UNC
COLLEGE OF
ARTS & SCIENCES

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November 16, 2012

To: Bobbi Owen, Senior Associate Dean for Undergraduate Education
Re: Revisions related to Biomedical Engineering and Applied Physical Sciences

Background: Many seminal scientific discoveries of the 21st century will be made at the interface between the traditional science disciplines. Translating those discoveries into solutions to the critical problems of society will require the integration of the basic sciences with applications driven research. On the basis of the report of a year-long task force study, "A Strategic Roadmap for Applied Physical Sciences," the College of Arts & Sciences at the University of North Carolina at Chapel Hill proposes to establish The Department of Applied Physical Sciences. with the following goals:

- to expand interdisciplinary research and teaching by creating an intellectual climate in which science is collaborative and problem-based
- to create connections among disciplinary departments in the natural sciences (e.g., Biology, Chemistry, Mathematics, Physics and Astronomy, and Computer Science)
- to facilitate the breakdown of traditional boundaries that once separated the basic sciences from applications
- to enhance the natural science disciplines in the College and interface with the university's distinguished research activities in the health sciences
- to grow and diversify the University's portfolio of federal research funding in the rapidly changing funding landscape.
- to generate employment opportunities and economic development in the state

In parallel with the establishment of the Department of Applied Physical Sciences, as recommended by the task force report, the College proposes to formalize the Department of Biomedical Engineering as a joint department between the School of Medicine, the College of Arts and Sciences, and The North Carolina State University School of Engineering. Biomedical engineering resides at the interface between the natural sciences and the health sciences and a closer association with the College would represent a significant step forward in creating bridges across traditional schools.

In order to carry out these activities, we ask that the Administrative Boards consider the following recommendations:

1. Revise the name *Curriculum in Applied Sciences and Engineering* to *Department of Applied Physical Sciences*, effective July 1, 2013.

2. Revise the reporting structure of the *Department of Biomedical Engineering* to be a joint department between the School of Medicine and CAS, effective July 1, 2013.

3. Change the home unit of the *major in applied science* from the Curriculum in Applied Sciences and Engineering (#3232, in CAS) to the Department of Biomedical Engineering (#4275, to be joint between CAS and School of Medicine), effective Fall 2013. [The current

graduate program in Materials Science (MS, PhD) will remain with Applied Physical Sciences.]

4. Unless specified explicitly as an exception here, existing APPL courses should be assigned to Biomedical Engineering as a home unit, while existing MTSC courses should be assigned to Applied Physical Sciences. The exceptions are that
    a. APPL 390,
    b. APPL 470,
    c. APPL 491L,
    d. APPL 492L, and
    e. APPL 520L should be assigned to Applied Physical Sciences.

Sincerely,

Karen M. Gil

Karen M. Gil, Dean of the College of Arts and Sciences

- We the undersigned support the proposed changes described above.

Terry Magnuson

Terry Magnuson, Vice Dean for Research, School of Medicine

Nancy Allbritton MD, PhD

Nancy Allbritton, Chair, Department of Biomedical Engineering and Chair, Curriculum in Applied Sciences and Engineering

Peter J Mucha

Peter J. Mucha, Incoming Chair, Department of Applied Physical Sciences

A Strategic Roadmap
for
Applied Physical Sciences
in
The College of Arts & Sciences
The University of North Carolina
Chapel Hill

Submitted to Dean Karen Gil
The Applied Sciences Task Force
July 2012

" Our to-do list is nothing less than the greatest problems of our time."

Chancellor Holden Thorp

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Our Global Problems

Henry Petroski
Duke University

Section 4 – Considerations for the Future of Applied Science

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Task Force Charge

In June 2011, Dean Karen Gil formed an Applied Science Task Force (ASTF), chaired by Edward T. Samulski, and charged to "develop a strategic plan to ensure that the College's first-rate sciences programs are positioned to help Carolina become a global leader in science innovation; … develop a definition and vision for applied physical science, define obstacles for moving forward, outline the principles upon which the initiative should be based, and develop ideas for establishing a structure in realizing that vision." The Task Force consisted of representative College of Arts & Sciences faculty—department chairs and researchers, some with extensive experience in interdisciplinary natural sciences.

While Dean Gil appreciated at the outset that applied physical science impacts non-natural science units within the College of Arts & Sciences (CAS) as well as programs in other Schools (e.g., Geological Sciences, Department of Marine Sciences, Institute of Marine Sciences, Institute for Environment, Curriculum for Environment and Ecology, and Enviromental Science and Engineering), but in order to make the task manageable we restricted our deliberations to consideration of implications for the basic sciences in CAS.

