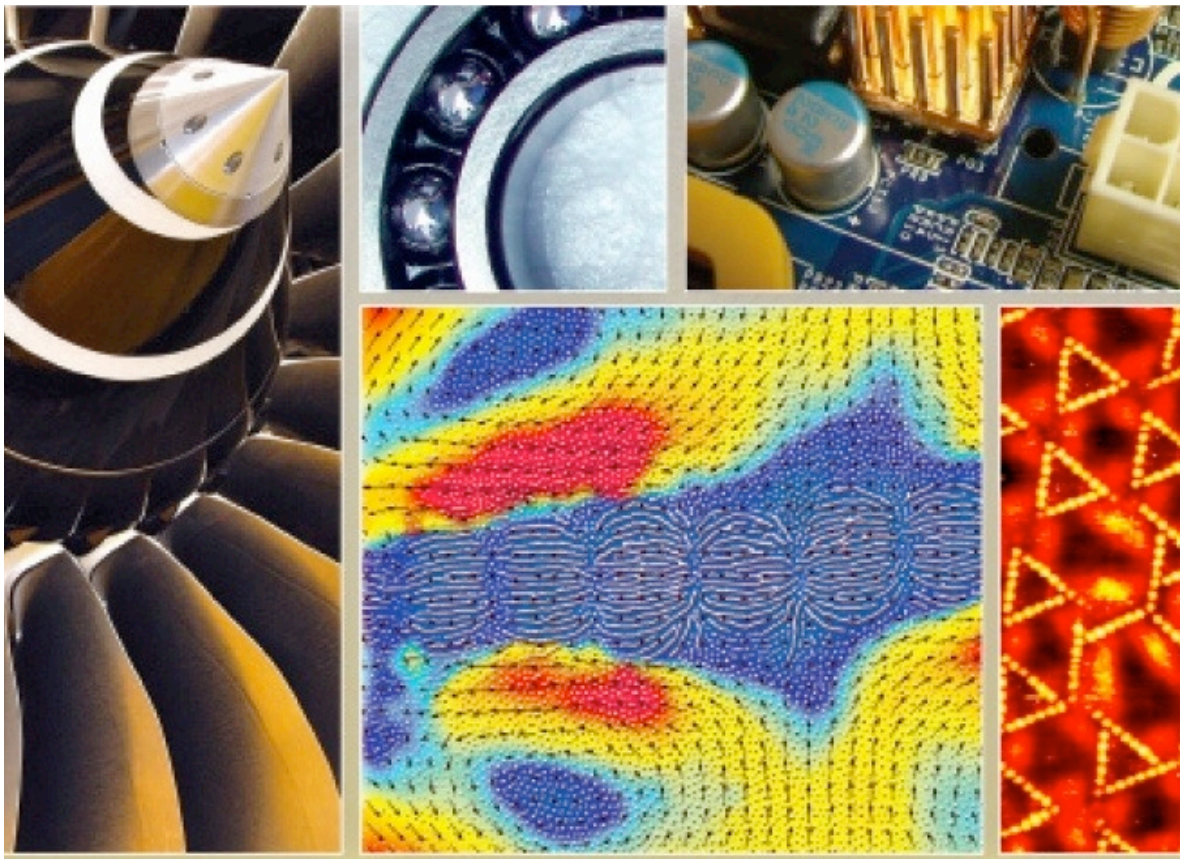


Engineering 2020

Ten-Year Strategic Plan

College of Engineering and Applied Sciences

STONY BROOK
STATE UNIVERSITY OF NEW YORK

mission

To provide**:**

- Comprehensive high-quality undergraduate education that motivates students to exceed expectations
- Advanced graduate and professional education and research opportunities with faculty who are pioneering new pathways in their disciplines
- Leading-edge research programs that probe the frontiers of knowledge, propel progress in other disciplines and generate the technologies of tomorrow
- Outreach and collaboration that transform and sustain the prosperity of innovation-based industry clusters, fueling the economic vitality of our region, state and nation.

vision

A mature college of engineering recognized for its leadership domains and poised to join the first tier of the nation's engineering institutions. The College will be distinguished by the excellence of attainment that we expect and inspire in our students, and the originality, talent and entrepreneurial drive of our faculty. We will lead as engineers and teachers of engineers who not only advance our own disciplines and create tools for others to make critical advances, but transform discovery into practical value to make a better life for all.

executive summary

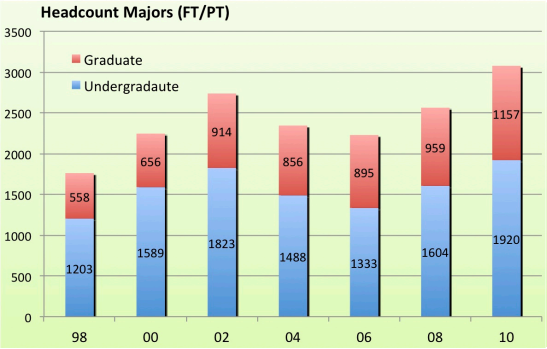
1. E2020: Toward A Higher Level of Excellence

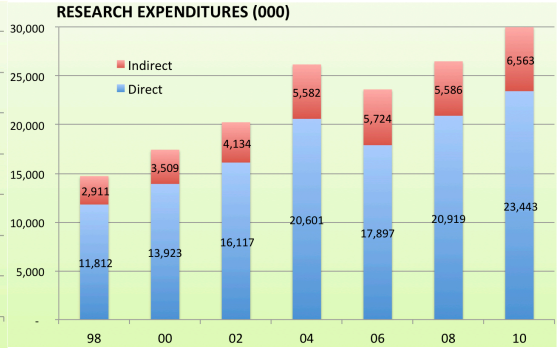
Engineers investigate, analyze and problem-solve. Their great joy is designing elegant solutions for big, difficult problems. The contemporary world provides a superabundance of such problems; for example, the National Academy of Engineering has identified fourteen Grand Challenges for the advancement of civilization in the new century (www.engineeringchallenges.org). The SUNY Strategic Plan has defined Six Big Ideas to guide the nation's largest university system for the next genera tion; while continuing to provide significant leadership for this ongoing effort, Stony Brook itself is thinking boldly in a comprehensive strategic planning initiative of which this plan is a part. The process of harmonizing the aspirations of our seven departments in a College-wide plan, consistent with these larger institutional goals, has revealed three common thematic areas – Biomedicine and Healthcare, Energy and Environment, and Security and Defense – that help to focus the elevation of our research, education and outreach programs to a higher level of excellence in the coming decade. Exceptional strength is these areas provides a strong foundation for future growth, including excellent opportunities for new and closer collaborations with Brookhaven National Laboratory. The approach we will take to these themes – as well as new ones that will surely emerge – aligns closely with SUNY's aims for a healthier, energy-smarter and more entrepreneurially successful New York. In addition, we will continue to develop our young competency in technology policy research focused on energy – a mini-theme – where our unique program design positions us for national visibility. Our world-class strengths in bioimaging, bioengineering and biomedical-inspired engineering, computation, computing and software, information and wireless technology, micro/nano-electronics and sensors, and materials, which will continue to produce important new knowledge, are singular resources for success in our thematic areas as well. The College's efforts in all these areas will contribute significantly to defining and achieving the university's goals.

The College's accomplishments under the previous ten-year plan prompt justifiable pride.

- Research expenditures have grown 72%.
- All of the $117 million in R&D construction on campus is primarily engineering-related.
- Our combined student enrollments at all levels are the highest ever at the same time that the quality of our students (measured by SAT scores) is the highest ever.
- All departments now offer bachelors, masters and doctoral programs. We are especially pleased to be the home of Stony Brook's first doctoral program focusing on policy research.

• The College leads the university in promoting technology-based enterprise: The SUNY Strategic Partnership for Industrial Resurgence conceived here, the College is home to all of the university's NSF Industry University Cooperative Research Centers and both NYS Centers for Advanced Technology, and provided the critical mass of support for the creation of the NYS Center of Excellence in Wireless and information Technology and the Advanced Energy Research and Technology Center. The impact of these programs on the regional and state economies is demonstrably significant.





We now set the bar much higher with continued confidence in our future success. Both the challenges and the opportunities are much larger and more complicated, but engineering research and education are highly attuned to multidisciplinary approaches to problems. The accelerating pervasiveness of technology in all aspects of our lives will magnify demand for what engineers do and we are excited to accept these challenges.

Building on our departments' core strengths and making selected additions will repay the required investments with the new opportunities to exploit these additional resources that we will capture in our theme areas and in additional target areas that will arise. The delay in rounding out our core engineering programs has given us the advantage of responding to the new demands that society is making on these disciplines and we will continue to build 21st century engineering programs as faculty are recruited – the environmental emphasis and an additional focus on transportation in civil engineering and the molecular science emphasis in chemical engineering, as well as new offerings and initiatives in established departments. Leveraging growing CEAS expertise at the intersection of medicine and engineering positions our College to make especially important contributions in this critical area. The College has the advantage of hosting Stony Brook's Departments of Applied Mathematics and Statistics and Computer Science, which facilitates increasingly valuable collaborations as needs for computation, modeling and simulation, information visualization, and manipulation of very large and complex datasets, among others, continue to grow.

The College's leadership capacities for innovative problem-defining and problem-solving, for original pedagogies serving diverse populations, and for technology-based economic development will help to accomplish the audacious goals of SUNY's and the university's strategic plans and will contribute to the fulfillment of the NAE's Grand Challenges. We relish the multiple opportunities ahead!

resources

The College's ability to achieve our ambitious and important goals depends on having sufficient resources, in faculty/staff and facilities and student support, to do more and do it at an even higher level than we have in the past ten years – just as we leveraged increased resources to make this a decade of accomplishment that exceeded the achievements of the preceding ten years. We are prepared to generate a substantial portion of these resources through our own efforts, as we have in the past. We believe that the investment of university resources in the College's growth will help the university as a whole to drive toward a higher level of excellence in both academic and research programs, as is shown by the multidisciplinary initiatives described herein.

Faculty and Staff

In addition to the faculty expansions required to raise our new academic programs in chemical and molecular engineering and in civil and environmental engineering to department status, a major increase in faculty will be needed to expand the academic programs of our existing departments – including Applied Mathematics and Statistics (industrial engineering and other areas), Biomedical Engineering (bioimaging and other areas), Computer Science (Information Systems major in anticipation of creating a separate department), Electrical and Computer Engineering (enrollment growth), Materials Science (new bachelors degree program), Mechanical Engineering (for its own development as well as for Civil Engineering), and DTS (new master's tracks and collaborations with COB) – while achieving parity with the average faculty:student ratios of AAU public engineering colleges. We estimate that 68 additional faculty lines will be needed.

Facilities

Critical College-wide needs to achieve our research goals fall into two groups:

Physical Facilities: Rehabilitation of the Light Engineering and Old Engineering Buildings, which are now 45 years old; laboratory facilities to foster multidisciplinary research activity as well as a multi-departmental clean room facility, enhanced electron microscopy, and additional computing capability as well as a hardware refresh for the New

York Blue supercomputer. Specific department needs include lithography and e-beam writing instrumentation for Electrical and Computer Engineering and *in situ* imaging capabilities for Materials Science and Engineering.

Instructional needs include a prototyping lab for undergraduate and graduate students to design, fabricate and test devices in Biomedical Engineering, Electrical and Computer Engineering, Materials Science and Engineering, and Mechanical Engineering.

Centralized Resources: A university Bioimaging Institute will serve CEAS and CAS departments as well as Medicine and Dental Medicine; a Center of Excellence in Computational Science and Engineering, which will become part of the New York Center for Computational Science, will follow the twin threads of computational science for physics and engineering based models and for data analysis and intelligence. Staffing the Center will require additional personnel.

Student Support

The quality of our current undergraduate students enables us to plan to raise our admission expectations to equal those of our nation's elite public and private engineering colleges, while our success in recruiting high quality graduate students fulfills our mission of forming the next generation of innovators and researchers, inspiring teachers and forward-thinking working engineers.

We need and intend to triple undergraduate scholarships.

We need and intend to increase graduate student support including fellowship stipends and tuition waivers.

We need and intend to enhance graduate student office facilities, graduate student research presenting groups, and resources for postdocs.

We intend to increase support for undergraduate student clubs including Stony Brook Motorsports, the solar boat club and the robotics club, which not only provide essential out-of-classroom learning experiences for our students but raise our national profile for innovation and creativity and for entrepreneurial students at all levels.

Goals At A Glance

METRIC Double research activity

RESEARCH

We will build on existing College-wide strengths, add new competencies and develop new and tighter linkages with partners including Brookhaven National Laboratory to double research activity and its impacts.

Biomedicine and Healthcare Leverage formidable strengths and resources in computing, visualization, imaging, materials, mechanics, nanotechnology and nanomedicine to bioengineer new biomedical research and clinical solutions.

Energy and Environment Help drive revolutionary improvements in energy efficiency and conservation through leadership in Smart Grid technology while achieving significant affordability improvements in renewable sources.

Security and Defense Expand current programs in cyber-security and intelligent computing for public safety, gamma radiation detection, self-powered/harsh environment sensors, self-deployable structures, markers for toxin-induced neuropathologies, and multiphysics, multiscale reactive fluid and structure interactions.

METRIC Establish at least one new major collaboration in each thematic area every year

Cross-cutting: Computation, Computing and Software, Micro/nano-electronics and Sensors, Materials, Policy Enhance and augment world-class computing and computational programs; the Center of Excellence in Computational Science and Engineering will enhance CEAS' role in supercomputing and the computer-mediated formation of knowledge. Expand exceptional programs in semiconductor optoelectronics and photonics, sensor systems, non-silicon ultra-high-speed processor design, and optical telecommunications. Further develop strong materials programs in thermal spray, nanomaterials and soft active materials for environmental, energy and biomedical applications, "green chemical engineering," and crystal growth. Raise the quality and visibility of NYEPI as one of the nation's premier technology-sophisticated energy and technology policy research organizations.

EDUCATION

We will continue building toward a mature, comprehensive engineering institution, capitalizing on new directions in traditional disciplines, addressing emerging educational needs and providing innovative instruction, and raising the quality of our students while sustaining our signature commitment to diversity and international engagement.

Programmatic Innovation Establish departments in chemical/molecular engineering and civil engineering with foci on transportation, infrastructure and environment; an undergraduate Materials Science major, a Graduate Program in

Biomedical Informatics including a unique concentration in bioimaging, new programs in industrial engineering, quantitative finance, information systems, intelligent computing, and "green" computing; new joint programs with business, psychology and health sciences, as well as other CEAS departments; new efforts to identify and encourage the entrepreneurs among our students; expansion of our international programs.

METRIC Raise the quality of incoming students and their outcomes to the level of elite publics and privates

Diversity. Continue to sustain and enhance the quality and the diversity of our student body and the impacts of programs including SUNY LSAMP AND SUNY AGEP, CSTEP, STEP, Project WISE, and TechPREP, and enlarge these impacts beyond the campus

Entrepreneurship A recipient of two NSF Partnerships for Innovation awards, the College consistently achieves the highest rate of student participation in Stony Brook's DARE student entrepreneurship competition. In the coming decade will tighten the productive interaction between academic and extracurricular entrepreneurship initiatives

METRIC Sustain and enhance national leadership as a diverse undergraduate and graduate institution

OUTREACH AND TRANSFORMATION

We will raise the level of outreach engagement, which already leads the university in its breadth, depth and impact, beyond the dimension of individual companies to help stimulate the growth of competitive industry clusters as regional economic drivers.

METRIC Drive the creation of nationally significant "communities of innovation" in the R&D Park

Stony Brook Research and Development Park As the university's single most important academic and research resource for the Park going forward, including its roles in CEWIT and the AERTC, the College will proactively seek to develop industrial R&D collaborations that capitalize on the Park's proximity to the campus and contribute to its intellectual and economic vitality.

