

The College of Physical and Mathematical Sciences has experienced several years of increases in enrollment, research funding and national stature, and our programs are positioned for even greater success. However, budgetary issues prove to be a limiting factor in our continued growth. This report highlights our achievements and challenges.

1. Changes in Service Environment

The College benefits from several trends: the national emphasis on drawing more students into science, technology, engineering and mathematics (STEM) careers; the recognition of climate change; water resources and environmental sustainability as crucial societal concerns; and broad university priorities in health, energy, environment and economic development. Through our many synergies with these trends, the College is helping shape the university's focus on these areas.

Our programs are well-matched to confront global challenges, and are essential partners with NC State's strong engineering and technology programs. However, adequate financial resources have not materialized to support necessary growth in related programs and research, nor the demands of increasing enrollment and competitive recruitment of our students and faculty by other institutions.

The College continued its growth in undergraduate enrollment. Faculty shortages and the need for increased stipends led to a decrease in the number of offers to graduate students in some areas.

This summer, Physics moves into the renovated Riddick Hall, and Marine, Earth and Atmospheric Sciences will occupy a portion of the Jordan Hall expansion. We look forward to the completion of the new Mathematics and Statistics building in 2008.

2. Compact Plan

In previous planning cycles, we built goals around the language of our research tools. Our goals have been modified to frame our initiatives in terms of the societal problems we attack with those tools. These problems, and our goals, are closely aligned with the University's strategic initiatives.

Fundamental advances in the energy field will draw heavily on the physical and mathematical

sciences. An impressive array of faculty bring expertise and global partnerships in chemical and physical processes governing solar energy harvesting and storage; wind and wave energy production; biomass conversion; new materials for thermal energy conversion and for advanced fuel cells; and nuclear energy. Others apply mathematical and computational modeling expertise to these problems.

Closely connected to energy is environmental sustainability. Public policies ensuring sustainable practices require solid scientific knowledge of the complex interactions of earth systems. As mankind must exist in an increasingly stressed environment, this knowledge is core to the economic vitality and quality of human life. PAMS faculty work to gain a comprehensive understanding of earth systems, inform decisions to sustain and improve environmental quality, safeguard human health, reduce the impacts of natural disasters and increase economic productivity. Complementary expertise in collection, management and analysis of the massive data streams required for understanding and modeling of such systems resides in several of our units.

With partners within and beyond the Research Triangle, researchers across the College make important contributions to medical research and practice in such areas as HIV/AIDS treatment strategy, drug discovery, diagnostic biomarkers for diseases such as ovarian cancer, and targeted chemotherapy delivery systems. They also are advancing our understanding of underlying biological phenomena such as DNA structure and blood flow. Our discoveries facilitate advances in medicine, agriculture, biochemistry and cell biology, impacting health for our state, our nation, and our world.

3. Diversity

The College plays a leadership role in the Women in Science and Engineering (WISE) Village, a living and learning community of female students in PAMS, CALS, CNR, Textiles, and Engineering. About 260 WISE participants are expected in fall '07.

We continued to enhance our support of minority students through peer mentor programs and other services provided through the Office of Multicultural Affairs and Student Services.

The Physics Department has more women faculty than any other program of its size. The

Chemistry Department hired its first African-American faculty member this year.

According to *Diverse Issues in Higher Education*, NC State ranks 1st among U.S. predominantly white institutions in the number of African-Americans receiving a bachelor's in the physical sciences in '05-'06, 2nd among predominantly white institutions (6th among all institutions) in the number of African-Americans receiving a bachelor's in mathematics/statistics in '05-'06, and 5th among all institutions in the number of African-Americans receiving a masters in mathematics in '04-'05.

The Science House continues providing K-12 programs aimed at girls and groups under-represented in the sciences. It collaborates with other organizations and historically black institutions on increasing the participation of students who belong to groups underrepresented in STEM disciplines.

4. Instructional Program Advances

In support of a redesign of most of its introductory laboratory courses, MEAS will soon open the first laboratory specially designed for marine sciences. Statistics offered 10 special topics courses and also has introduced WebAssign and is evaluating the use of StatCrunch software. Chemistry added two new computational chemistry laboratory courses. Physics is serving students from Maine to California through online courses. Mathematics continues to develop and implement distance and laptop courses, and introduced five new courses, including a special CALS-focused section and two graduate-level modeling courses, this year. Mathematics also continues to increase its use of instructional technologies, including WebAssign, Maple and QuickTime.

