate surface and secreted glycoproteins involved in cancer metastasis or drug responses.

• Proteomic imaging of prostate cancer and renal carcinoma tissue samples by MALDI imaging mass spectrometry.

• Development of novel glycan and glycopeptide profiling assays for custom tumor tissue microarrays.

INSTRUMENTATION

• Bruker Solarix 7T Dual Source MALDI/ESI FT-ICR MS (CID and ECD Fragmentation) – MALDI Tissue Imaging, Top-Down Protein Characterization

• Thermo Orbitrap Elite with VelosPro Ion Trap MS (CID, HCD, ETD Fragmentation) - LC-MS/MS for identification, characterization of modifications, quantitation of differential protein expression or posttranslational modification using SILAC, iTRAQ, or label free approaches. Top-Down protein characterization

• Thermo LTQ XL Linear Ion Trap MS (CID, PQD, ETD fragmentation) - LC-MS/MS for protein identification and characterization of fragile modifications

• Thermo LTQ Linear Ion Trap MS - LC-MS/MS analysis for protein identification and characterization

• Applied Biosystems 4800 MALDI-TOF-TOF Proteomics Analyzer - LC-MALDI-MS/MS for protein identification and quantitation of differentially expressed proteins using iTRAQ reagents

• Bruker Autoflex III MALDI-TOF-TOF MS - MALDI Tissue Imaging
- **Bruker Autoflex III MALDI-TOF MS** - Molecular weight determination of intact proteins and peptides
- **Associated HPLC systems** (5 LC Packings nano-LC systems and 2 Dionex Probot MALDI Spotters for LC-MALDI)

**GENOMICS**
The Genomics Core Facility offers state-of-the-art next-generation sequencing (NGS), including DNA-Seq, RNA-Seq, ChIP-Seq, Methyl-Seq, targeted sequencing utilizing Illumina HiScanSQ, and Ion Torrent instrumentation. The scientific director of this facility is Dr. Stephen P. Ethier, Professor of Pathology and Laboratory Medicine.

**INSTRUMENTATION**
- Illumina HiSeq 2500 ultra-high-throughput sequencing system
- Life Technologies Ion Torrent Personal Genome Machine
- Microarray - whole transcriptome and miRNA expression profiling, SNP and ChIP-Chip analysis
- Genetic Diagnostic Services

**LIPIDOMICS**
“Lipidomics” is a comprehensive analysis of the lipid molecules and their cellular actions (enzymes, binding proteins, receptors). The Lipidomics Shared Resource (LSR) at the Medical University of South Carolina provides tools to monitor changes in the levels and compositions of the bioactive lipids for potential use as disease biomarkers.

The diversity of bioactive lipids and their interconnected metabolism provides a network of pathways regulating intra- and inter-cellular signaling and function. Several sphingolipid metabolites act as bioactive molecules; their individual contribution to the regulatory pathways that govern cell growth and death are currently being established. Dysfunctions in these pathways contribute to the pathobiology of specific diseases such as cancer progression and metastasis, accelerated aging, inflammation, and fungal pathogenesis.

This shared resource, led by Dr. Alicja Bielawska, supports and promotes research into the role of bioactive lipids and their metabolites in pathobiology, providing services to MUSC and research institutions throughout the world in addition to pharmaceutical companies. The resource includes “both” analytical and synthetic units. Analytical approaches are based on High Performance Liquid Chromatography-Tandem Mass Spectrometry (LC-MS) technology. This sensitive and specific analytical methodology is applicable to a broad spectrum of diversified chemical compositions of sphingolipids and glycerolipids.

- Conceptual and practical training in various aspects of lipidology
- Resource personnel assist investigators in experimental design, selection of lipid of interest and interpretation of the analytical results
- Qualitative and quantitative analysis of lipid components from different biological materials (cells, tissue, biological fluids) - Analyses are performed at a basic metabolomic level covering approximately 300 different lipid species including sphingoid bases and their phosphates, molecular species of ceramide, dihydroceramide, phytoceramide and their phosphates, molecular species of
sphinigomyelin, hexosylceramide, lactosylceramide, and diacylglycerol

- Synthetic molecular tools to study lipid metabolism - functionalized and fluorescent ceramides, site-specific radioactive sphingolipids and diversified synthetic lipids and analogs for cellular, in vitro, and in vivo studies (organelle-targeting sphingolipids and organelle-targeting inhibitors of sphingolipid metabolizing enzymes)
- Extensive library of synthetic lipids