New Venture Creation Through the vibrancy of its research programs and the enhancement of entrepreneurship in its academic programs, the College will triple its contribution to the growth of new and established enterprises and help to create and retain jobs regionally, statewide and nationally.

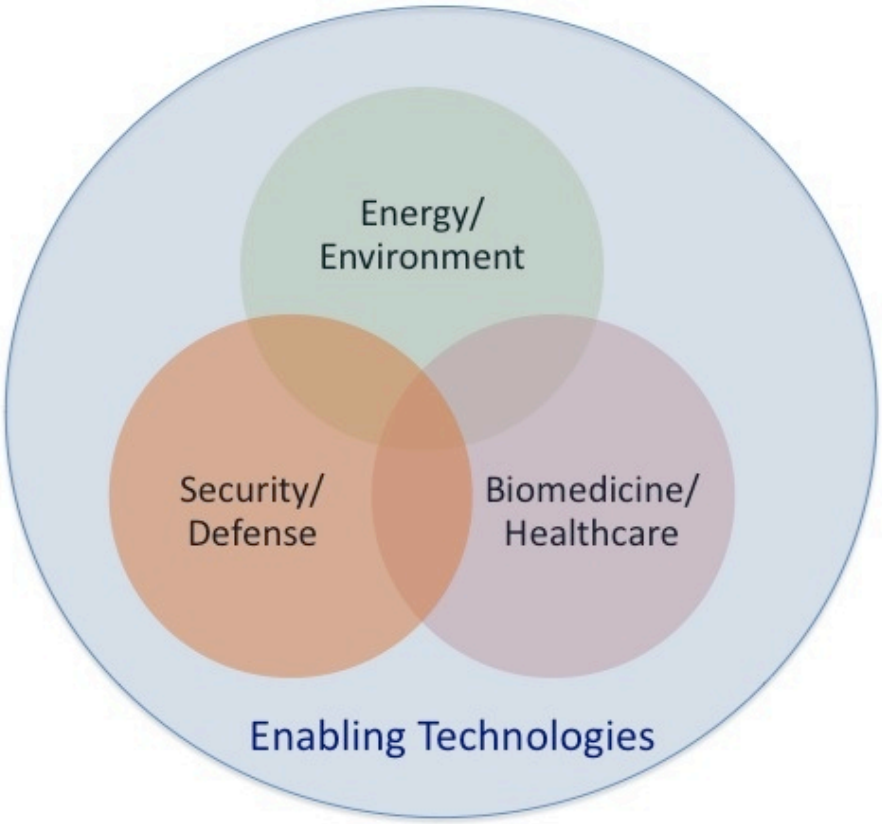
METRIC Triple outreach activity and results

METRIC Help the University achieve recognition as the model engine of a formidable regional economy

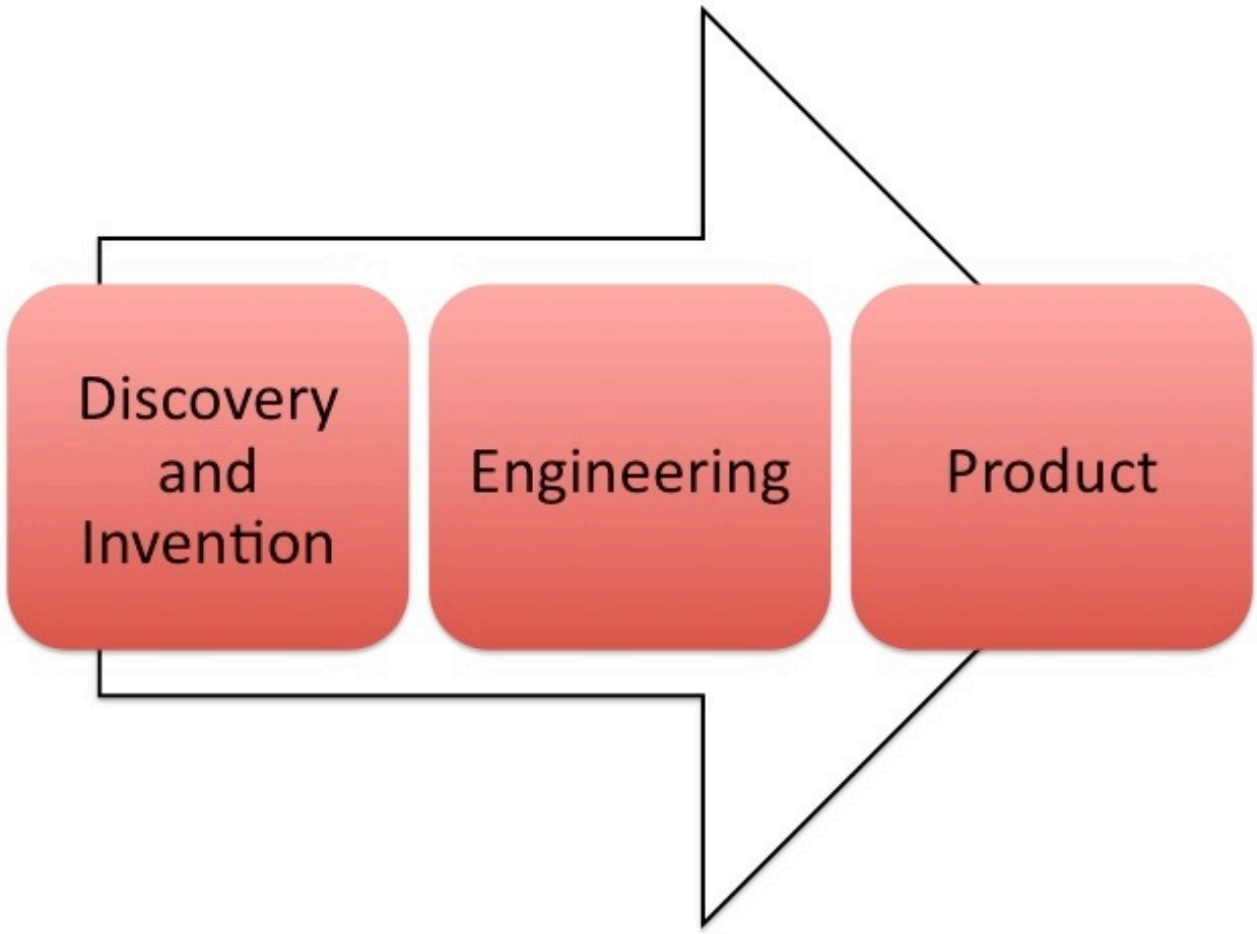
Innovation-driven Industry Clusters The thematic areas that will focus our growth efforts for the decade ahead are synonymous with those identified at regional and state levels to define our industrial future. We will triple SPIR and our existing outreach programs, accelerate the transfer of technology to the private sector, and bring our academic and research resources to bear on industry needs and opportunities to drive the growth and consolidation of nationally recognized industry clusters in these areas.

Global Reach In addition to expanding our academic programs in the Pacific Rim, the presentation of our sixth CEWIT conference in Korea this year – the first outside the U.S. – points the way toward a higher profile for the College abroad.

The College's deep relationships in our broad thematic areas of profound global challenge will cross sector boundaries. As the basic research strengths of the College are enhanced and additional capacities developed, many new applications and enabling technologies will emerge.



Engineering is the essential link between the fruits of discovery and invention in every discipline and the usable products that sustain and enhance our lives.



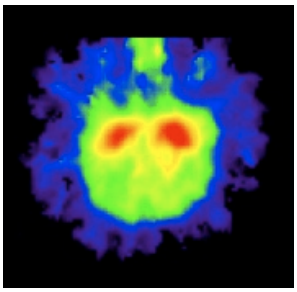
2. Three Broad Themes

Critical Crosscutting Domains

research

The growth of College research programs over the last decade reflects new NSF centers in growth fields (cyber security and bioenergy), more than a dozen CAREER awards – promise of greater things to come from exceptional young faculty–across the College, cross-disciplinary collaborations that have brought major funding not only from NSF, but also from NIH and DOE, and, in the most recent years, close alignment with the development of the Stony Brook R&D Park. The planning process revealed a high degree of consistency in the directions our colleagues have chosen for their new and multidisciplinary efforts. Engineering disciplines are infrastructure-intensive and, in order to fulfill the exciting purposes summarized here, significant needs will have to be addressed for electron microscopy, lithography and e-beam writing instrumentation, and a multidepartmental clean room, as well as the ever-growing needs for additional computing power and capacity.

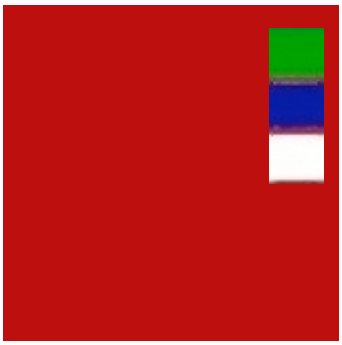
2.1. Theme: Biomedicine and Healthcare

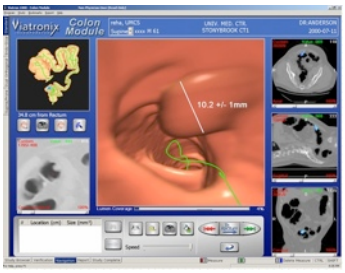


As biomedical research enters the genomics age, much of our understanding of complex, system-level interactions which control biological processes will arise from rigorous multidisciplinary interactions between the physical and biological sciences. It is an opportunity and a challenge to promote interactions between disciplines in a meaningful and substantive way, and to train the next generation of scientists to think across disciplines, recognizing the quantitative and qualitative benefits of collaborative research. Nowhere is this more evident than in the interaction between engineering and medicine, and there is no better time for CEAS to build up areas of emphasis and collaboration in biomedicine, given the emphasis at SBU in several multidisciplinary areas of biomedicine, including Neurosciences, Computational Genomics, Cancer, Infectious Diseases, Imaging, and Translational Research. Increasing CEAS's role in defining the success and impact of biomedical research at Stony Brook and on Long Island represents a central emphasis of the CEAS vision as defined in E2020. We will focus on three areas: Biomedical Informatics, Bioimaging, and Translational Biomedical Research.

Biomedical Informatics

Biomedical informatics is a multidisciplinary field of already significant and rapidly growing importance for the three research powerhouses on Long Island: SBU, BNL and Cold Spring Harbor Laboratory (CSHL). We propose to expand and deepen this research, as indicated below and in the following section, based on the well established, multidirectional and highly





successful efforts already in place in biomedical computing. Additionally, we will establish a multidisciplinary Graduate Program in Biomedical Informatics with details provided below (please see pp. 27-28).

Develop biomedical informatics tools for systems biology studies.Our goal is to integrate the vast knowledge we now have of causes and effects in biological networks with data driven pathway analysis paradigms to facilitate pathway discovery and confirmation, especially for disease processes.

Develop supercomputing paradigms for clinical and translational research. This initiative will bring to bear the supercomputing resources of SBU and BNL, home of the New York Center for Computational Science (NYCCS) and the NY Blue supercomputer, as well as novel cost effective parallel computing architectures such as Graphics Processing Units (GPUs,) upon the exponential growth of information in molecular and cellular biology that has occurred in the last decade.

Develop visual analytic and data mining tools for clinical and translational research. CEAS leadership in visual analytics and data mining, which has developed the 3D Virtual Colonoscopy for colon cancer screening, BrainMiner for brain functional connectivity analysis, autoROI for brain regions of interest extraction and volumetric analysis, and proteoExplorer for protein mass spectrometry data analysis and visualization, will be expanded in novel directions.

Develop modern health informatics platforms and devices. There is a growing consensus that health care informatics can greatly enhance the quality and efficiency of medical care. The deluge of medical data that will be collected through patient monitoring sensors, wireless networks and automated documentation of patient physician encounters will challenge the computing community to develop new techniques to move, store, archive, secure, analyze, and visualize massive amounts of data of a sensitive nature.

Bioimaging

CEAS is integral to establishing a world-class Bioimaging Institute (BI) in New York State as part of a university-wide initiative. Integrating the unique imaging facilities and formidable scientific expertise of Brookhaven National Laboratory, Cold Spring Harbor Laboratory and Stony Brook will form the nucleus of the Bioimaging Institute. Multi-disciplinary education programs will foster understanding of research principles from the bench to the clinic—meeting imaging challenges ranging from the high-resolution structure of complex macro-molecules to the intricate real-time function of the human brain. Bridging the BNL and SBU campuses, the Institute will define the frontier of bioimaging science across length scales, to discover, develop, translate, validate and commercialize technologies that will lead to new diagnostics, therapeutics, computational and signal processing methods and medical devices to improve the quality of health care. These expansive goals and broad multidisciplinary sweep are possible by leveraging the complementary strengths of a multidisciplinary national laboratory and a research university possessing the full range of biomedical research, engineering and medical care capabilities.

Translational Biomedical Research

Realizing the importance of translational research, in 2001 the College of Engineering and the School of Medicine established the Department of Biomedical Engineering which spearheads translational research and collaboration with the School of Medicine. An exceptional opportunity now exists through the enhanced integration and interaction of basic and applied scientists and engineers with those driving clinical science and technology development to promote human health through the discovery, development, translation, application and commercialization of basic and applied bioscience. Until recently, the US academic culture, in large part, has been slow to fully seize this opportunity, and in the majority of institutions, no formal mechanism exists adequately to bridge the gap between basic science discovery and translation into the clinic. As a result, a university's principal asset, its research capacity, is most often left underdeveloped. As a central tenet of the CEAS 2020 vision, our college will work to initiate, complement, and strengthen several areas of translational research and education, including collaboration with clinical departments on translational projects, participation in the NIH Center for Translational Biomedical Science, strengthening all levels of research in the School of Medicine, and strengthening biomedicine as a core component of the undergraduate and graduate engineering and applied science curriculum. Collaboration will drive the discovery, development and evaluation of new diagnostics and therapeutics in areas such as cancer, neurosciences, infectious diseases, obesity, musculoskeletal and skin disorders, as well as the design of novel, functional biomimetic materials for tissue engineering and drug delivery. The state-supported Center for Biotechnology will play a key role in these activities.

2.2. Theme: Smart Energy

The rapid and accelerating growth of energy consumption has made affordable, abundant, environmentally benign energy the single most important challenge facing humanity in our time. A $3 trillion a year business worldwide, energy is by far the biggest enterprise of humankind. New energy technologies will play a key role in the nation's prosperity and energy independence. They are also critically important for the reduction of carbon emissions, one of the major sources of greenhouse gases. However, technological progress faces us with a Catch-22: some of the very same technologies with which we seek to replace heavy carbon emitters also represent potentials for large additional demands for electric power, such as, for example, plug-in electric vehicles. This is not to say that we should turn aside from these new energy technologies, but the conundrum highlights the complexities of the energy problem and the need to inform policymaking with deep engineering and scientific knowledge. This issue is addressed in detail below (please see pp. 43-44).

No alternative or renewable energy source, including wind power, has yet eliminated the cost and reliability barriers to its immediate and

widespread adoption. We therefore address the energy problem in two timescales:

- For the near and medium terms, we focus on improving the efficiency of energy generation, transmission, distribution, and consumption, with emphasis on research and development of Smart Grid technologies.

- For the long term, we focus on research and development of more efficient and environmentally safe energy sources, including but not limited to renewable energy sources.