5. Research

Funded research activity continues to be impressive, with about 73 percent of faculty leading externally funded programs totaling about \$30 million – about 88 percent of which is from federal sources, a key indicator of the quality of our faculty and programs. Notable highlights are:

- Senior faculty members in Statistics and Mathematics have established a Center for Quantitative Sciences in Biomedicine.
- PAMS is providing leadership in developing a broad, campus-wide energy research initiative.

- PAMS has three NSF-funded Research Experience for Undergraduates (REU) programs in chemistry, mathematics and physics. The NSA provides additional REU funding for mathematics.
- Mathematics obtained significant funding for graduate training programs from NSF and NSA.

Research highlights include:

Chemistry: Stefan Franzen found that plant viruses can act as cargo vessels for nanomaterials, including small molecule therapeutics, proteins and other materials. Paul Maggard discovered a molecular-level design of advanced solid-state materials that can efficiently utilize solar energy for the production of hydrogen. Alex Deiters developed novel combinatorial technologies for the rapid assembly of small molecule libraries, revealing compounds that act as specific RNA inhibitors and modifiers of developmental pathways.

MEAS: Mary Schweitzer again brought international attention to NC State with a confirmation that actual dinosaur protein was preserved in the sample in which she previously found soft tissue. Lian Xie and Len Pietrafesa led a research group that achieved a new level of hurricane prediction. Jim Hibbard's new findings about Appalachian geology will be featured on a Discover Channel program this fall. Nicholas Meskhidze's work on iron fertilization of the oceans shows that our current understanding of this process is far from complete, and has implications for climate change.

Physics: Our nuclear physicists continue working on a DOE-funded effort to measure the electric dipole moment of the neutron with a precision hundreds of times finer than previously possible. Construction of the necessary experiment will take several years. John Blondin, Stephen Reynolds and Kazimierz Borkowski's discoveries about supernovae explosions have changed fundamental understandings of these powerful events, and formation of certain elements.

Mathematical and Statistical Sciences: Both the Mathematics and Statistics departments are partners in research projects at the NSF-funded Statistical and Applied Mathematical Sciences Institute (SAMSI) in RTP, which recently received a five-year renewal of funding. According to the NSF, NC State is now ranked fifth nationally in total research and development expenditures in the mathematical sciences and fifth nationally in competitive federally financed research and development expenditures.

6. Extension

Faculty across the College provide outreach and extension service through classroom, club meetings and public agency presentations, demonstrations, field visits and consultations.

The Science House works to attract more students to STEM disciplines, and serves more than 3,000 teachers and 20,000 students yearly from across the state. In addition to teacher training programs, science demonstrations, student camps and other activities, it offers distance learning, and its Web site receives 1,500 hits per day. The Science House serves North Carolina through six offices, and has developed programs in several other states.

The State Climate Office (SCO) offers an important resource for public and private agencies, as well as individual citizens. Its Web site now averages more than 10,000 unique visitors and 60,000 hits monthly, a 20 percent increase over last year.

7. Faculty - Honors, Awards and Recognition -- A selection

Chemistry: *Alex Deiters* – Arnold Beckman Award; Myung-Hwan Whangbo – Docteur Honoris Causa, Universite' de Nantes, Nantes, France; *Lin He* and *Paul Maggard* – NSF CAREER Award;

MEAS: *Viney Aneja* – Member, NC Governor's Task Force on Hazardous Materials, EPA Science Advisory Board Committee on Integrated Nitrogen and US Agricultural Air Quality Task Force; *Mary Schweitzer* – David and Lucile Packard Foundation Fellowship

Mathematics: *William Waters* – W.W. Ranking Award, NC Council of Teachers of Mathematics; *Moody Chu* – Alumni Distinguished Undergraduate Professor

Physics: *Bob Beichner* – George B. Pegram Award for Excellence in Teaching, Southeast Section of the American Physical Society; *Karen Daniels* – NSF CAREER Award

Statistics: *Marie Davidian* and *Subhashis Ghosal* – Fellow, Institute of Mathematical Statistics; *Marie Davidian* – Fellow, American Association for the Advancement of Science; *Bill Swallow* – UNC Board of Governors' Teaching Excellence Award; *Hao "Helen" Zhang* – NSF CAREER Award

8. Students

The College's undergraduates score among the University's highest in high school grade point average and SAT V and SAT M scores. Our total fall '06 undergraduate population was 41.4 percent female and 7.2 percent African American. We expect to far exceed our Fall '07 enrollment target with 225 first-year students, including 12 African Americans. The graduate population was 40.7 percent female and 4.8 percent African American. Our students won an impressive array of scholarships, nationally competitive graduate fellowships, and awards from professional societies.

9. Fund Raising

The College will surpass its goal of \$10 million private fund raising for fiscal year '06-'07.