**INSTRUMENTATION**

- Four Thermo Scientific TSQ Quantum™ triple-stage quadrupole mass spectrometers with super high pressure HPLC system, electrospray ionization and atmospheric pressure chemical ionization probes connected to HPLC systems
- Applied Biosystems SCIEX 2000™ Q-trap triple-stage quadrupole/ion trap combination mass spectrometer LC-MS combo, ESI and APCI probes connected to Berger FCM 1200 Supercritical Fluid Chromatograph

**FUNCTIONAL GENOMICS**

The shRNA Shared Technology Resource provides access to genome-wide human and mouse libraries that together encode a total of almost 160,000 shRNA clones against over 41,000 genes. The resource utilizes The RNAi Consortium’s genome-wide lentiviral mouse and human libraries, and investigators have the option of ordering shRNAs targeting single or multiple genes and gene family sets as well as pathway-specific pooled libraries.

The library will allow access to multiple shRNAs for a single gene, which is important for validation against off target effects. Dr. David Turner in the Department of Pathology and Laboratory Medicine leads this resource.
SIMULATION CENTER

The MUSC Healthcare Simulation Center is an 11,000 ft² multidisciplinary training facility featuring 14 multipurpose rooms configurable to teach a variety of simulation-based education activities. The goal of the MUSC Healthcare Simulation Center is to improve the quality of delivered care, promote patient safety, advance the practice and training efficiency of a critically understaffed workforce, and grow into an international focal point for health sciences education and innovative research in education and safety.

The center is a powerful resource for expertise to develop simulation-based educational materials for didactic and research purposes. Simulation-based education involves using a variety of low-and high-fidelity manikins as teaching tools for healthcare professionals. Low-fidelity manikins (i.e., task trainers) represent a portion of the human body such as an arm or torso and can be used to teach procedural skills, whereas high-fidelity manikins are capable of mimicking physiologic responses that can be used to teach complex clinical scenarios such as moderate sedation.

Dr. John Schaefer III, director of the Healthcare Simulation Center and Healthcare Simulation South Carolina (HCSSC), developed a technique known as Practical Simulation™. Practical Simulation™ was first implemented at the MUSC Simulation Center and has since been expanded to 15 organizations across the Southeast under the collaborative umbrella of HCSSC.

In order to achieve Practical Simulation, the HCSSC promotes unique training methods known as Cooperative Learning Simulation Skills Training™ (CLSST™) and Diagnostic Educational Objectives-based Reflection™ (DEORTM) – an evidence-based method of debriefing.

- Practical Simulation™ involves writing evidence-based checklists for the simulator software, allowing instructors or students to run the simulations consistently from class to class thereby reducing operational costs by not having to utilize a Simulation Specialist to operate each manikin.
- CLSST™ uses task trainers coupled with checklists programmed into simulation software, allowing participants to practice skills in pairs thereby making the learning process more efficient. This methodology allows participants to practice the skills and evaluate each other to a mastery level before performing the skill on a patient.
- DEORTM is based upon best practices and standardizes the debriefing activity to put emphasis on critical items missed during the simulation-based educational activity. In the Practical Simulation™ methodology, all participants are debriefed so learners process and interpret what happened during the activity and why. How much participants learn and retain relies on the effectiveness of the debriefing.
HealthCare Simulation South Carolina’s collaborating partners include:

- Central Carolina Technical College
- Florence-Darlington Technical College
- Greenville Health System
- Greenville Technical College
- Horry Georgetown Technical College
- Medical University of South Carolina
- Midlands Technical College
- Robeson Community College
- Trident Technical College
- University of South Carolina Aiken
- University of South Carolina Beaufort
- University of South Carolina Columbia
- University of South Carolina Upstate
- Wallace Community College-Hanceville, Alabama
- Wallace Community College-Selma, Alabama
INNOVATION ECOSYSTEM
INNOVATION ECOSYSTEM

MUSC has established a broad innovation ecosystem to accelerate the movement of discoveries forward for further development and application. This ecosystem includes creative research teams, advanced technologies, and business connectivity. The South Carolina Clinical & Translational Research Institute (SCTR), the South Carolina Research Authority (SCRA) and various regional development resources [Charleston Regional Development Alliance (CRDA) and South Carolina Biotechnology Industry Organization (SCBIO)] along with a new physical infrastructure provide an organizational network for commercialization.