In addition to their national significance, both of these are areas of particular need for our region–which routinely competes with New Your City for the distinction of having the highest energy prices in the nation– and our state–because high energy prices are not limited to the downstate region. They are also areas of great opportunity. Although no new Energy Frontier Research Center awards are anticipated, there will apparently be one or more additional Energy Innovation Hubs and a variety of demonstration and investment programs, and ARPA-E, modeled on DARPA in its focus on high-risk ventures, is here to stay. New York State energy research funding is also increasing, both from the state's own resources and via pass-throughs of federal funds. Stony Brook is well-positioned to capitalize on these availabilities, not least through our close relationships with BNL, which the College intends to expand – we are already developing an MOU with the Laboratory to map out future collaborations in this area. The campus and the College have already had major successes.

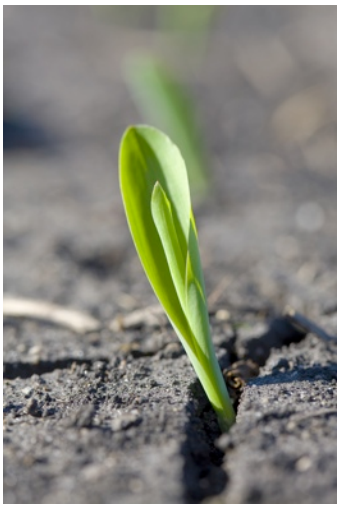
In addition to the NOSESC Energy Frontier Research Center led by a Stony Brook chemist, Stony Brook successfully competed at both national and the state level to win: **"Smart Energy Corridor,"** a DOE Smart Grid Demonstration Project, joint with the Long Island Power Authority and Farmingdale State; a DOE funded **simulation study of nuclear fuel separation and chemical reprocessing** in the Department of Applied Mathematics and Statistics; the NYSERDA-funded **New York Energy Policy Institute** (NYEPI), led by Technology and Society. The Smart Energy Corridor project reflects the extent to which Stony Brook has transformed its position in energy research with the construction of the first two facilities in the R&D Park, which are founded primarily on engineering resources. Both the Advanced Energy Center (AERTC) and the New York State Center of Excellence for Wireless and Information Technology (CEWIT) are critical resources for the project. CEWIT-affiliated faculty researchers are leading two of the major components of the project, and the cybersecurity testing facility that will be created as part of the project will provide one of the foundations for the the Virtual Smart Grid Testing and Validation Facility to be established in the AERTC.

Smart Grid Research and Development. The development of the Smart Grid will constitute the biggest

technology revolution in the energy sector in more than a century. The grid could not become "smart" without the advances of the last half-century, and particularly those that are occurring now, in computing and telecommunications. Sensing, measurement and control devices with two-way communications can be inserted at every point in the electricity value chain, from production to transmission, distribution and consumption, allowing operators to achieve significantly increases in efficiency, reliability, and security and generating "self-healing" automated responses that could prevent or mitigate blackouts. These technologies will be essential for the large-scale integration of renewable energy sources resulting from distributed generation into the grid, while enabling customers to achieve unprecedented control over their consumption. Important research initiatives drawing on core CEAS strengths include mathematical and computer modeling using the torrents of new data the Smart Grid will generate for load forecasting, Smart Grid cybersecurity – a crucial federal concern – supercomputer simulation of large-scale energy networks, data visualization, signal processing, integration of power and telecommunication technologies, new materials for renewable energy generation and energy storage, and energy policy analysis. Key research collaborations going forward will include CEWIT, whose location adjacent to the AERTC in the R&D Park already facilitates close relationships, IBM, CA Technologies, and Brookhaven's Advanced Electric Grid Innovation Support (AEGIS) Center, already an AERTC affiliate. The research and development of Smart Grid technologies will lead to significant scientific discoveries and new technologies that will have significant industrial and economic impacts. It will also create demand for preparing a new generation of engineers and scientists, and lead to the development of new educational programs. The AERTC led the formation of the New York State Smart Grid Consortium (NYSSGC) whose mission is to make New York a world leader in the design, development and implementation of Smart Grid technologies. The Consortium is based in the AERTC.

Renewable Energy Sources. The principal research directions are: research and development of biofuels; modeling of physical processes in renewable, nuclear, and traditional energy sources; development of photovoltaic technologies; and new materials for renewable generation.

The four focus areas for biofuel research and development are: 1) Feedstock agronomy, breeding and supply, 2) Biomass processing using microbes and enzymes to fuels, 3) Thermochemical biomass processing to fuels, and 4) Modeling and process life cycle analysis. The work will be conducted within the recently-established, NSF-funded National Center for Bioenergy Research and Development (CBERD), housed in the Materials Science and Engineering Department.



CEAS will continue research on mathematical and computer modeling of physical processes in renewable, nuclear and traditional energy sources. The use and expansion of current supercomputing facilities is critically important for this line of research. The main goal is to capitalize on the success of our fundamental studies of turbulent multiphase reactive flows and, aided by modern supercomputers, transform them into innovative engineering solutions. Research priority will be given to the computational optimization of fuel separation and safety assessment of processes in new generation nuclear reactors, improvement of the efficiency of combustion engines ranging from traditional diesel to scram jet engines. Our unique models, numerical algorithms and simulations of inertial confinement targets, fueling of thermonuclear fusion devices, studies of innovative ideas in magneto-inertial confinement fusion, and targets for particle accelerators will contribute to the design and exploration of large US and international facilities. These will include the International Thermonuclear Experimental Reactor (ITER), National Ignition Facility, innovative fusion experiment at Los Alamos, and a new generation of particle accelerators.

CEAS will advance photovoltaic research targeting improved lower cost solar cells with optimal electrical and optical efficiencies. This research should be expanded to new clean sheet of paper solar cell designs based on bio-inspired forms and materials. CEAS should drive the development of solar energy and its integration into the grid by leveraging, coordinating and aligning with the Smart Grid vision its existing research strengths, which include Stony Brook's capabilities for atmospheric and solar insolation measurement, new PV materials fabrication processes, nanomaterials for PV (with BNL), reliability prediction, and energy modeling. Cooperation with BNL, the future site of the largest solar energy farm in the Northeast, is important for this line of research.

New materials for renewable energy generation and high-density energy storage are at the heart of new energy technologies development. CEAS will be well served by focusing on the science of materials. A molecular-level understanding will require seamless probing of systems from nano to meso scales. An *in situ* imaging capability will provide a powerful new tool to establish dynamic behavior of materials that can help develop high-density renewable energy technologies using a hybrid approach.

2.3. Theme: Security and Defense

While classified research has never played a role in Stony Brook's research programs, the character and increasing complexity of critical national networks and systems, including the information infrastructure, the smart electric grid, and the port system, invite the application of some of the College's most notable strengths. CEAS' National Security Agency Center of Excellence in Information Assurance and NSF IUCRC in Information Protection provide a basis for major expansion of our outstanding resources and activities in cyber-security and intelligent computing for public safety. Defense against cyber attack will continue to be a high priority both for government information systems and for the private sector. The nation's information infrastructure is a mission-critical foundation for daily operations in business and industry sectors from finance to advanced manufacturing to healthcare. It is also an essential tool for disaster response, whether from natural or human causes, which can make the difference between inconvenience and tragedy, as we saw to our dismay in Hurricane Katrina. Stony Brook's efforts in this regard address both the security of computer and file systems themselves as well as the security and effectiveness of wireless communications, particularly ad hoc wireless networks, that will be the primary means of contact for first responders and emergency teams as well as troops in combat.

Applications as diverse as flight trajectory and combat systems analysis and defense against airborne toxins benefit from our capabilities in the simulation of fluids and structures, while our expertise in stochastic modeling, fluid dynamics and turbulence has applications to the control of complex multi-scale networks and jet engine design. Our existing strength in long wavelength semiconductor laser and detectors, which has already produced notable advances in gamma radiation detection, will achieve national significance as it is further developed. Our existing cluster of resources in self-powered and harsh environment sensors, which embraces multiple departments, is also targeted for significant growth as needs will continue to increase in both the national defense and homeland security arenas.

CEAS researchers will continue to move forward with efforts to develop nanotechnology-based sensor chips for rapid detection and analysis of the presence of trace amounts of viral or bacterial pathogens *in situ,* new single molecule fluorescent imaging nanotechnologies for separation and analysis of biomolecules at extremely low concentrations, novel biosensors based on electrostatically driven self-assembly, nano-composite metal oxides for the detection of harmful airborne chemicals, and nanostructured biosensors for monitoring conditions in high-value and other sensitive environments. More and closer collaborations with the Center for Functional Nanomaterials at BNL. Molecular dynamics simulations of biotoxins on ultrascalable supercomputers will provide the basis for devising efficient defenses against them. Emergency responders and battlefield commanders will rely on new

visual computing methodologies for depicting the forecasted dispersion of airborne contaminants and more generally for displaying large volumes of data from multiple sources. New strengths will be built on existing modest but sound foundations in the development of biomarkers for toxin-induced neuropathologies and of self-deployable structures for defense and emergency applications.

CEAS researchers participate in the National Nuclear Security Administration (NNSA) Predictive Science Academic Alliance Program (PSAAP) Center at Stanford, one of five such university-based centers that apply advanced computing and simulation techniques to critical national security issues. The Stanford Center focuses on predictive simulations of multi-physics flow phenomena and their application to integrated hypersonic systems, which are intrinsically multi-physics, multi-scale complex systems. Stony Brook's contribution relates to quantified margins of uncertainty in the design of a Scramjet. In general, CEAS researchers' work in multiphysics, multiscale, complex flows, reactive flows, fluid structure interactions, plasma and magnetohydrodynamics all have national security implications. There is also CEAS participation in a DOE Center for enabling technologies related to computational science and interoperable grid tools.

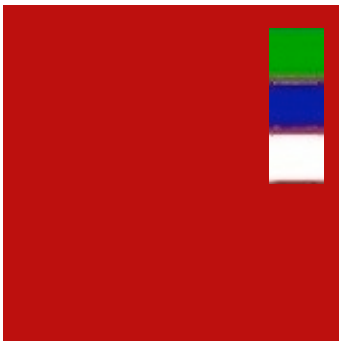
Crosscutting Domains: Computation, Computing and Software; Micro/ Nano-electronics, Devices and Sensors; Advanced Materials; Policy

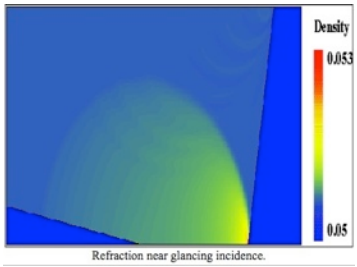
Computational science is one of the most striking developments in a century. By its nature, it is strongly multidisciplinary, leading to new and promising collaborations. From sequencing genomes to monitoring the Earth's climate, many recent scientific advances would not have been possible without an increase in computing power and sophistication. Computing enables the transformation from qualitative to quantitative science and technology. It provides the tool to create optimized designs that work the first time, without an expensive, time consuming and non-competitive build and test cycle.

Center of Excellence in Computational Science and Engineering: Advanced simulation, modeling and data analysis encourage and practically require collaboration, not only across disciplines of CEAS, and Stony Brook University, but regionally, nationally, and with laboratories and industries. Recent advances in computing technology, from processing speed to network volume and the internet, have revolutionized the way we live, the way we work, the ways we communicate and socialize, and the way we research. To take advantage of these opportunities and to build on existing leading expertise within CEAS, we will form a Center of Excellence in Computational Science and Engineering. This Center will be related to and become part of the NYCCS which links similar efforts across Stony Brook University and BNL. As an integral part of CEAS, it will ensure participation of all of CEAS. It will follow the twin threads of computational science both for physics and engineering based models and for data analysis and intelligence, as expanded below. It will link the computation-enabling groups in Applied Mathematics and Computer Science with the computation-using groups in the rest of CEAS. It will be a center for collaborations of CEAS faculty across much of Stony Brook University, and with New York State industry. Beyond this, it will provide a basis for national and international collaborations.

More disciplines are embracing computer-mediated formation of knowledge, from medicine to law. More and more scholars in the core of other disciplines need an education in computing and information science. Other areas that will gain even more importance are very large databases: libraries, scientific data, medical data, streaming image data; very large scale parallelism -- high performance computing and simulations and server farms; search engines for various specialized applications; robotics, image and voice processing, which are becoming much more prevalent, for example, for security.

Center of Excellence researchers will also improve the capabilities of computer hardware, focusing on parallel systems design and analysis research that will emphasize ultra-high speed processor design with new non-silicon technologies such as superconductors and parallel architectures for petaflops-scale computing,





Refraction near glancing incidence.

and hardware and software development for cloud computing.

The Center of Excellence in Computing within CEAS is an opportunity to help direct and lead this revolution that computing entails. A number of the new faculty hires in various departments over the ten years will be associated with the CEAS Center for Excellence in Computing, thus impacting all areas of CEAS, not only the areas currently strong in computing but also the various emerging ones, as outlined elsewhere in E2020.

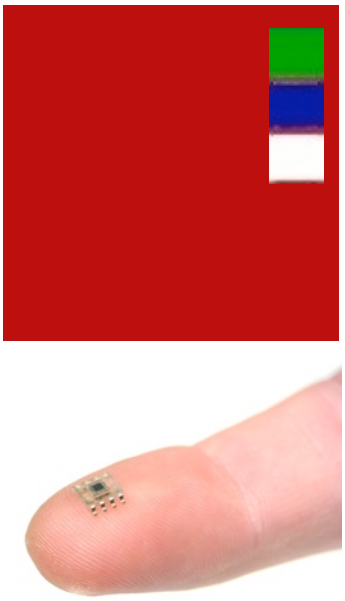
Physical/Engineering Based Models. The use of mathematical and computational models to simulate physical events and the behavior of engineered systems is essential for all large scale enterprises and for many smaller ones. Today, we experience the beginning of the new era in computational science. Computational models enable scientists and engineers to predict the behavior of extremely complex natural and human-made systems. In physics and engineering based sciences, numerical simulation is gaining equal status with theory and experiments as the major cornerstone of scientific understanding. Simulations, or 'theoretical experiments', not only complement but even substitute for real experiments which could be controversial (biology and medicine), dangerous, difficult or impossible to instrument (climate science, astrophysics, aerodynamics, nuclear security, crash testing), or expensive (new ideas in the design of unique facilities, accelerator and nuclear fusion sciences). The goal of CEAS in the next 10 years is to enable the qualitatively new level of simulations in physics and engineering systems capable of dealing with the expanding scientific and technological challenges of our society. This goal will be accomplished through a coherent program linking applied mathematics, computer science, scientific and engineering applications.

The staggering growth of raw processing speed of today's supercomputer hardware architecture is a success factor for the CEAS program. The NewYorkBlue supercomputer and future upgrades to this facility will enable national leadership across all of CEAS in supercomputing. However, as impressive as modern supercomputers have been, their impact will come only together with achievements of applied mathematics and computer science research in the area of novel mathematical models and new programming paradigms. Applied mathematicians, computer scientists and engineers will jointly develop multiphysics and multiscale models and the corresponding numerical algorithms and software optimized for massively parallel, multi-core supercomputers and provide applications scientists with computational tools to study processes that span scales ranging from atomistic to continuum matter. Another component of the CEAS program is the verification and validation of computational models, and the development of tools for uncertainty quantification of simulation data. Supercomputing remains a crosscutting theme for several of the NAE's Grand Challenges. Research priorities will be given to fundamental science problems, energy sciences, engineering and defense applications. Fundamental science research will range from the classical but still unresolved problem of the theoretical foundations of turbulence to understanding the fundamental structure-property

relationships in advanced materials over multiple (structural or functional) length-scales. Large scale simulations of matter at the nanoscale, performed in collaboration with Brookhaven's CFN, will pave the way towards the fabrication of new functional materials with desired properties. Advances in molecular dynamics simulations of the behavior of self-assembling polymeric and biopolymeric systems, "Future Fuels" production technologies complementing CO_2 mitigation, nanocatalysis, environmental remediation etc. are necessary for break-through in the biofuels area. On the meso- and continuum scale, supercomputing will enable the simulation of properties and behavior of complex heterogeneous systems, especially at extreme conditions pertinent to nuclear fission and fusion reactors, particle accelerators, laser and mechanical test facilities. Complex network type systems include sequences of semiconductor devices, sophisticated circuits, computer grids, smart power grids, and aerospace systems. Using supercomputers, engineers are particularly interested in designing high performance, minimal cost and ecologically and societal friendly systems. The combination of advances in simulations, data analysis and visualization, rigorous verification and validation effort will lead to optimized designs and a competitive advantage for NYS industry. these applications will include the financial industry, where there is a significant need for advancing the computational state of the art.