We introduced a double incentive match to the state legislature's professorship match, resulting in three commitments for \$1 million professorship endowments during the year. Other notable new commitments include \$500,000 for a mathematics fellowship endowment, \$126,000 for the Dale Sayers Fellowship, and \$193,500 for graduate program support in Chemistry and Statistics.

Our Alumni & Friends Advisory Board provided direction and support for the second Alumni & Friends Weekend, which increased involvement of, and broadened support from, these constituencies.

10. Administration

David Eggleston was named director of the Center for Marine Sciences and Technology. Ryan Boyles was named director of the State Climate Office and State Climatologist.

11. Recommendations and Concerns for the Future

Critical facilities needs: The University must address the critical need for safe and modern chemistry research space, and overall facility renovation and repair. Rental costs are an ongoing concern.

Programmatic support: We struggle to provide the research infrastructure, both in facilities and staff, demanded of our programs. We need bold commitments from the University and a willingness to include our needs among its legislative priorities.

Recruitment concerns: High teaching loads and non-competitive salaries are a deterrent to retaining and hiring new faculty. Graduate student stipend levels and tuition support remain an

impediment.

Sustained core funding: This is needed for mature outreach programs that have proven their value to the University, such as The Science House, Anderson Academy and the State Climate Office.

12. Producing world leaders

Many PAMS students have become leaders in their fields. James Goodnight is CEO and co-founder of SAS, W. Donald Johnson is head of DuPont-Japan, and Jacob Belin is president of Kern Oil Co. Many others, such as Ji Zhang of sanofi-aventis and Jun Zhu of Zhejiang University, hold high offices within their organizations. And still others, such as J. Stuart Hunter and Bruce Weir, are esteemed within academia as influential leaders within their fields.

13. Impacting energy and the environment

In Chemistry, Jon Lindsey synthesizes organic materials to mimic the sun-harnessing power of chlorophyll for a new type of solar cell. His work has led to the formation of start-up companies in the booming photovoltaics industry. In support of a future hydrogen economy, Paul Maggard has blended transition metals with known photocatalysts for better hydrogen-producing reactions.

A recent Physics PhD student used skills he learned at NC State to become a member of the U.S. team observing U-235 deblending facilities in Russia. The uranium hexafluoride he is monitoring today will be powering North Carolina's electrical grid tomorrow. Another physics graduate student is studying DVD-RAM technology to learn about computer memory applications that may have potential implications for energy efficiency across the computer industry.

PAMS researchers developed a hurricane seasonal forecast that produced the only accurate forecast for the mild 2006 season. Scientists at the Center for Marine Sciences and Technology (CMAST) track spawning migrations of adult female blue crabs, one of the region's most economically and ecologically important fishery species. This information influences policy regarding long-term sustainability of the blue crab population and harvest. PAMS developed an innovative real-time model forecasting depth, location and duration of dangerous storm surge flooding along North Carolina's

coast, enabling emergency management and first-responders to better plan evacuation and mitigation plans in advance of an approaching tropical storm. PAMS is a world leader in the emerging research area of agricultural air quality.

14. Improving health and well-being

PAMS statisticians developed sophisticated statistical designs for complicated clinical trials for treatments of diseases with many variables where standard clinical trial designs are inadequate, including HIV. These methods are broadly applicable to diseases in which treatment involves multiple decision points. A Chemistry research group uses proteomics – the study of all proteins expressed by a given genome at a point in time – to understand the biological basis of disease, discover new diagnostic markers, and develop new clinical tests. Since '03, this group has identified five candidate biomarkers for early diagnosis of ovarian cancer, one of which is being tested in larger patient populations.

Working with statisticians, public health experts, veterinarians, ecologists and anthropologists, PAMS mathematicians have developed predictive models to describe the spread of infectious disease across a region. These models assist in designing better control measures for disease outbreaks or bioterrorism.

15. Creating educational innovation

PAMS is a national leader in improving STEM education, conducting educational research and improving instruction through state-of-the-art techniques. SCALE-UP (Student-Centered Activities for Large Enrollment Undergraduate Programs) courses integrate lecture and lab, enhancing learning with discovery and collaboration. This approach reduces failure rates for minorities and women by factors of four or more, and has been adopted by 50+ institutions. Introductory physics curriculum Matter & Interactions teaches students to apply powerful problem-solving techniques and 3-D computer graphics to everything from planets in far-away solar systems to atomic particles. It is being adopted at several universities. WebAssign is the world's largest web-based homework delivery system, serving more than one million students. Chemistry education researchers are developing lessons for the physically challenged, helping students utilize all their senses to study complex topics.