FOUNDATION FOR RESEARCH DEVELOPMENT

The Foundation for Research Development (FRD) serves as MUSC's technology transfer office and a primary point of connectivity with industry for idea and technology development across such areas as therapeutics, diagnostics/biomarker platforms, devices, medical equipment, healthcare software, and education tools. Working closely with the Center for Innovation and Entrepreneurship, FRD’s primary mission is translating the development of new knowledge in the laboratory and clinic to real-life solutions for today’s medical problems.

Michael Rusnak serves as the Executive Director of FRD. Mr. Rusnak, whom joined MUSC in fall of 2013 has over 25 years of life sciences experience most recently holding the position of Director of New Ventures and Technology Development within the technology transfer office at the University of Rochester Medical Center. In his six-year tenure at Rochester, he led the office in life science licensing and directed the University’s Technology Development Fund and the award process. Mr. Rusnak also played a lead role in additional fund raising, including SBIRs and STTRs, for the Fund’s applicants, pre and post award.

FRD’s strengths include a board of directors with high-end industry experience and expertise, plus a prior record of success in establishing and nurturing corporate-academic partnerships. The board has a wide range of expertise regarding strategic development, medical devices, diagnostics/biomarker platforms, and therapeutics.

FRD has received more than 900 invention disclosures, leading to 560 patent filings, and 55 issued patents. FRD has entered into 85 license and option agreements for innovations arising from MUSC research. MUSC invented technologies have led to the creation of 39 startup companies throughout the United States.
Commercializing early-stage university research opportunities is a primary goal for our programs. MUSC startups have attracted substantial investment dollars and have generated FDA-approved products. The technologies and ideas they’ve developed have attracted investor interest, leading to subsequent acquisition by publicly traded corporations and major pharmaceutical companies.

In the past three years, two pharmaceutical-based startup companies based on MUSC technology were acquired. Immunologix, whose platform technology permits the discovery of fully human antibodies that can target any antigen type, was acquired in October 2011, by Virginia-based Intrexon Corporation, a privately held synthetic biology company. In addition, Alexion Pharmaceuticals acquired Taligen Therapeutics, which created a therapeutic platform based on local and targeted regulation of the undesirable effects of excessive amplification of the complement system, in 2011.

CENTER FOR INNOVATION AND ENTREPRENEURSHIP

The Center for Innovation and Entrepreneurship (CIE) provides a primary gateway for corporate partner engagement and is a major resource for entrepreneurially oriented biomedical scientists at MUSC. Thomas Finnegan is the Director of the Center for Innovation and Entrepreneurship. Mr. Finnegan served as the Vice President of Finance and Corporate Development at Introgen Therapeutics, a publicly traded biotech company (NASD: INGN) based in Austin, Texas. His primary responsibilities were to head the finance and business development functions. After taking Introgen public, Tom raised over $120 million of public and private capital for the company. In addition to his wealth of experience gained in Texas, Mr. Finnegan has continued his involvement in the startup of companies since moving to Charleston a few years ago. He has negotiated the license of several technologies, advised startups, funded companies, wrote business plans and formed several companies in which he played an active management role.

Through seminars and organized mentorship programs, both internal and external, the center provides a platform for education and support in a range of technology and idea development activities. CIE fosters collaborations across disciplines and the partnering of clinicians with basic scientists for targeted discovery and development.
STARTUP COMPANIES

• Apollo Endosurgery, Inc was founded on the initial work of the Apollo Group, an international think tank of world-renowned gastroenterologists and surgeons from five leading universities (Mayo Clinic, Johns Hopkins, MUSC, University of Texas Medical Branch-Galveston and Chinese University-Hong Kong). Apollo Endosurgery, Inc. was founded to commercialize the Group’s inventions and innovations in the areas of endoscopic surgery, which enables surgeries done for bariatrics, cancers, and other gastrointestinal disorders to be conducted without scarring.

• CharlestonPharma focuses on developing therapeutic products for cancer patients and healthcare providers. It is developing human monoclonal antibodies (mAbs) to the cell surface receptor, nucleolin. The company has a worldwide license for the method of production of the mAbs and use of the anti-nucleolin antibodies to treat cancer patients. CharlestonPharm, incorporated in 2010, is based in Charleston, South Carolina.

• Halimed Pharmaceuticals Inc. (“Halimed”) is an early-stage biotechnology company developing a pipeline of affective disorder drugs. The company’s technology is centered on a proprietary peptide modification chemistry platform and intellectual properties of a portfolio of non-natural amino acid analogs of arginine and lysine that, when incorporated into biologically active peptides, improves the overall pharmacological profile of each.