Computing for Data, Intelligence, Information. The computer and its uses play a major role in many inventions that significantly impact our lives. The internet and broadband communication, laptop, and mobile computers, electronic mail, mobile phones, office software, e-commerce, online social networking, are common examples. Extracting intelligence through computation and the management of large data sets is transforming astronomy, climatology, genomics, imaging, health technologies, electronics, and more. Securing cyberspace, enhancing virtual reality, amplifying intelligence through visualization, advancing health informatics, reverse engineering the brain, and advancing personalized learning will be important issues for the coming decade.

In science and technology, the growth of computational hardware and software capabilities makes it possible to analyze enormous amounts of data generated by experiments and simulations. The STAR experiment at the Brookhaven National Laboratory generates petabytes of data resulting from the collisions of millions of particles. Data management tools make it easier for scientists to transfer, search and analyze the data from such large-scale experiments. The ability to understand the behavior and predictive capability of models for a complex system depends in an essential way on the data associated with that system. Such data comes in many forms—observational data of varying quality, multiple types of experimental data and results of computational simulations. The data analysis presents significant challenges to researchers. Frequently data are spatially and temporally heterogeneous; even large volumes of data can be sparse in the sense of incomplete characterization of complex systems. The collection, storage and



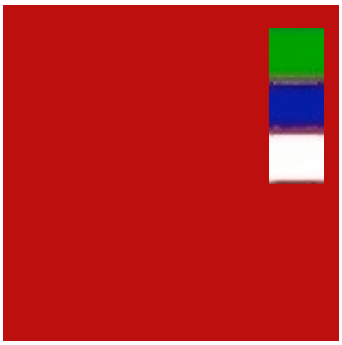
processing of data often entails large costs. Pattern recognition in large data sets and uncertainty quantification are also among major challenges associated with large data sets. Statistical and mathematical analysis of large, heterogeneous data sets raises the need to develop new approaches for dimensional reduction in order to discover the essential features represented in the data.

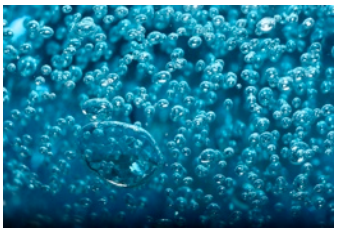
Embedded processors will gather data and then move the data around using wireless communication to the computers that will analyze them further to make decisions. The overarching goal is to understand, improve and augment people-to-people and people-to-environment interactions. These advances will have a tremendous impact on urban planning, environment, infrastructure security, transportation, energy usage, health-care, and will generally improve the quality of daily life.

CEAS has a strategic plan for meeting these challenges. We will work on efficient methods for the statistical analysis of large data sets, using rigorous, but computationally feasible methods for dimensional reduction of data. We will focus on mathematical and computational approaches for quantifying various forms of uncertainties in the data. Our capabilities in the visualization of large, distributed data sets will provide a deeper understanding of experiments and simulations. Networking research in collaboration with the BNL Computational Science Center will enable efficient data distribution and transfer. We will strengthen our expertise in the disciplines of sensing and material science, wireless communication, robotics, bio-medical engineering, and human computer interaction. CEAS will also promote interactions with other disciplines such as psychology, social sciences, public health and policy and health technologies.

Micro-/nano-electronics, Devices and Sensors Sensors and the larger categories of micro- and nano-electronic devices of which they are examples will have critical roles as enabling technologies for the broad purposes identified as areas of research focus for the College going forward. Fulfilling these roles will not merely require the applications of known principles and the production of widgets from established formulas and recipes. CEAS researchers will build on their past work to pursue fundamental new understandings of semiconductor laser design and create a nationally recognized center at Stony Brook specializing in infrared optoelectronics and photonics. The state-supported Sensor CAT based in the College, which received a CAT Development award for high efficiency, high power electrically pumped laser sources, will have a key role in this work. Our research in optical networks, which are expected to be the backbone for the next generation of the Internet, wireless networks, wireless ATM, and multicast communications will emphasize predictable quality-of-service (guaranteed multicast latency and bandwidth).

Sensors and processors will be pervasive. They will not only be used for specialized applications including those described in the foregoing major areas of research activity, they will be embedded in the majority of the objects and the physical spaces that





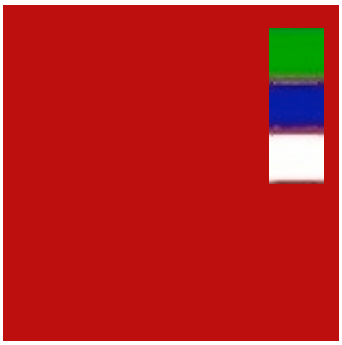
surround us – including cars, buildings, furniture, appliances, various forms of urban infrastructure. The sensors will gather detailed data from the physical spaces about their status and the human activities and interactions around them. CEAS' strong capabilities in both sensor development and new networking technologies provides an excellent foundation for the development of sensor swarm technologies for detecting conditions across broad geographic areas, and reacting to them, potentially without human intervention.

Widespread use of advanced technologies to gather medical data through wearable, sensor-based monitoring that is integrated with electronic health records is on the horizon. Integration of sensors with internet data mining and wireless communications can alert health-care professionals to individual or public health threats and help them anticipate and respond to medical emergencies. Automated documentation of patient-physician encounters in daily clinical practice can greatly improve the efficiency and effectiveness of health care providers. These technologies raise sensing, signal processing, security, and networking challenges to a new level.

Another area of particular interest is the nanofabrication of biosensors or diagnostic chips, including biocomposites for selective chemical sensing. A well-established program in Direct Write thermal spray technology will continue to develop sensors with unique microstructure and nanometer-scale features that result in unique thermal, mechanical and electrical properties and produce excellent performance at high temperatures, i.e., in excess of 1,000°C, and in harsh environments. It has been demonstrated that these sensors can be fabricated directly onto engineering components for exceptional reliability. A key application already identified is their use in land-based turbines and high-temperature, high-pressure boilers for more efficient power generation, condition-based rather than failure-based maintenance, and optimal performance.

As noted above, micro- and nano-electronics applications to biomedicine are another area of particular interest for CEAS researchers, including nano-based implantable "theranostics" for cancer and medical devices for treating diabetes and obesity.

New and Engineered Materials New, advanced and engineered materials will be essential to fulfilling the College's thematic research goals. Describing and understanding the uncharacteristic behavior of familiar materials at the nanoscale, as well as the potential for developing and engineering new materials, represent fundamental challenges to discovery and investigation. These include the development of nanoparticles and nanostructured catalysts for important, environmentally relevant oxidation and reduction reactions, renewable hybrid sources, high-density hybrid renewable energy technologies based on a molecular-level understanding of systems from meso to nano scales. A near term opportunity to improve energy efficiency lies in developing replacements for conventional silicon-based semiconductor technology with power devices based on silicon carbide-materials, which recent theoretical studies have



shown will greatly outperform silicon. In additional to laser technology itself, CEAs researchers will continue to study laser-material interactions and develop functional designer fluids. The study of soft active materials from experimental, computational and theoretical points of view, across relevant length and time scales, will be another area of focus. The ultimate objective is not only to generate much needed fundamental knowledge about these materials, but also to use this knowledge to guide material design for smart energy devices. Fundamental studies at nano-, micro-, and macro- length scales of shape-memory polymers, gels, electroactive polymers, will lead to materials design for lightweight multifunctional structures for automotive and textile industries (e.g., self-repairing bumpers, coatings, smart clothing, etc.), and lightweight multifunctional structures for energy and aerospace applications (energy harvesting materials, self-deployable structures, morphing wings, etc.)

The Thermal Spray Center will continue its basic research on this critical coatings technology, whose applications include gas turbine engines (propulsion and energy), automotive, pulp/paper, and infrastructure maintenance, while emerging applications include coatings for orthopedic and dental implants, solid oxide fuel cells, and functional sensors for harsh environments.

Policy Stony Brook's successful proposal to be designated the New York Energy Policy Institute (NYEPI), led by CEAS' Technology and Society, was a great triumph for the young doctoral program in Technology, Policy and Innovation. More importantly, NYEPI provides a strong base for the development of Stony Brook's first nationally recognized policy research institute. NYEPI's balance of science and engineering knowledge and research capability that is both broad and deep and seasoned policy expertise is highly unusual if not unique nationally. The Institute has been asked to address one of the most critical issues regarding the state's and indeed the nation's energy supply, the implications of developing the Marcellus shale gas deposits that underlie New York and other states. The scale of the potential reserves and the serious environmental concerns about their extraction make this an important and challenging issue for science-based policymaking.

The College will develop future policy support efforts on the NYEPI model of exceptional science and engineering capacity and deep policy expertise.

education

3. New Departments and Programs

New Pedagogies, More Opportunity

In the last decade, the College has added four new undergraduate programs and six new graduate programs: every one of our seven academic departments now offers the full range of bachelors, masters and doctoral degrees, we have initiated the chemical and molecular engineering program at the bachelors level and approval has been received for a civil engineering bachelors degree program, which we will initiate in Fall, 2012, if sufficient faculty resources are available. The SAT scores of our first-year students have been rising steadily and those of Fall, 2010,entrants are the highest we have yet seen and the highest of any academic unit in the university – at the same time that our enrollment of more than 3,000 at all levels is the highest ever. This progress has laid the foundation for the College to attract students comparable with those of the best engineering institutions in the nation.

CEAS in the next ten years will make creative advances in education in parallel with creative advances in research. On the basis of demonstrable need and with appropriate resources, we anticipate establishing an undergraduate Materials Science major, a Graduate Program in Biomedical Informatics including a unique concentration in bioimaging, new programs in intelligent computing, “green” computing and new joint programs with business, TSM and psychology; we will make new efforts to identify and encourage the entrepreneurs among our students; extend international programs. These advances will provide our students with a better education and foster better learning. Through publications and software, CEAS faculty will help improve the learning of thousands more students at other institutions across the country. Gaining a reputation for innovative education will allow the College to attract more high-quality students to its programs. CEAS will accomplish these goals with imaginative new instructional materials, virtual laboratories, new programs, expanded internships, scholarship support and undergraduate research opportunities, as well as increased recruiting and retention of women and minority students and faculty

3.1. New Programs

CEAS in the next decade will design and implement several degree programs, within the College and across colleges. Examples include Civil Engineering, Information Systems, the Master of Engineering designation, and the B.S.E.E. online. In addition to Biomedical informatics, Ocean Engineering and potentially other new programs would integrate complementary CEAS expertise with other sectors of the campus.

Civil Engineering. Civil Engineering is critical to Long Island, New York State and the nation. Civil engineering is a collection of engineering disciplines including transportation engineering,

environmental engineering, and the many engineering fields associated with building and maintaining the physical infrastructure of factories, cities and regions. There is currently no civil engineering program to serve Long Island and its 2.8 million residents. Local engineering firms now have to go out of state to hire civil engineers. Recognizing this need, CEAS sought and received state authorization for a new program, Bachelors of Engineering Civil Engineering (BECE), expected to start in 2012. It will initially be housed in the Department of Mechanical Engineering. When a critical mass of courses and faculty is reached, ABET accreditation will be sought.

The program's courses and faculty will address the broader impact of civil engineering on quality of life and energy technology, including research in novel bio-inspired nanocomposites and environmentally benign materials and structures, geosynthetic materials, aging infrastructure, impact of waste water and environmental nanotechnology, energy harvesting and sensing systems, and wind and water energy technologies. Many of these problems will involve collaboration, both in research and teaching, among CEAS departments, the School of Atmospheric and Marine Sciences (SoMAS) and the Department of Geosciences.

Chemical and Molecular Engineering. The new Chemical and Molecular Engineering (CME) Program was initiated to broaden the scope of the CEAS and in response to requests by the growing regional pharmaceutical and cosmetics industries. This new program distinguishes itself from other chemical engineering programs in SUNY, through its emphasis on nanotechnology and molecular scale design, areas where the program capitalizes on its proximity to the BNL Center for Functional Nanoscience (CFN) and the strong research programs of the host Department of Materials Science. The program is also unique in its integration of a strong research component into the traditional chemical engineering curriculum, and its requirement that all its graduates complete a senior thesis. The program has grown very rapidly, attracting some of the best students in CEAS, and receiving full ABET accreditation in 2010.

The CME program will continue to grow into the next decade through increasing and diversifying its research programs while fostering collaborative programs and new synergies. The program plans to hire a number of new faculty members, establish a CME graduate program, encourage the growth of existing NSF funded centers and attract external funding for the establishment of new multidisciplinary research centers. Key research directions will include: (a) Transformative research in energy which will provide a fundamental understanding of generation, conversion, storage and transfer; (b) Molecular engineering leading to breakthrough technologies for the production of carbon neutral fuels, high efficiency organic solar cells, improved carbon sequestration methods, and "smart" materials for smart grid

applications; (c) Establishing new directions at the interface with medical and dental sciences through molecular level process control of drug delivery systems, three dimensional, multi-functional tissue engineering scaffolds, manipulation of the stem cell environment, and precision design of nanocomposites for dental reconstruction; and (d) Applying molecular engineering technologies for environmental remediation, nanotoxicology, and monitoring workplace health and safety. Industrial and community outreach are central to growth of the program. The proposed Bridge to Research programs are designed to recruit students from community colleges and minority high schools, and ease their transition into research intensive engineering programs . Joint research projects, with regional industry, which result in internships for our students, and job creation for NY State will be expanded. Entrepreneurship will be encouraged through support of faculty and staff participation in small business initiatives. Extramural industrial PhD and MS programs, will be incorporated into the future graduate program.

Industrial Engineering. Industrial Engineering (IE) is a diverse discipline that addresses the design of integrated and highly efficient systems of people, materials and equipment across the spectrum of manufacturing and service operations. Moving from the traditional emphasis on production systems, we look to current emphases on the integration of computers, information, and technology to operate and control complex systems, and the dispersion of the principles of lean manufacturing throughout the organization. To preserve and enhance manufacturing in our region, our state and our nation and ensure competitiveness across industry sectors, we propose to create an IE program over the next five years. The only IE program on Long Island. it will be housed in Applied Mathematics and Statistics, which has a five-faculty Operations Research group (OR), and will leverage current undergraduate courses, which already cover most of the required educational components, in AMS, Mechanical Engineering and Computer Science. The new IE undergraduate program will seek ABET accreditation. The College will develop new undergraduate courses on manufacturing, logistics, and computer simulation.

Joint Graduate Training in Biomedical Informatics. While BME offers a graduate track in Bioimaging, which it plans to expand, many graduate student research assistants in CEAS departments work on problems of Bio/Medical/Informatics at SBU Medical Center and also CSHL and BNL. However, there is currently no graduate training program at Stony Brook in these areas, which requires the joint knowledge of biology, computer science, mathematics and statistics. Thus in collaboration with the SBU Medical School, CSHL and BNL, we propose to establish a *Graduate Program in Biomedical Informatics* with tracks in Bioinformatics and Medical Informatics and the intent to enrich the existing track in Biomedical Imaging. The faculty team will be drawn

from CEAS departments and Ecology and Evolution, Microbiology, Neurobiology, Centers for Molecular Medicine and Biology Learning Laboratories (CMM/BLL), Laufer Center for Computational Biology and Genome Sciences, Preventive Medicine, Radiology as well as the Watson School of Biological Sciences at CSHL. Curriculum development will include a strong focus on providing breadth beyond the students' areas of specialization This new training program will provide exceptional synergy among the three Long Island research institutions to complement research collaborations in the area of Biomedical informatics.