• MitoChem Therapeutics, is developing a treatment for degenerative retinal conditions such as Age-related Macular Degeneration and Retinitis Pigmentosa. A library of 50,000 compounds was screened to identify compounds that protect against cell loss by increasing mitochondrial function. Subsequent experiments revealed that some of these compounds might have vision-saving properties. That promising work inspired a national nonprofit organization focused on sight-saving research, Foundation Fighting Blindness, to fund the company’s early mitochondria research, which helped the company further develop these compounds and to generate three new chemical entities that guarantee freedom to operate. These compounds improve mitochondrial capacity and show great potential for slowing vision loss caused by a variety of environmental and genetic triggers of retinal degeneration. Since mitochondrial dysfunction is associated with many degenerative diseases in organs as disparate as kidney, heart, brain and eye, these compounds may find widespread therapeutic applications.
STARTUP COMPANIES

• **FirstString Research Inc.** is a clinical-stage biotech company leading the development and commercialization of therapeutics for scar prevention and tissue regeneration. The company is currently advancing the topical formulation of a lead peptide through human clinical trials for scar reduction and treatment of chronic wounds. Preclinical studies are also being conducted with connexin-based peptides for indications having high unmet therapeutic needs in segments that include ophthalmology, central nervous system injuries, cardiac injuries, organ transplants, pulmonology, and oncology. FirstString received FDA approval for human testing of its product after completing specific animal testing trials. The product deals with the skin’s wound repair process using a bioengineered peptide, based on a naturally occurring protein in the body that helps regulate communication between cells to accelerate wound healing and tissue regeneration with significantly reduced scarring.

FirstString’s proprietary therapies modulate intercellular communication to significantly reduce the development of scar tissue and, at the same time, improve the body’s ability to produce healthy, functional cells. The lead compound’s target is well expressed and has shown efficacy in many tissue types, including the skin, spinal cord and internal organs. A new wound-healing process created through research at MUSC spawned the biotechnology company in December 2005, with a license from MUSC’s Foundation for Research Development. The company was the first in the Charleston area to secure funding from SC Launch, the venture capital arm of the South Carolina Research Authority, and subsequently obtained follow-on private capital funding.

• **SphingoGene, Inc.** is a cancer therapeutic development company focused on sphingolipid metabolism, recognized as a key factor in tumor cell survival and metastasis. Sphingogene scientists have developed a portfolio of highly potent small-molecule drugs that can affect this pathway and that have established a substantial worldwide patent position in the field. A few of the company’s drugs are in late-stage pre-clinical development and have demonstrated highly significant results.

The SphingoGene team includes experts in the field of sphingolipid metabolism and, through its partners and advisors, the company has access to the industry’s leading cancer drug commercialization resources.
IMMUNOLOGIX

Immunologix, Inc went from developing its technology to acquisition in less than eighteen months! The Company’s platform technology permits discovery of fully human antibodies that can target any antigen type including, but not limited to: cancer cells, viruses, bacteria, toxins, and those epitopes related to autoimmune diseases such as diabetes, lupus, rheumatoid arthritis, and multiple sclerosis. Through its exclusive patent license from MUSC, the Immunologix platform potentiates delivery of key unmet needs in antibody-based therapeutics.

In October 2011, Blacksburg, Va.-based Intrexon Corporation acquired Immunologix and integrated the technology into Intrexon’s mAbLogix™ platform as part of its California-based protein production division. Acquisition of the technology and expertise provides Intrexon with an enhanced process for development of valuable, fully human therapeutic antibodies. Intrexon Corporation is a privately held biotechnology company focused on collaborating with companies in Health, Food, Energy, and the Environment to create biologically based products that improve the quality of life and health of the planet. It employs modular DNA control systems and other genetic engineering solutions to control the quality, function, and performance of living cells for a wide variety of applications. The current market for therapeutic and diagnostic antibodies is estimated to exceed $40 billion per year worldwide, and many of the current marketed antibodies are not fully human.

TALIGEN THERAPEUTICS

Lab-to-market success story Taligen Therapeutics created a therapeutic platform based on local and targeted regulation of the undesirable effects of excessive amplification of the complement system. The platform was based on research from MUSC and the University of Colorado demonstrating excessive activity of the complement amplification loop is central to the pathogenesis of a number of important diseases. Taligen’s lead therapeutic candidates were recombinant fusion proteins and monoclonal antibodies focused on orphan diseases, age-related macular degeneration, and severe inflammatory diseases.