Over the next decade, we anticipate a number of other new educational collaborations between engineering and biomedicine at all levels. For example, the top high school students interested in engineering are being recruited from across the nation into the School of Medicine through the new program of "Engineering Scholars in Medicine." Graduate training will follow research in areas such as nanotoxicology, tissue engineering, stem cell research, bioimaging, and bioinformatics. These subjects will be strengthened through joint faculty hires. A case in point is the new instruction in materials in the School of Dental Medicine curriculum. An outgrowth of the Dental Materials course, co-taught by CEAS faculty, will pave the way to the Certificate Program in Dental Materials Science, that will eventually lead to a joint Masters degree in Engineering/DDS.

Ocean Engineering, to be developed with SoMAS, is an example of additional multidisciplinary programs we envision.

We will increase our efforts to foster entrepreneurship through course offerings in Electrical and Computer Engineering – recipient of two NSF Partnerships for Innovation awards –and Mechanical Engineering, the latter in collaboration with the College of Business, and will raise College-wide student participation in the DARE student entrepreneurship competition to the level achieved by Computer Science.

3.2. Renewing Instruction

Instructional Innovation. Engineering is undergoing a renaissance as society realizes that the solutions to major global challenges in energy, the environment, physical infrastructure and technology will come from engineers. Engineering education needs to attract more talented young people and give them the tools and the visions to address these challenges. The College will establish a college Center for Educational Excellence to promote instructional innovation that connects core engineering theories and techniques with these exciting societal problems. The Center will also assist faculty in securing external support from industry and government for developing these innovations. The Center will facilitate multidisciplinary educational projects within the College, in the spirit of the current NSF-funded Nanoscience minor and the Biology, Chemistry and Applied mathmatics joint program, the educational

components of the Garcia MERSEC, as well as inter-college projects, like those currently involving CEAS faculty, science faculty, and the Center for Science and Mathematics Education. CEAS seeks to be among the leading engineering colleges with a critical mass of engineering educators and a culture that fosters innovative educational activities in the classroom and in the laboratory.

Integration of Education and Research. Over the next ten years the college will create a seamless integration of our research programs with our undergraduate as well as graduate education. Bringing research into classrooms adds a unique dimension to the coursework and increases its relevancy to real world applications. The expertise gained by our undergraduate students increases their competitive advantage in the workplace and in future graduate studies.

Undergraduates from CEAS represent a large fraction of the research abstracts presented at the campus-wide URECA conference, and nearly all of the senior design symposium presentations. Research-based efforts to increase diversity include programs such as Women in Science and Engineering (WISE), AMP, and STEP to recruit underrepresented students into the Science, Technology, Engineering and Mathematics (STEM) disciplines and research programs. In the next decade, CEAS will expand these efforts to create a refereed journal for undergraduate engineering research CEAS faculty work with high school students and occasionally high school teachers along with undergraduates, graduate and post-graduate students, as witnessed by the many Intel Talent Search finalists and semifinalists mentored by CEAS faculty.

Provide multi-platform, multi-disciplinary clinical and translational research mentoring opportunities to clinical and translational research trainees. Research collaborations among BNL, CSHL and SBU provide excellent opportunities for novel clinical and translational research and education. Medical school and CEAS faculty members have joined forces in applying for NIH training grants for medical interns and students in biomedical informatics.

Electronic Classrooms. We believe that the next decade will see a radical restructuring of how professors provide instruction and of how students learn. CEAS intends to be a leader in this effort. Artificial intelligence-based instructional software will answer students' spoken questions and guide them through exercises developing mastery of technical skills. Classroom instruction will be dominated by simulations and virtual labs that give a physical reality to theories and equations. Students in a classroom will download diagrams, formulae and

explanations to their tablet PCs, and then annotate them with their own notes. Web conferencing will enable engineering students to work with mentors and experts from around the world. Artificial-intelligence-based homework software will promote better student learning.

As an example of this trend, the Department of Electrical and Computer Engineering is planning to offer its B.S. in Electrical Engineering online. In a trial effort, courses have been offered online to non-matriculated students with enthusiastic responses by faculty and students. The BSEE on-line degree program will seek ABET accreditation, and expand to a full-fledged program serving thousands of students worldwide while enhancing our reputation and bringing substantial external educational resources to Stony Brook.

3.3. Student Opportunity

Minorities and Women. CEAS has several highly successful programs, funded through State and federal grants, to enhance the participation of underrepresented minority and/or economically disadvantaged students in STEM disciplines at both the undergraduate and graduate levels. Prominent examples include: NSF-funded SUNY Louis Stokes Alliance for Minority Participation (LSAMP), SUNY Alliance for Graduate Education and the Professoriate (AGEP), Scholarships for STEM, and the New York State Education Department-supported Science and Technology Entry Programs (STEP for high school, and CSTEP for college/university). Over the next ten years, a parallel effort will be mounted to increase the number of female students in CEAS departments. A recent AAUW report, entitled "Why So Few?", makes the strong case that "College and university administrators can recruit and retain more women [in STEM careers] by implementing mentoring programs and effective work-life policies for all faculty members." CEAS will build on the success of WISE and the Society of Women Engineers (SWE) to develop strategies and programs to enhance the recruitment and retention of women students and faculty. These broad diversity efforts will benefit CEAS and in addition, establish models that can be used by other institutions.

Internships and Scholarships. By the year 2020, CEAS will triple scholarships and greatly expand opportunities for internships for students and will develop new synergy with industry and government to enhance the hands-on education of our students, in collaboration with SPIR, the Career Center, and CET training programs. CEAS will likewise expand scholarships, many related to industry and government internships.

Service Learning and Experiential Education. CEAS and its various departments have been active participants in many areas of service learning and experiential education. Target areas include K-12, educational and community outreach, internships, civic engagement and life-long learning through ongoing and special projects. In the next ten years, CEAS will expand opportunities and outreach in these areas to enrich students' learning experience by broadening the participation in global activities relevant to energy, sustainability, environment, and medicine through college-wide initiatives and organizations such as Engineers Without Borders. CEAS students won first prize in the 2009 Supercomputing

Student Cluster competition, achieved top rankings in the international Mini-Baja and IEEE Extreme competitions and have been involved with faculty in FIRST, JSHS, Intel, and summer programs that enhance college and high school students' learning experiences, promoting our exposure. The integration of these efforts with CEAS'/SB's initiatives for recruitment and retention will increase our competitiveness in attracting young talent.

Education and Globalization. The College has undertaken various initiatives to develop degree programs collaboratively with international partners in Korea, Taiwan, and Mexico. Formal joint degree programs have been initiated with Ajou and Konkuk Universities in Korea, and Nanjing University in China.

Exchange agreements specifically designed for engineering students exist with EFREI in France, Konstanz University, in Germany, the City University of Hong Kong, the Chinese University of Hong Kong,and Tel Aviv University, Hebrew University and the Technion in Israel. We have encouraged our students to avail themselves of fellowships offered by the German DAAD, the Fulbright Foundation, the Santa Barbara International Materials Institute, the Australian ARC, and other agencies, to travel abroad and participate in the international research efforts of the CEAS faculty.

With globalization and the availability of innovation and technology, CEAS is poised to create and foster opportunities to have global presence in education and research. It is inevitable that the world's leading universities, such as Stony Brook, will have international campuses by the middle of the 21st century. The vision of CEAS is to integrate the programs of such global campuses with the same world-class standards of education and research that are in place at home.

4. Talent, Regional/Global Innovation

outreach and transformation

Already the university's leader in engagement with regional economic needs, the College will refocus and greatly enlarge these efforts as part of the economic development mission.

4.1. Training

At all levels, College academic programs have a global reach, as described above and in Section 4.4 (below, p. 35); regionally, they are among the university's most important for a knowledge-based economy reliant on a highly-skilled workforce. The College is by far the largest supplier of entry-level degreed professional engineers on Long Island and the only source for doctoral education in the traditional engineering disciplines as well as Applied Mathematics, Computer Science, and the emerging discipline of technology policy. Part-time access to many degree offerings, including all College master's programs, provides skills enhancement and career advancement for incumbent workers. These strong academic curricula provide a solid foundation for certificate and non-credit programs, including short courses, workshops, seminars, and CEWIT's customized professional development program, for credentialing and skill-building, delivered on-campus, on-site and via distance learning. In consultation with major business associations, including the Long Island Software and Technology Network and the Hauppauge Industrial Association, the leaders of the diverse industry sectors represented on the Dean's Council, and the university's Center for Emerging Technologies and its industry advisory board, the College will continue to develop such offerings opportunistically in areas of high and emerging need. Current high demand areas include Excellence in Management and Operations, Emerging Technologies and Software, and LEED certification; areas under development include Smart Grid Engineering certification, healthcare IT and operations, and sustainable building processes. There may be opportunities for the College to help develop standards for the new and integrated professional certifications and credentials that will be required for the ongoing development of a "green" economy.

4.2. Economic Development and Regional Transformation

The College is a critical contributor to the fulfillment of the campus' economic development mission; it is poised to amplify that contribution in the coming decade. As the

birthplace of the Strategic Partnership for Industrial Resurgence (SPIR), SUNY's only multi-campus economic development program, based in its colleges of engineering, the College pioneered fast-turnaround advanced technology assistance across the spectrum of technology sectors for companies of any size at any stage of development. Both of the university's New York State Centers of Advanced Technology (CATs), which foster the growth of targeted industry sectors, are co-located with CEAS departments, the Sensor CAT in Electrical and Computer Engineering, and the Center for Biotechnology (CfB) in Biomedical Engineering. CEAS supplied most of the faculty who have collaborated with the Sensor CAT's 70 industry partners, while the CfB's co-location with BME in its new facility will drive collaboration in such commercially promising areas as diagnostic and therapeutic imaging, bioengineered devices including implantables and ingestibles for monitoring, diagnosis and drug delivery, and robotics.

These programs will continue to be pillars of the university's economic development strategy because they consistently produce impressive results. In its 15 years, for example, SPIR has assisted more than 400 New York companies in obtaining more than $100 million in federal funding and creating or saving a projected total of more than 12,000 jobs. Tripling these programs' modest state investments will correspondingly triple their near-term results and begin to scale their impacts on whole sectors of the technology economy, but their payoff is not limited to these linear near-term increases. Because these programs also support tenant companies in university incubators, and other cash-poor technology start-ups, with access to the billion-dollar research infrastructure of Stony Brook and Brookhaven and their world-class talent, they also have significant long-term potential. For example, a start-up that received SPIR assistance for programming two years ago on its initial product, an SaaS solution for automated staff scheduling in 24/7/365 healthcare environments, has tripled its employment. The College's new emphasis on entrepreneurship, guided in part by the entrepreneur support programs pioneered by the Center for Biotechnology and Stony Brook's incubators, will help drive an important new university focus to help give birth to the CA Technologies, Symbols and OSIs of the future.

The Stony Brook Research and Development Park adds new dimensions to the university's academic and research missions while providing direct new opportunities on-site for industry collaboration and economic growth. The first two buildings in the Park, the New York State Center of Excellence in Wireless and Information Technology (CEWIT) – opened spring, 2009 – and the Advanced Energy Research and Technology Center (AERTC) – opening in fall, 2010, with programs already underway in temporary locations – house multidisciplinary R&D programs with strong industry interest in the solution of threshold problems that block the progress of technology

innovation in sectors that are critical to our economic future. CEWIT's Chief Scientist and most faculty affiliates are members of CEAS departments; the Center has created a Medical Technologies Division – which is already obtaining federal and private sector funding – in response to needs in the Schools of Medicine and Health Technology and Management, University Hospital and the Long Island State Veterans Home.

This development demonstrates the great potential for CEAS in this setting – including its innovatively-focused new departments –to collaborate with other disciplines, as well as industry, in pioneering solutions to threshold problems. For example, CEWIT is partnering with the Energy Center to develop new Smart Grid technologies, but the breadth of the conventional and alternate energy needs the AEC is mandated to address is prompting a broader reach into Chemistry, Physics and other academic units; the third building, which will have a biomedical focus, will drive yet more diverse multidisciplinary partnerships. The Park focus areas already identified are central to the progress of the world economy in this century, and they are only the first three of what are expected to be ten buildings over the next 15-20 years, offering scope for broader initiatives – for example, advanced materials are a potential focus, especially in collaboration with the resources of Brookhaven's Center for Functional Nanomaterials, and it is likely that national security issues will continue to require new solutions. With its current and planned academic and research programs, CEAS will be a leadership resource for the university's economic development mission and the R&D Park.

4.3. Community Outreach

Campus-wide, about 5% of semi-finalists and of finalists in the national Intel and Siemens competitions annually are mentored by Stony Brook faculty and students, about half of whom are in CEAS. No other U.S. university comes close to this percentage. These mentoring activities provide a highly visible enhancement of the educational opportunities for young people on Long Island, which in turn makes Long Island industry more competitive in attracting highly educated professionals to live and work on Long Island. Second, this educational outreach is integrated with CEAS recruitment initiatives to attract talented students to Stony Brook. Finally, the CEAS graduate and undergraduate students who participate in this educational outreach are learning to see mentoring talented youth as an integral part of their future professional careers.

Excellence in inter-collegiate team competitions has always been a proud component of CEAS students' education, as reflected in high rankings in national and international competitions such as the Mini-Baja, the Student Supercomputing, the IEEE Extreme contest, the robotics competition, and others. In addition, CEAS students and faculty have a long tradition of mentoring Long Island high school students in individual and team science and engineering competitions, including the Intel International Science and Engineering Fair, the Siemens Science

Talent Search, the FIRST Robotics Competition, the Junior Science and Humanities Symposium, and others.

4.4. Global Outreach

International outreach is a critical component of our mission, which will continue to grow in the coming decade. With the increased globalization of science and research, both in academia and industry, it is important that our graduates have the skills to function across the globe. Our international reputation allows us to recruit some of our best students from among the highest ranked schools in the world, which benefits our under-graduate and graduate programs. International exchange agreements with other institutions allow us to expand the educational experience of our students and make them more competitive in the global job market.

In the coming decade we plan to grow our international programs and increase our visibility abroad . In particular we would like to focus on expanded global interactions with industry. Using the successful models developed with regional industry through the SPIR and CAT programs, we plan to initiate similar collaborative programs with companies based in other countries. These should greatly benefit our students through internship opportunities in the respective countries which will provide them with the desired global perspective on industrial engineering and research directions. Major international industrial collaborative programs with Korea are already in place through CEWIT. Other initiatives are in the planning stage through the AERTC.

5. Departmental Plans

5.1. Applied Mathematics and Statistics

Overview

The Applied Mathematics and Statistics Department embodies within the mathematical sciences the same selective excellence in attacking critical scientific problems as is central for the University's plans. There is no peer department in terms of the breadth of its excellence. Our department includes biostatistics, high-performance computing, computational biology, computational geometry, energy modeling, and quantitative finance, all areas of importance to the University and the region. Interactions among these different areas makes the whole stronger than the sum of its distinguished parts. Each of our 20 faculty make significant contributions in multiple areas of applications through collaborations with Applied Math colleagues and with researchers in other Stony Brook departments and outside organizations.

Achieving our goals for the coming decade will require the addition of faculty lines in bio-informatics-related, energy and smart grid-related and quantitative finance-related fields, participation in center of excellence in computational science and engineering, and staff positions to support program growth and related computational requirements.

Research

Expenditures totalling $3.7 million last year will more than double as a result of the new initiatives described here.

Biomedical Modeling. The goal is to advance critical areas of biomedical research using biostatistics, biomedical informatics, and computational methods, in collaboration swith Medical School faculty and other researchers across campus. This effort will include systems biology, computational molecular biology, drug design, visual data mining and community health surveillance.

Applied Mathematics faculty have been called upon to oversee the biostatistics analysis for large clinical trials and other major research studies at leading New York City medical centers. They are eager to help design and support more such studies at Stony Brook. Our biostatisticians are also positioned to play a leading role in problems in biomedical informatics, especially imaging informatics, where our distinguished computational geometers also have a role to play. Bioinformatics research is discussed more fully above (Section 2.1. Research: Biomedicine and Engineering).

Computation is the only method to dissect specific energetic and structural components

that contribute most to, and best describe, many experimentally observed phenomena in biology. Our computational biologists are collaborating with biomedical researchers in the development of the Laufer Center for Computational Biology and Genome Sciences and the Institute for Chemical Biology and Drug Discovery to help Stony Brook build the critical mass of scientists needed to secure NIH Centers in these areas. Computational methods will better quantify, understand, and predict atomic-level molecular recognition. This key goal has a great potential to save billions of dollars in drug development costs, to reduce the time associated with bringing clinically useful medicines to market, and through studies of viral mutation probabilities, to develop pharmaceuticals with improved "drug resistance" properties.

High Performance Computing. High performance computing is becoming a necessary component of cutting-edge research in many areas of engineering and science. The Applied Mathematics Department is a leader in high-performance computing and, as discussed above (Section 2.4.), will collaborate with faculty across CEAS to help them incorporate high-performance computing in their research from drug design to materials design and defense applications.

Computational science research within the department spans a scale ranging from atomistic to continuum matter. On the micro-scale, scalable methods for the density functional theory will be developed for the support of quantum chemistry and nanoscience. Algorithms for molecular dynamics will impact computational biology programs. Pseudo-particle methods will support computations at meso-scale, and algorithms for multiphase systems will improve continuum simulations of complex systems. In energy research (discussed below), high performance computing is central to studies of the Smart Grid, renewable energy sources and nuclear fission and fusion. Research will be performed in collaboration with the Advanced Energy Center, New York Center for Computational Sciences, BNL Center for Functional Nanomaterials, and the joint SBU-BNL Center for Accelerator Science and Education.

Energy and the Smart Grid. Operations research, computational mathematics, and statistical groups in Applied Mathematics will expand their energy research programs, including renewable energy sources. Algorithms and software will be used for Smart Grid modeling and optimization, large scale simulations of processes occurring in new generation nuclear power plants, new ideas of magneto-inertial fusion hybrids, and renewable energy sources. Research projects will be conducted jointly with the Advanced Energy Center, New York Center for Computational Sciences, and the Sensor CAT. These projects will attract significant federal, state, and industrial funds, and have significant scientific, technological, and industrial impact at the regional, national, and international levels. The ongoing energy research cooperation with BNL and IBM will continue to grow.

Quantitative Finance. One of the founders of this discipline recently observed that it has evolved over the last 15 years "to the point where it's really applied math." The department's Center for Quantitative Finance will build a high-quality, high-visibility teaching and research program in quantitative finance. A unique feature of this program will be its focus on systematic trading and alpha generation, along with risk management. This effort will initially be built around four Applied Mathematics faculty who have extensive experience on Wall Street. The Center will have associated with it a quantitative hedge fund that the students will help run. To enhance the visibility of the program and serve the regional community, the Center for Quantitative Finance will run a series of executive short courses for the finance community.

The goal is for Stony Brook to become known as one of the world's leading centers for quantitative finance. We expect graduates of the program to be in high demand by hedge funds, proprietary trading desks, and risk management groups. Some will start their own local businesses with support from the Center. Anchored by Renaissance Technologies and with additional hedge funds formed by former Renaissance Technologies employees and graduates of our Center for Quantitative Finance, Stony Brook will become another "Greenwich" in the hedge fund world.

Education

Stony Brook graduates the highest percentage of mathematics majors, mostly in Applied Mathematics (who numbered 287 undergraduates last year), of any U.S. public university. Innovative educational efforts have brought millions of dollars in federal funding to the campus over the past 15 years. In the future, the department plans to expand educational projects by collaborating with other CEAS departments in multidisciplinary undergraduate STEM grants. Prof. Tucker will continue to play a leading role in national initiatives to improve U.S. school mathematics instruction.

As described above (please see Section 3.1. on new academic programs, p. 27), this Department will house an innovative, multidisciplinary undergraduate program in Industrial Engineering focusing on the integration of computers, information, and technology to operate and control complex systems, and the dispersion of the principles of lean manufacturing throughout the organization.

Building on the success of the recently initiated graduate track in computational biology, a new Graduate Program in Biomedical Informatics will be established. This multidisciplinary effort is discussed in Section 3.1. (above, pp. 27-28); Applied Math will play a major role in this program. Graduate Assistance in Areas of National Need fellowships and a training grant in computational biology will be sought to support this program, which will enlarge our current graduate student population of 209 (AY 2009).

Outreach and Transformation

Applied Mathematics faculty maintain a number of research collaborations with local industry, most notably the Smart Grid initiative with LIPA. Two areas planned for

major increases of industrial outreach are: energy, working through the AERTC on diverse studies for LIPA; and high performance computing, where we will assist efforts of New York companies to use the NYCCS Blue Gene to maintain their technological edge.

Other outreach activities include a hedge fund incubator proposed by the Center of Quantitative Finance to help financial entrepreneurs launch new hedge funds on Long Island; and biostatistical collaborations with Medical School faculty on clinical and regional health care studies, which should increase with the growth of the Medical School.

5.2. Biomedical Engineering

Overview

The Department of Biomedical Engineering was established in December 2000, jointly underwritten by the College and the School of Medicine (SOM), and facilitated by awards from the Whitaker Foundation. The mission of the Department is to integrate the cutting edge of engineering and physical sciences with state-of-the-art biology to advance our understanding of biomedical problems, and to use that science to drive the development of therapeutics, diagnostics and medical devices.

The BME Department has grown rapidly to 16 core faculty, with research expenditures exceeding $6M per year, and a student body of approximately 260 students (35% graduate, 65% undergraduate). Areas of research expertise include biomechanics, bioelectricity, tissue engineering, bioinstrumentation, cell and molecular bioengineering, bioimaging, nanobiotechnology, and biomaterials. The department has secured a wide range of intellectual property rights in these areas and faculty have served as principals in the start-up of several medical device companies.

This past year BME opened the STAR Center for Biomolecular Diagnostics and Therapeutics, a 27,000 GSF building funded largely by a grant from the New York Science, Technology and Innovation Foundation (NYSTAR). Several faculty members have research laboratories in the Health Sciences Center to facilitate translational biomedical research collaborations with faculty in the School of Medicine. A comprehensive description of the department and its research and education programs may be found at: www.bme.sunysb.edu.

Fulfilling BME's goals will require expanding the core faculty, with focus in areas of translational research (e.g., cancer detection and therapeutics, regenerative medicine) and bioimaging, to further strengthen ties to the School of Medicine, Cold Spring Harbor Laboratory, and Brookhaven National Laboratory. We anticipate a growth in class size through expansion of bioimaging, bioinformatics, and biotechnology educational programs. We aim to exceed $10M in annual

research expenditures by 2020, and to secure at least one training grant (e.g., bioimaging) and one program project grant (e.g., musculoskeletal bioengineering).

Research

The Department of Biomedical Engineering enjoys strong funding records from diverse granting agencies, including the National Institutes of Health, National Aeronautics and Space Administration, American Heart Association, National Science Foundation, National Space Biomedical Research Institute, US Army, Office of Naval Research, Whitaker Foundation, Coulter Foundation, National Osteoporosis Foundation, NYSTAR and private industry. Looking forward, our department will:

Increase our emphasis on **discovery and securing of intellectual property** in the areas of translational biomedical research and applied science. Areas range from nano-based "theranostics" for cancer, to medical devices for the treatment of obesity and diabetes. A broad portfolio of intellectual property will promote opportunities for licensing, commercialization and company formation, and will catalyze collaborations with clinical departments within the School of Medicine, the bioscience and bioengineering industries, and create a revenue stream back to the department, college and university. These multidisciplinary, cross-college collaborations will also strengthen future proposals for translational biomedical research (e.g., CTSA to NIH).

Establish a **Bioimaging Institute** to develop and implement a research and education focus in imaging biological structures as part of a university-wide initiative, and in alliance with strategic partners (e.g., CSHL and BNL). Hiring a BI Director with an exemplary history of multidisciplinary funding in bioimaging will be the first priority.

Enhance **multidisciplinary research** and promote **clinical collaborations** through increased programmatic funding and translational research. Our goals include Bioengineering Research Partnerships, training programs (e.g., T-32), and PPG grants from NIH and other funding agencies.

Education

The BME faculty has developed challenging, rigorous, and compelling programs in the integrated discipline of biomedical engineering. Areas of specialization are offered in biomechanics and biomaterials, bioelectricity and medical imaging, and cellular and molecular bioengineering. In developing curricula, the department accepted the charge put forth by the National Academy of Sciences to prepare students as entrepreneurial leaders in academia, medicine, industry or government, in part by fostering multidisciplinary interactions. We will develop two new educational programs, Bioimaging and Biotechnology, to facilitate such collaboration.

Bioimaging: We are in the initial stages of developing a unique graduate program in bioimaging, crossing time and length scales, that will build on the great strengths in CEAS and the School of Medicine, and bridge to Brookhaven National Laboratory. In addition, a specialization in bioimaging will be optional in some graduate programs

and some of the courses will be cross-listed for upper level undergraduates with an interest in imaging biologic systems. This educational initiative will also cultivate multidisciplinary interaction by introducing graduate students, particularly those who otherwise might study solely in the physical sciences or engineering, to the challenges that lie at the convergence of biology, physics, chemistry, engineering and computational sciences.

Biotechnology: External advisory boards emphasize that industry and government regulators need graduates who understand the science, policy and business of the bio-based field. Responding to that need, we will offer a unique curriculum in medical biotechnology, ranging from recombinant technologies and bioprocessing to regulatory affairs and intellectual property. Initially, these will be supplemental courses, but our goal is to join the handful of institutions across the country offering graduate degrees in biotechnology.

Outreach and Transformation

Outreach serves three purposes: to provide SBU students with hands-on experience, to enhance educational opportunities for students in the local community, and to recruit students to SBU. Our department engages in each of these activities.

Industry-based outreach. Industry internships for current BME students provide invaluable hands-on learning experiences. Students may earn academic credit through BME 475, Industry Internship, or may collect a stipend paid by the industry. The Center for Biotechnology has facilitated internships with Pall Corporation, OSI Pharmaceuticals and Nanoprobes, Inc.

Education-based outreach. BME faculty share their experience and expertise in the local community through activities such as judging at science fairs and describing their research to student groups. Several BME faculty host high school students in their laboratories during the summer and many of these mentored students have progressed to the INTEL competition.

Recruitment-based outreach. BME undergraduate students may volunteer as ambassadors to their hometown high schools, acting as informal recruiters. They speak to science and math classes and provide an informal view of college life and the BME major.

5.3. Computer Science

Overview

The Department of Computer Science (CS) is ranked in the top 10% of research CS departments nationally. The Department plans to continue to excel in great creativity and innovation in CS research, education, outreach, and community and economic development. The Department plans to continue to excel in great creativity and innovation in CS research, education, outreach, and community and economic development. As the computer significantly

impacts every aspect of our lives and plays a key role in every research discipline, CS is in the best position in the University for interdisciplinary collaboration with every single department at Stony Brook, while being the primary force in advancing the future of software and hardware technologies. The Department boasts internationally distinguished faculty who have made significant contributions to the state of the art in CS and to multidisciplinary research and have been awarded the highest levels of recognition. The Department plans significant growth in research funding, faculty size, and graduate and undergraduate majors both in CS and Information Systems (IS).

Research

The Department's research strength is in computer systems and networks, cyber security, visual computing, algorithms, concurrency and verification, and intelligent computing – including applied logic and information systems. The Department is significantly resourceful in two of these disciplines, where it runs very successful centers: the Center for Cyber Security and the Center for Visual Computing. The Department is also the founding and foremost player in the New York State Center of Excellence in Wireless and Information Technology (CEWIT). In the next decade, CS plans to solidify its core strengths and complement them in the directions of strategic importance and greatest impact to the broader computing and engineering communities, to the University and to SUNY, and will play a major role in all CEAS initiatives in *computing, biomedicine*, and *energy*. The planned directions of major research effort are cyber security, intelligent and interactive computing, biomedical computing and IT, and smart energy and green computing. These directly address three of the NAE's grand challenges for engineering, Secure cyberspace, Advance health informatics, and Enhance virtual reality, and will contribute to six others from solar energy to medicine to scientific discovery.

Cyber-Security. Generating, processing, transmitting and consuming digital data regulate virtually every aspect of modern life. Thus, securing the systems that perform all these functions from attack and keeping the data private is critical. The complexity of this issue will continue to grow as computers become more embedded in our physical space, data is generated automatically from sensors, and wireless communications become pervasive. CS has a very strong group in cyber security and related areas. Our plan is to strengthen our cyber security group further, to complement it in networking, distributed/cloud computing and dependable systems, and to expand it in the critical applications of health informatics and smart grid.

Intelligent and Interactive Computing. It is widely anticipated that three issues will be critical to computing in the coming decade. First, computers have to deal with a deluge of data coming from disparate sources, including sensors and the web. Second, humans will interact with computers using more natural interfaces. Third, computers will be pervasively embedded in the physical space. Thus,

disciplines such as artificial intelligence (AI) and machine learning, human computer interfaces and virtual reality, embedded and pervasive computing will grow in importance. CS has a very strong presence in visual computing and small but growing AI and sensor/wireless network groups. These strengths will be supplemented by growth in the above areas. This effort will nicely complement the established CEAS focus, pushed along by the Department's and the College's tight linkages to CEWIT, on IT and Smart Environments.

Biomedical Computing and IT. In no area of human life does the use of computers and processing of information make a greater impact than in biomedicine and healthcare. The department has a long tradition of multidisciplinary research in this direction, including medical imaging, visualization of medical data, computational biology, modeling of biological systems, pervasive computing in health care, mining and security of medical data. CS will pursue these multidisciplinary efforts in tune with the CEAS thematic research emphasis on Biomedicine/ Healthcare and Engineering. Several of our existing strengths will be critical in this endeavor. For example, we will play a key role in the establishment of the Bioimaging Institute as the leading department in visual computing. Similarly, our strength in information systems, algorithms, computational biology, cyber-security, verification, AI, and wireless networking will play a primary role in the Biomedical Informatics aspect of Biomedicine/ Healthcare and Engineering.

Smart Energy and Green Computing. The discipline of computing has a critical place in the nation's energy future. Stony Brook is a key partner in the Smart Grid Demonstration Project with LIPA and the department is heavily involved in Smart Grid initiatives, capitalizing on its strengths in cyber security, sensors and wireless networking, AI and user interfaces. CS will build on these involvements and other capacities to play a leading role in the CEAS Smart Grid and Renewable Energy research initiative. These activities are already making the department a key resource for the AERTC. In addition, we will leverage our existing strengths in computer systems to perform new research to address the Catch-22 of the computing-energy relationship and develop architectures and systems to make computing platforms themselves more energy efficient.