The company was granted a patent for the composition of TT30. The patent, “Targeting Complement Factor H for Treatment of Diseases,” includes method-of-treatment claims that could apply to diseases such as macular degeneration, rheumatoid arthritis, ischemia reperfusion, organ transplant rejection, membranoproliferative glomerulonephritis type II (MPGN II), hemolytic uremic syndrome (HUS) and lupus nephritis. Taligen then built a team of experienced employees and collaborators, raised approximately $70 million from blue chip venture capital investors, advanced novel preclinical candidates, and secured important exclusive licenses from institutions that pioneered research relevant to the science underlying its platform. In 2011, Alexion Pharmaceuticals, Cheshire, Conn., acquired Taligen for $111 million in cash and future payments based on product performance.
The South Carolina Research Authority (SCRA), a nonprofit contract R&D organization established to grow South Carolina’s knowledge economy, provides significant commercialization support for businesses. Subject-matter expertise, extensive experience in federal contract management, and the ability to organize multi-source collaborations enable SCRA ($260 million FY13 operating revenues) to help companies take discoveries to market.

In partnership with the state’s three research universities, SCRA has established a network of Innovation Centers and Launch Zones to assist startup and existing businesses with commercializing new technologies.

**SCLaunch**

SCRA-affiliated SC Launch was established to facilitate applied research, product development, and commercialization to strengthen the state’s knowledge economy by creating high wage-earning jobs. Offering qualifying companies commercialization support, guidance, and seed funding, SC Launch has been recognized by Forbes Magazine as one of the nation’s Top Five Entrepreneurial Support Programs.

SC Launch was funded with an initial investment of $12 million and continued funding through the Industry Partnership Fund established with the SC Industry Partners Act in 2006. Contributions to the fund from private donors are certified by SCRA to the State Department of Revenue and are eligible for a 100% tax credit against South Carolina income taxes, insurance premium taxes and certain license fees.

**THE PROGRAM INCLUDES:**

- Financial assistance to potentially successful Knowledge Economy startups, thereby helping to bridge the funding gap
- Qualifying companies are eligible for equity financing of up to $200,000
- Matching funds for recipients of Phase I Small Business Innovation Research Program and Small Business Technology Transfer Awards
- Assistance to universities to turn promising research technologies into commercial realities
- Resources to encourage Knowledge Economy companies to relocate to South Carolina
- Mentoring, training and networking opportunities for the companies in the SC Launch program, providing them with valuable resources
SC Launch has provided funds for the development of technologies and startups coming out of MUSC, as well as small businesses and startups across the state – more than half of which are in the biomedical sector and many of which have also received external funding.

Additional academic-industry partnerships coordinated by SCRA include the following:

• The Copper Air Quality Program, designed to improve indoor air quality and explore the potential for copper-based components of heating, ventilating and air-conditioning systems to kill harmful microbes, such as molds and harmful bacteria. Partners in the study include MUSC, USC, Albrecht Environmental, Piedmont Metals LLC, BCS Inc, the Copper Development Association, and the SCRA-affiliate Advanced Technology Institute.

• The Copper Touch Surfaces Program, designed to reduce the measure of pathogens in healthcare facilities and ultimately lower the rate of hospital-acquired infections. Primary partners in the study include Memorial Sloan-Kettering Cancer Center in New York, MUSC, and the Ralph H. Johnson VA Medical Center in Charleston.

• The Healthcare Information Technology Standards Panel, a cooperative partnership between the public and private sectors, established to integrate standards for healthcare information technology to meet clinical and business needs for sharing information among organizations and systems.

• Development of three innovation centers across the state for incubating new companies.
INNOVATION CENTER

A partnership between MUSC, SCRA, and the City of Charleston, the Innovation Center, supports the sophisticated requirements of Charleston’s growing biotechnology cluster organizations whether early-stage or mature. The 28,400 ft² facility consists of flexible-use, multi-tenant laboratory and office space for biopharma, biomed, and biotech research and commercialization.

The center already houses several biomedical startup initiatives and includes eleven wet laboratories equipped with case works; a secure laboratory area accessible by card key; a common shared laboratory area with dishwasher, freezers and shared equipment; network access; on-site business, legal, financial planning and administrative assistance; a common reception area with receptionist and meeting rooms; and on-site parking.