Education

CS enrollments nationwide have fluctuated in the past decade. While CS enrollments at Stony Brook reflected this overall trend, the Department has experienced renewed and accelerating growth in the last three years. CS is now the largest CEAS undergraduate program with 377 declared majors last year, as well as 298 graduate students. These numbers are expected to rise steadily throughout the next decade. The growing breadth of CS and its emergence as a foundational field for many if not most disciplines have prompted a revision of the CS program and development of tracks in key areas to provide more flexibility for students to apply

their skills in multidisciplinary contexts. We plan to expand our existing specializations in information assurance, human-computer interaction, and game programming and introduce new ones in intelligent computing, virtual reality, and medical imaging.

In 2008 the department reconceived more broadly its undergraduate concentration in Information Systems (IS) and reformed it as an inherently multidisciplinary curriculum focused on the use and application of computers rather than programming. The traditional specialization limited to business IS was augmented with new application areas in psychology and technological systems management. We plan to add specializations in digital media, medical informatics, social networks, and numerous others. The new IS major has met with a very favorable response from students: the number of declared IS majors has grown by 75% since 2007. We worked with the College to develop a plan to respond to this current and foreseeable demand, and will be establishing Information systems as a separate department in a School of Computing within CEAS which will serve as an umbrella for all CEAS computing and IT education and research programs, including but not limited to the CS and IS departments.

The CS graduate program is the largest on campus and in the past few years has seen increases in enrollment, especially at the M.S. level. Although our graduate programs remain in high demand, the growth of the Ph.D. program is lagging behind the increase in our research funding. In the next decade we will focus on growing our Ph.D. program, aggressively recruiting higher-tier applicants while also increasing the proportion of under-represented and domestic students in our programs. We believe that the new graduate programs we plan to establish in intelligent computing, interactive computing, medical informatics and bioinformatics, and in biomedical imaging, and the primary role we expect to have in CEAS initiatives in these areas, will help us to achieve these important educational goals.

Outreach and Transformation

CS faculty and students have in excess of 100 research collaborations and industrial internships with local, national and international companies, from several successful startup companies founded on the strength of CS research at Stony Brook to Fortune 500 companies. Members of our department form the largest contingents of Stony Brook faculty involved in the industry interactions fostered by CEWIT and SPIR. Further increases in industrial interaction, technology transfer and student internships and employment opportunities are anticipated through CEWIT, its new affiliate CEWIT-Korea, SPIR and other avenues. CS faculty already collaborate with researchers throughout the College, the university and beyond. We plan to expand substantially CS interdisciplinary collaboration to practically all departments and research centers at Stony Brook, focusing particularly on areas

in biomedical computing and IT (through the medical school, the life sciences departments in the College of Arts and Sciences, and other departments in CEAS) as well as smart energy and green computing (though the AERTC among other vehicles).

5.4. Electrical and Computer Engineering

Overview

The Department of Electrical and Computer Engineering at Stony Brook is a top-ranking department with a strong commitment to teaching and research. With more than 20 full-time faculty members within the department, we have made significant contributions in multiple areas of expertise through collaborations both within the College and Internationally.

Research

The Department's leading research programs include: optoelectronics, semiconductor devices, sensors, biophotonics, VLSI and mixed-signal IC design, advanced parallel systems design and analysis, telecommunications, signal processing, and network theory. The areas of particular research emphasis are:

Semiconductor Optoelectronics and Photonics. Recently, we established an exceptionally strong nationally recognized group focusing on the innovative design of semiconductor lasers. We shall build on this strength in collaboration with a number of industrial partners. Over the next three to five years we shall see the emergence of a nationally recognized center at Stony Brook specializing in infrared optoelectronics and photonics with the primary focus areas in long wavelength semiconductor laser and detectors, as well as semiconductor scintillators for gamma radiation detection.

Sensor Systems. Sensor systems engineering has been an exceptionally successful area of research in the last several years. This research has led to dramatic technical innovations that offer a many-fold reduction in the cost of DNA sequencing due to reduced reagents consumption and unprecedented parallelism. With generous funding from federal and industrial sources, leveraged by the Sensor CAT, Stony Brook has assembled an exceptional ECE technical team working on the development of DNA instrumentation. Another strong ECE team at the Sensor CAT works on gamma radiation detectors for homeland security applications.

Parallel Systems. Parallel systems design and analysis research will emphasize ultra-high speed processor design with new non-silicon technologies such as superconductors and parallel architectures for petaflops-scale computing.

Telecommunications. Telecommunications research will focus on networking, parallel processing, e-commerce, mobile

agents, multicasting communication, quality of service, optical networks, wireless networks, and wireless ATM. Our research in multicast communications will emphasize predictable quality-of-service (guaranteed multicast latency and bandwidth). Optical networks, expected to be the backbone for the next generation of Internet, will be addressed.

Space remains the critical and limiting unresolved issue. Our current facilities are spread over three buildings and for most programs are totally inadequate. These constraints on our research programs will be partially resolved through the planned construction of Device Fabrication and Device Growth Facilities to allow fabrication of semiconductor lasers that operate across a wide spectral range at room temperatures. These laser sources will be important in such areas as free space communication, gas detection devices for environmental monitoring, control of manufacturing processes, combustion diagnostics, and numerous medical applications for diagnostics and treatment.

To capitalize on the strengths of our basic research activities in a fiscal environment that will continue to be tight, we intend to recruit research faculty to form team-oriented research centers for solving complex real world problems as well to support basic research efforts. In addition, we plan to increase global research cooperation in order to increase the visibility of the department internationally as well as to strengthen our research programs. We are currently engaged in international collaboration with several Korean universities and research institutes, and we intend to expand this work further through CEWIT-Korea.

Education

The Department has ABET-accredited programs in Electrical Engineering and Computer Engineering. Strengthening both programs, while maintaining their synergy, is the central educational goal of the department.

An optional five-year undergraduate program produces master's-level professionals. The program teaches a basic understanding of critical issues of the discipline, while providing the depth at the same time. We intend to strengthen laboratory facilities. In particular, we plan to establish an electrical shop that enables students to implement and test prototypes of their design using current technology to manufacture and test printed circuit boards, as well as computers with data acquisition hardware. We will provide a world class laboratory experience.

We will continue the development of a modern curriculum that prepares our students for entry-level positions in industry, with emphasis on the design and implementation of engineering systems and devices. At the same time, our program should strive to stimulate better citizenship through humanistic and ethical studies and interaction with people in diverse academic and corporate settings.

The recruitment of a large number of high-quality doctoral students is the most important issue for our graduate program; our goal is to more than double enrollment to reach the range of 60 to 100 Ph.D. students before the end of the coming

decade. Several issues will be addressed in a dramatic fashion to improve our graduate education. To finance an incoming class of 15 to 25 Ph.D. students each year, we will seek a significant expansion of our industrial scholarship base. These funds will be supplemented with SBU resources in the form of TA positions, while faculty research funds will support students in the following years. We intend to enlarge and enhance graduate student workspaces, particularly for the larger number of doctoral candidates we anticipate supporting, to enable them to perform at the top of their capacities. To help us teach our graduate students to obtain solutions for the real world, and to increase our attractiveness to industrial scholarship sources, we plan to introduce additional graduate offerings in Computer Engineering. New York's downstate region is home to almost 60% of the state's information technology companies and half of the IT workforce, and the computing paradigm shift has accelerated from mainframe to desktop to mobile to SaaS, cloud and embedded systems. We have identified substantial unmet demand for graduate work to enable experienced and highly knowledgeable engineers keep up in this rapidly changing field. To meet this demand and to serve regional industry, we plan to expand both our graduate certificate and our master's degree programs in computer engineering.

The department received its second NSF Partnerships for Innovation award last year and has added a lower division Engineering Entrepreneurship course to discover and encourage entrepreneurship in our students.

Outreach and Transformation

Electrical and Computer Engineering faculty maintain a number of research collaborations with local industry through the Sensor CAT, SPIR and other connections. Projects initiated by department faculty have become new ventures housed in the CEWIT incubator. Other outreach activities include supervision of Long Island high school students in national science competitions.

5.5. Materials Science and Engineering

Overview

The Department of Materials Science and Engineering at Stony Brook is committed to providing comprehensive undergraduate and graduate education of the highest quality while carrying out Materials Science research at the cutting edge of the discipline, tackling grand challenge problems that will result in the design and implementation of the next generation of materials systems.

Research programs in the Department of Materials Science and Engineering (MSE) focus on the engineering and scientific aspects of the structure, properties, processing (including synthesis and manufacturing) and performance (application) of materials. Computational materials science is also a growing area of research for the department. Research is being carried out into:

- Developing novel materials and processes;
- Understanding the behavior and properties of existing materials;
- Selecting materials to design functional components.

Our research is interdisciplinary in nature and runs the gamut of all types of materials —biomaterials, ceramics, electronic materials, glasses, metals, minerals, and polymers—and their composites. Many of these programs also involve multi-investigators and close collaboration with other disciplines.

In this plan we will focus on four areas of research judged to have the greatest impact: Thermal Spray Coatings Research, Environmental Materials, Materials for Energy Applications, and Biomaterials.

Research

Thermal Spray Coatings. The Center for Thermal Spray Research (CTSR) at Stony Brook was established in 1996 through the NSF Materials Research Science and Engineering Centers program. Since its inception, CTSR has been at the heart of a number of exciting fundamental science and applied engineering initiatives to enhance the scientific base of thermal spray (TS) coating technology. TS technology continues to grow and services a broad industrial community; coatings are ubiquitous in gas turbine engines (propulsion and energy), automotive, pulp/paper, and infrastructure maintenance. Emerging applications include coatings for orthopedic and dental implants, solid oxide fuel cells, and functional sensors for harsh environments. CTSR's research philosophy is based on an integrated and interdisciplinary approach to thermal spray process and materials R&D, along with multi-level education, addressing problems that are both of fundamental and practical engineering importance. The Center seeks to link research to practice to enable: implementation of thermal spray coatings into the design cycle; utilization of robust processing methodologies; and simple, yet

scientifically based, characterization and property measurement tooling.

Environmental Materials. The Department has faculty involved in the Consortium for Inter-Disciplinary Environmental Research (CIDER), a University-wide initiative undertaken to bring together the many faculty at the university from diverse disciplines, housed in many departments, to create synergistic collaborations that could address large, complex environmental issues. The focus of our research in this area is the development of novel materials for environmental and related energy applications. We are particularly interested in designing nanoparticles and nanostructures to use as catalysts for various environmentally relevant oxidation and reduction reactions. We are also interested in the application of surface science techniques to study catalytic interfaces. Other faculty have interests in the area of "green chemical engineering," a rapidly growing field deemed to be indispensable for the 21st century. In order to put the concept into practice, faculty are focusing on environmentally-friendly nanofabrication of polymer surfaces by using supercritical carbon dioxide.

Materials for Energy Applications. In order to meet the challenges of producing the next generation of materials required for energy production, faculty plans to focus on the following four initiatives and work closely with the AERTC: *Low Carbon Systems (LCS)*. Focus on renewable hybrid sources such as Solar-Biomass to produce renewable energy on demand or synthesize renewable fuels for transportation. *Imaging*. Develop *in situ* imaging to provide a powerful tool to establish dynamic behavior of materials that can help develop high-density renewable energy technologies using a hybrid approach. Such a tool will provide a molecular-level understanding of systems from nano to meso scales.; *System Engineering*. Contribute to the development of distributive energy production systems. While distributive energy production systems can reduce our carbon footprint, in order to engineer such systems it is necessary to achieve economies of scale." This requires development of materials that can simplify system engineering. *Materials for "Smart Grid" Implementation.* Currently, power devices used for "Smart Grids" are all implemented in conventional silicon-based semiconductor technology. Recent theoretical studies have shown that SiC power devices will greatly outperform silicon power devices and these devices are therefore expected to drastically improve the distribution and efficient usage of electric power in the 21st century. Faculty in the Department are working closely with industry to enable this next generation of power electronics by facilitating the optimization of the SiC crystal growth process. This work involves research carried out by faculty at the National Synchrotron Light Source and at the Center for Functional Nanomaterials at Brookhaven National Laboratory.

Biomaterials. As the need grows for the development of non-petroleum based plastics, the design of novel, functional biomimetic materials for tissue engineering

and drug delivery is an area of great interest to the Department. Modification of the physical and chemical characteristics of materials surface can influence initial cell adhesion, spreading, migration, proliferation, and gene expression. Materials Science and Engineering faculty have expertise in rheology of biopolymers, micro- and nano-fabrication, microscopy, and cell biology. Currently, investigations are being carried out of cell-surface phenomena on synthetic micropatterned polymers as well as biodegradable nanocomposite materials. The multidisciplinary nature of biomaterials research fosters collaboration with other departments across the Stony Brook campus (Biomedical Engineering, Mechanical Engineering, Physics and Astronomy) and also at Brookhaven National Laboratory (National Synchrotron Light Source, Center for Functional Nanomaterials).

Education

With 230 students, enrollment in the CEAS undergraduate program in Engineering Science reached an all-time high in 2009-10. A major new thrust going forward will be the planned offering of a new undergraduate major in Materials Engineering developed on the foundation of the materials-related areas of specialization in our current Engineering Science Program. This new program will respond to the national upsurge of interest in materials. The program is expected to run in parallel to the existing Engineering Science Program. Our faculty gives Engineering Science undergraduate students every opportunity to become involved with current research projects. Undergraduate research is also promoted by the existence of NSF-sponsored university undergraduate research opportunities. As a result, approximately 40% of our undergraduates engage in research activities through research courses, fellowships, research internships employment, voluntary participation, research grants, or REU supplements to faculty grants.

Outreach and Transformation

Faculty have active research collaborations with industry partners. In the CSTR, such collaborations have been formalized in the Consortium on Thermal Spray Research, involving 26 fee-paying company members in a forum and vehicle for dissemination of research results and initiatives at CTSR and collaborative discussions among the consortium members. Complementary funding has been received from NSF and DoD to support CTSR/Consortium research activities.

Our faculty participates actively in educational outreach programs. The Garcia Summer Scholars program involves high school teachers, graduate and undergraduate students in a program that introduces high school students to research in order to improve the enrollment and retention of domestic students in science and engineering. High school students in this program have gone on to win Siemens, Intel and Westinghouse fellowships. The program also contains within it a Research Experience of Teachers component, where high school

science teachers are encouraged to perform research in the Department. Many faculty from the Department also take part in an annual Open House in which high schools across the New York metropolitan area are invited to participate in a day of experiments, talks and hands-on projects.

5.6. Mechanical Engineering

Overview

The overall research and educational theme of the Department's ten-year plan is to improve quality of life and to promote energy sustainability as summarized in the NAE's Grand Challenges. As will become apparent, the initiatives we are planning will help us fulfill the strategic plan goals of the campus and SUNY. We currently have 16 tenured and tenure-track faculty members approximately equally divided among three specializations: Solid Mechanics, Thermal and Fluid Mechanics, and Design and Manufacturing. To achieve the goals outlined here, we will need to increase faculty size in the next ten years. One of the most exciting initiatives will be the launch of a new Civil Engineering program, initially housed in our department, which has been approved by the State Education Department and anticipates admitting its first students in the fall of 2012. At this early point, additional faculty members will be required to support the program. We plan to add faculty gradually to the Civil Engineering program to reach a number by the end of the ten-year period that will enable the program to become an independent department at that time.

Research

The core research competency of the Department rests in three specialized groups: thermal/fluid, design and manufacturing, and solid mechanics. The paragraphs below briefly summarize the aspirations of each specialized group while demonstrating our intent to maintain the cohesiveness of the entire department and promote synergistic research among the groups, in the College, and across the university.

Thermal/Fluid Group We propose the following research emphases: *Nanotechnology and Biotechnology*, comprising microfluidics, nano- and micro-scale fluid dynamics, micro-channel heat sink, biological fluid dynamics, statistical mechanics, laser-material interactions, photonics, drug delivery engineering, bio-magnetic separation and functional designer fluids; *Power and Propulsion,* including turbulent flow, flow control, combustion and advanced combustion design, and internal combustion engines; and *Sustainability Science and System Based Technologies*, which includes energy technologies, battery storage, solar thermal technologies, solar

photovoltaic technologies, wind technologies, building energy dynamics, passive solar buildings, life-cycle analysis of engineering products and activities, water resource and desalination technology, entropy balance of ecosystems and the conservation of natural ecosystems, as well as urban and transportation system development based on the theory of transect.

Design and Manufacturing Group

Since the passage of the Americans with Disabilities Act (ADA) two decades ago, an industry has emerged to provide products and services to aid disabled persons and support their inclusion and integration into every aspect of our society. The growing demand for such products and devices has been enlarged significantly by the escalation of aging populations in the world's industrialized countries, where the numbers of people with age-related disabilities are increasing. In parallel with these developments, the past two decades have witnessed a convergence of informatics and telecommunications with more traditional technologies for the integration of computers and robotics in the industrial production process and for automatic and intelligent control systems generally. This convergence of technologies now presents a great opportunity to bridge the gap between the traditional, production-centric robotics and automation technologies and next-generation, human-centric technologies for service-oriented industries to improve the quality of life not only for the disabled but for everyone. Enabling technologies for better quality of life could include service and medical robotics, haptics and VR technologies, human-friendly mechatronics, human-centric design, intelligent sensors and controls, intelligent fault detection and diagnosis, intelligent assistive technologies, and energy harvesting technologies. The major research areas we propose, which align with College-wide, university and SUNY priorities, are human centered design of machines and devices, intelligent sensors and controls, energy harvesting devices, and biomedical devices.

Solid Mechanics Group The main objective of the solid mechanics group is to establish a comprehensive team with a unique capability to study biological tissues and soft active materials from experimental, computational and theoretical points of view across relevant length and timescales. The ultimate objective is not only to generate much needed fundamental knowledge about these materials, but also to use this knowledge to guide the cure of disease and material design for smart biomedical as well as smart energy devices. This compound objective serves the goals of the Department and the College – and the University and SUNY – in connection with the biomedical/healthcare and energy themes and the improvement of quality of life for all. The group's critical mass of expertise will constitute a strong base on which to secure funding, as federal and state priorities over the next ten years are expected to grow steadily in these two areas. We have defined these specific areas of research: *Biological Tissues* - Fundamental studies at nano-, micro-, and macro-length scales of soft

biological tissues (focusing on cancer tissues, wounded tissue and its healing mechanisms, tissues involved in csardiovascular disease, etc.), hard biological tissues (bones and dental materials), and biomimetic material design; *Soft Active Materials* - Fundamental studies at nano-, micro-, and macro-length scales of shape-memory polymers, gels, electroactive polymers, and material design for biomedical devices (e.g., biodegradable self-tightening sutures, stents, scaffolds, etc.), lightweight multifunctional structures for automotive and textile industries (e.g., self-repairing bumpers, coatings, smart clothing, etc.), and lightweight multifunctional structures for military and aerospace applications (energy harvesting materials, self-deployable structures, morphing wings, etc.).

Education

The most recent report of the American Society of Mechanical Engineers (ASME) Vision 2030 Task Force on the mechanical engineering curriculum of the 21st century indicated that major changes need to be made to prepare students for the demands of biomedicine, nanoscience and nanotechnology, information technology, and multidisciplinary involvement generally, and that students need to have practical experience taking apart "something substantial" and putting it back together again to enable them to transfer their engineering knowledge to practical problem-solving. The faculty looks forward to adapting the content of existing courses to address these needs. Our other major curricular innovation will involve collaborating with the College of Business to respond to the urging of the NAE President last year that the future engineer must be entrepreneurial and innovative. The Department will collaborate with the COB to incorporate these elements into our capstone senior design course.

We believe strongly in the learning community as an effective educational tool. Our department has very active student clubs. Stony Brook Motorsports has brought national recognition to Stony Brook through its high ranking in the Baja SAE – truly exceptional for an institution without an automotive engineering program; the solar boat club made a nationally noted Solar Splash; and the robotics club also competes at the national level. Students in these clubs work together, study together and socialize together, acquiring skills that cannot be learned in a traditional classroom setting. Our goal is to continue promoting these activities and support the students as much as we can.

Outreach and Transformation

As noted in the College-wide section on education (please see above beginning on p. 25), our department has taken a leadership role in reaching out to local communities by working on the FIRST Robotics Competition and the Long Island Junior Science and Humanities Symposium. We intend to continue these activities and expand the University's involvement by soliciting additional participation within and outside the College.

5.7. Technology and Society

Overview

Thirty years ago, the Department of Technology and Society (DTS) was established to address the issues that arise from the intersection of technological development and societal changes. In its early years, DTS rapidly became a leader in the national thrust to enhance students' understanding of the socio-technological interplay that demands a consideration of scientific, social, political, economic, behavioral, legal, and ethical aspects of problems. Today, what we do is at the forefront of recent advances in our nation's thinking about "holistic engineering education" – the emphasis on bringing the understanding of technology to the social realm (including policy decisions), and taking knowledge of social issues and social impacts and using such understanding to make technologies that better serve society. In this socio-technological realm, DTS plays a role that no other CEAS department, and no other department at Stony Brook, can play. Over the last few years, the addition of faculty members together with the initiation of our Ph.D. program in Technology, Policy, and Innovation (TPI), has energized our department and provided the intellectual focus for 2020 and beyond. The interaction of technology, policy, and innovation will be at the core of our intellectual activities, tying together undergraduate and graduate academic programs and faculty scholarship.

We are now in the second year of the TPI program. There are a very small number of similar doctoral programs in the world. The most successful ones include the Engineering and Public Policy Program (EPP) at Carnegie Mellon, the Technology and Policy Program (Ph.D. in Technology, Management, and Policy) at MIT, the Department of Management Science and Engineering at Stanford, and the Systems Engineering and Policy Analysis Program at the Delft University of Technology in the Netherlands. Some of the research areas for TPI overlap those of the similar doctoral programs; however, TPI differs from the other programs in two major ways: greater inclusion of aspects of education, and stronger emphasis on the interplay among technology, policy, and innovation—including studies on technological innovation (development and diffusion). In particular, TPI has two major dimensions: 1) theory, methodology, and study of the practice of TPI, and 2) applications of TPI, including energy and environmental systems, policy and leadership for STEM education and educational technology, and studies in technological innovation. Hence, TPI provides both a platform that can support others as they engage in interdisciplinary scholarship and active working groups on critical interdisciplinary applications where the technical details matter. As such, TPI will be a valuable force within CEAS and a force for linking CEAS to the broader

university campus. We are already exploring the potential for linking to Health Sciences to build a TPI group on health policy and health technology.

In all of our efforts, we will build on the extraordinary success that we have had in attracting external funding for our projects. In fact, given that our research thrusts (energy and environment, STEM education, educational technology, and the promise of a TPI group on health issues) are aligned with national and global priorities, the prospects for growing external funding are strong. In addition to attracting governmental and private funding, we are poised to exploit our innovative teaching methods to expand our SUTRA activity – regionally and statewide, nationally and globally.

DTS applies concepts and tools drawn from the natural sciences, engineering, and the social sciences to examine and enhance the relationship between technology and society, both regionally and globally, in three major areas: energy and environmental systems; innovation and policy for STEM (science, technology, engineering, and mathematics) education and educational technology; and technology management, engineering entrepreneurship, and science and technology policy. The alignment of the Department's research with pressing global issues affords unprecedented opportunities for the next decade. During this period, DTS will strengthen its collaborations within CEAS, throughout Stony Brook, and nationally and globally to emerge as a world leader in technology and society.

Research

Energy and Environmental Systems

There are three major research thrusts:

Technology assessments of specific current, emerging, and future energy, environmental, and waste management technologies, materials, products, and policies. These investigations are multidisciplinary and can address some or all of the scientific, engineering, economic, regulatory, environmental, energy, community and societal, military/homeland security, and ethical and policy prospects and impacts – at a variety of scales.

Studies of energy, environmental, and waste management dimensions of important transformative technologies such as nanotechnology, advanced materials, green chemistry, computer and information technology, and biotechnology.

More general theoretical or analytical studies, such as examinations of systems analytical tools such as life-cycle analysis, risk analysis, and waste stream analysis.

Although DTS has fruitful collaborations across CEAS, the University, and Long Island, one of the keys to the department's research future in energy and environmental systems will be its leadership role in the **New York Energy Policy Institute (NYEPI)**

NYEPI, with leadership from DTS and BNL, will establish DTS as an important information source for local, state, and national leaders. The institute will enable DTS to work on the development of innovations in climate change measurement and mitigation, implementation of the smart grid and the creation of a new low carbon society. These areas are of great research interest for other departments in CEAS and other engineering and science departments across our nation and the world.

Innovation in and Policy for STEM Education and Educational Technology. From its inception, educational activities have been an important part of DTS. The department will leverage both its technical focus within CEAS and its recent position as academic home to the Educational Leadership program to offer technically-focused educational programs. DTS will enhance its research efforts in the following areas:

Novel educational applications and their impact on students' learning. Technologies explored may include tangible user interfaces, multi-modal inputs, collaborative learning spaces, computer-supported collaborative work, physical computing, and multiplayer games and simulations. A new research thrust focuses on tying these learning activities to technologies for assessing the impact of these applications on student learning, attitudes, and behaviors, using data generated by the educational applications.

New paradigms for education in engineering and applied sciences. Topics include approaches for effectively teaching engineering and applied sciences, what attracts (or repels) students to science and engineering careers, accessibility issues, and strategies for attracting and retaining a richer diversity of students in engineering and applied sciences.

eLearning. Issues include new teaching and learning paradigms for the medium, technologies for two-way communication and information sharing, and strategies for managing distance learning initiatives. A special interest of faculty is virtual schools, which make primary use of online methods of instruction. We plan to make virtual school research a core strength within DTS.

Informal science education. Questions include how to attract and engage informal learners, how to measure the effectiveness of informal learning in terms of retention and long-term perception, and how different technologies can be used most effectively in various informal learning settings.

Intelligent tutoring. Problems explored include models of knowledge and understanding, the role of intelligent agents in learning systems, and strategies for guiding groups of learners.

Policy studies in educational technologies and education in engineering and applied sciences. Through a collaboration of faculty in STEM education, educational technology, and educational leadership, topics to be explored include assessment of educational technology projects and assessment of educational innovations in engineering and applied sciences.

Technology Management, Science and Technology Policy and Engineering Entrepreneurship. Much of the research in DTS has broad implications for technology management and science and technology policy. Of particular interest to several faculty members is the relationship of technological innovations to science and technology policy. The increasing role of social media and virtual collaboration tools across disciplines in industry, education, and society at large will continue to challenge traditional management, innovation, communication and learning models. The department performs pioneering research in how new technologies and trends impact

outcomes such as innovation, trust, and success. In addition, through the New York Energy Policy Institute and in conjunction with BNL and other partners, DTS will explore technologies and potential policies for the creation of a low carbon society. As an advisor on policy issues where the technical details matter, the next decade will see DTS as a member of an elite group of programs meeting such challenges. In collaboration with colleagues in ECE as well as outside the College, we wish to explore the implications and impacts of new approaches to the education of the next generations of business leaders that are considered "e-school" rather than "b-school," or entrepreneur-oriented rather than traditional business executive-oriented.

Education

In DTS, research and education have been and continue to be inextricably intertwined. We already see that scholarship in TPI will have educational implications well beyond the Ph.D. program. Such scholarship will enhance what we do in our B.S. and M.S. in Technological Systems Management. In our bachelors program, students are required to have a specialization in natural sciences or engineering and applied sciences, and project management and technology assessment courses. Conceptual frameworks and tools derived from TPI will be critical as we enhance the undergraduate major. Furthermore, we are already in the process of reviewing our M.S. program (concentrations in energy and environmental systems, educational technology, and global operations management), with the aims of strengthening the technical foundations, and creating tracks for the global operations management concentration in energy, information technology, and health. Also, we are exploring new collaborations with the College of Business, including the cross listing of some of our M.S. courses with MBA courses. Since non-majors can take many of our undergraduate and graduate courses, our curriculum also supports the development of students' technological understanding – regardless of their primary academic program.

Since so much of the curriculum relates to contemporary socio-technological issues, there are abundant opportunities to engage undergraduate and graduate students (masters and Ph.D.) in faculty research. Furthermore, research and education in DTS are interdisciplinary. Our primary aim for the next decade is to strengthen our collaborations within CEAS and the wider Stony Brook academic community, and with local agencies, nationally, and globally. These partnerships will allow us to build internship programs for our undergraduate and masters students and expand research opportunities for the Ph.D. students in our new doctoral program in Technology, Policy and Innovation. While enhancing the excellence of our programs, we expect to grow our enrollments: undergraduate enrollment from 70 students to 150 students, M.S. (on-campus) enrollments from 70 students to 100 students, and Ph.D. enrollment from 18 students to 40

students. At the same time, we expect to add 100 students to our overseas eLearning (blend of distance and face-to-face) program.

Outreach and Transformation

Through its multidisciplinary approach, DTS is one of the key vehicles by which Stony Brook University collaborates with other universities and colleges, schools, government and industry to tap the critical talent reserves of underrepresented populations. Such collaboration is reflected in nearly all of the department's research and educational programs, including the research thrusts cited above (please see pp. 55-57). In addition to collaborations for research and curricular programs, the department collaborates with multiple agencies as it furthers its national reputation in enhancing diversity in science, technology, engineering, and mathematics (STEM). Under the STEM Smart umbrella:

- Over 400 undergraduate students and over 100 graduate students at Stony Brook alone are served each year through a mix of NSF and New York State-funded programs

- Each year, the total scholarship and fellowship funds for Stony Brook's STEM students exceed $500K.

- Cumulative academic honors for the graduating and continuing NSF undergraduate scholars includes 25 members of Golden Key, 53 students who made Dean's List in the Fall of 2009, and 44 students who were on the Dean's List for the Spring of 2010.

- Stony Brook is the lead institution of the NSF funded SUNY Alliance for Minority Participation (SUNY LSAMP) and Bridge to the Doctorate (BD) . SUNY LSAMP continues to increase student enrollment, degree production and entrance to graduate school. Since 1996, SUNY LSAMP has increased under-represented minority (UREP) science, technology, engineering and mathematics (STEM) enrollment by 330 % and increased UREP STEM bachelor's degrees by 95.4%. Since 2006, we have added five bridge to the Doctorate (BD) programs at Stony Brook and Buffalo. The BD programs at Stony Brook have funded 36 UREP STEM masters and doctoral students from sixteen institutions across the country. Funded by an NSF research grant, we have identified best practices in UREP STEM education that we will be publishing through the ERIC educational clearing house.

- Since the inception of the State University of New York AGEP (Alliance for Graduate Education and the Professoriate) Program in 1999, comprehensive activities and services have been created to broaden access to and success of historically underrepresented minority (URM) students in science, technology, engineering, and mathematics (STEM) doctoral programs. These activities were designed to help students successfully

advance through rigorous curricula via a series of strategic interventions, advocacy, and support with the ultimate goal of transitioning our well trained scientists into the workforce, with an emphasis on careers in the professoriate. Stony Brook has achieved notable success, graduating more URM doctorates (71) than the other three SUNY Centers combined in a ten year period. Moreover, 63% of our graduates have positions in academia. Also, in 11 installments of the the AGEP Summer Research Institute, a total of 116 interns were trained, which has yielded 70% of bachelor's degree recipients entering graduate programs, most at Stony Brook. Perhaps the most significant outcome of the AGEP initiative is the creation of the Center for Inclusive Education which has been a major force in promoting inter-departmental communications and activities to maximize resources and outcomes.