The location, along the corridor that leads to Charleston’s historic district, offers easy access to the MUSC complex, I-26, the Charleston International Airport, and Mount Pleasant. This secure facility has card reader entrances and a police substation on site.

The recently renovated historic building earned an “Excellence in Construction” award from the Associated Builders and Contractors of the Carolinas.

BUILDING SPECIFICATIONS

- 645 Meeting Street, downtown Charleston
- Base building – 28,400 ft²
- Eleven wet laboratories equipped with case works
- Secure laboratory area accessible by card key
- Common shared laboratory area with dishwasher, distilled water, sub-zero freezers
- Laboratories range in size from 600 to 1200 ft²
- Ten separate enclosed offices available in the lab area
- Fully vented laboratories & fire protection
ADDITIONAL REGIONAL DEVELOPMENT RESOURCES

CHARLESTON REGIONAL DEVELOPMENT ALLIANCE AND BIOSCIENCES

The Charleston Regional Development Alliance (CRDA), a professional economic development organization representing Berkeley, Charleston, and Dorchester counties, promotes the region’s business, academic, and lifestyle strengths to attract the best companies, entrepreneurs, and professional talent.

Charleston is currently home to more than 35 medical device and pharmaceutical manufacturers and more than 50 research laboratories and development companies employing more than 1,600 workers. With a large and growing network of business, academic, and governmental partners, the CRDA assists companies with competitive location or expansion projects by connecting them with the right people, the appropriate resources, and the most meaningful and relevant information. CRDA coordinated the development of the strategic plan Operation Next: Building A Globally Competitive Economy for the Charleston Region. Opportunity Next’s objective is to drive economic prosperity and to balance new business recruitment, local business retention/expansion, and entrepreneurial support.

Opportunity Next goes a step further to align the region’s community development, workforce development and economic development initiatives. The plan lists four target areas (Advanced Security & IT, Aerospace, Biomedical, and Wind Energy) and provides metrics on the convergence of biomedical R&D, applied medicine, devices and clinical trials in the area with specific outcome indicators.

SCBIO

As the South Carolina affiliate of the national Biotechnology Industry Organization, SCBIO is the “voice” of the state biotechnology industry and its link to global industry partners. SCBIO also forges links between researchers, investors, and industry to advance the commercialization of research and ensure South Carolina’s companies, research institutions, and citizens reap the economic and societal benefits of a world-class life sciences cluster. SCBIO also includes the SC MedTech Council, which represents the fast-growing medical device community and works to foster a competitive business environment in South Carolina for biotech and medical device companies from conceptualization to commercialization.

SCBIO fosters South Carolina’s business environment for startup and existing life science companies by advocating innovation-friendly policies and infrastructure that support industry growth. It also builds relationships among life science companies and other ally groups, including government agencies and service industries, to create greater business opportunities and bottom line growth. More than 572 companies and institutions employ 13,520 people with an average annual wage of $53,275 in South Carolina. Life science businesses and institutions impact 46,032 jobs, according to a 2010 study by the Battelle Institute.
HORIZON PROJECT
MUSC and the City of Charleston have announced plans for a $1 billion, 20-year development for the Horizon District, near the Ashley River between the medical complex and “The Joe” (Joseph P. Riley, Jr. stadium for the Charleston minor league baseball team). The joint public-private project could be the largest single development in Charleston’s 350-year history. The project would include ~2.7 million ft$^2$ of development space for housing and retail businesses as well as research and development initiatives involving both MUSC and companies from the biotechnology, medical device, pharmaceutical and diagnostics sectors.

BENEFITS OF DOING BUSINESS IN CHARLESTON, SC
• South Carolina ranked as one of the top five most business-friendly states for the past six years by the Pollina Corporation
• Charleston International Airport provides direct flights to major cities in the southeast, northeast and midwest, 4 executive airports
• Charleston identified as a hotspot for new technology business
• SC has a competitive wage structure in the biosciences sector
• An enhanced Jobs Development Credit, which allows approved bioscience facilities to capture cash rebates for eligible expenditures
• Very favorable regulatory climate
• One of the lowest corporate income taxes in the Southeastern U.S. at 4.6% and no state property or local income tax
• The ability to negotiate the apportionment formula used to calculate corporate income tax liability
• As a right-to-work state, South Carolina’s workforce has one of the lowest unionization rates and lowest work-stoppage rates in the nation
• Reliable, fast, broadband network