The Applied Science Task Force makes these recommendations in the spirit of what is in the best interest of the university as a whole, and the prosperity of its individual departments.

We thank all of those who contributed their time and ideas to this effort. Special thanks to Carol Shumate for editorial contributions to the Roadmap.

Submitted by

Edward Samulski, Task Force Chair
and the Applied Science Task Force

Applied Sciences Task Force

Edward Samulski, ASTF Chair, Chemistry

Nancy Allbritton, Chair of Biomedical Engineering

Lowry Caudill, Chair of the Innovation Circle, Board of Trustees (Facilitator)

Arthur Champagne, Chair of Physics & Astronomy

Michael Crimmins, Sr. Assoc Dean (ex officio)

Joseph DeSimone, Director of Institute for Advanced Materials

Anselmo Lastra, Chair of Computer Science

Thomas Meyer, Director of Energy Frontier Research Center

Peter Mucha, Chair of Mathematics

Richard Superfine, Physics & Astronomy

Bruce Carney, Provost

Judith Cone, Special Assistant for Innovation & Entrepreneurship

Barbara Entwisle, Vice Chancellor for Research

M. Gregory Forest, Applied Mathematics

Karen Gil, Dean of College of Arts & Science

William Kier, Chair of Biology

Matt Redinbo, Chair of Chemistry

Sergei Sheiko, Chemistry

Russell M. Taylor II, Computer Science

Holden Thorp, Chancellor

Executive Summary

In spring of 2011, Chancellor Holden Thorp asked Dean of the College of Arts & Sciences Karen Gil to determine whether Carolina should formally establish interdisciplinary research and teaching in applied science that would enhance the natural science disciplines in the College and complement the university's distinguished activities in the health sciences. The motivation for this assessment was the recognition that the boundary that once separated the basic sciences from applications has blurred. This changing research landscape challenges traditional models for disciplinary departments in the natural sciences (e.g., Biology, Chemistry, Mathematics, and Physics and Astronomy) and raises profound questions for the optimal organization of the research enterprise at institutions like Carolina that aspire to address global challenges.

> "It has been said that most innovation arises from the application of the principles of one discipline to the problems of another."
>
> University of Chicago
> Molecular Engineering Task Force
> September 18, 2009

The Applied Physical Science Roadmap is a set of initiatives that would establish a Department of Applied Physical Science (APS) in the College of Arts & Sciences (CAS), with the goal of growing the University's research portfolio and positioning Carolina for increased and more diversified Federal R&D revenues in the rapidly changing funding landscape. The proposed new APS represents a thematically important expansion of the University's overall research program at the interface of the biological, physical, computational, and medical sciences. In parallel with the establishment of the APS, we advocate that Dean Gil explore the possibility of formalizing the Department of Biomedical Engineering (BME) as a joint department between the Health Sciences and the College of Arts and Sciences. BME resides at the interface between the natural sciences and the health sciences and a closer association with CAS would represent a significant step forward in creating bridges across traditional schools.

The APS structure recommended herein is a new free-standing tenure-granting academic unit in the College with the authority to appoint faculty and award graduate degrees. The Chair of APS will report to the Dean of Arts & Sciences while aggressively pursuing relationships with other College departments, with the Health Sciences and the School of Public Health. The Chair of the new unit will be appointed by the Dean of CAS and tasked with developing and executing a research and educational vision that integrates and amplifies complementary ongoing research and teaching in the College and the University. At the outset, a Core Faculty will be constituted from existing faculty in the traditional sciences via formal joint appointments. The Chair will lead the recruitment of additional faculty to the APS, constituted primarily by new outside faculty hires, both joint and full to the APS. Joint and full appointments to APS may be offered to extant faculty members from existing disciplines when mutually agreed to by unit chairs and affected faculty.

In the beginning, and in collaboration with the traditional sciences disciplines within the College, the new APS faculty will offer research opportunities to both undergraduate and graduate students, will develop introductory and specialized graduate courses in APS, and will contribute to undergraduate teaching via first year seminars and extant undergrad tracks as appropriate given its initially constituted faculty. When a critical mass of faculty has been reached, an undergraduate mission will be established that will deliver a world-class curriculum.

The benefits of such an enterprise to the College, the university, and the state are considerable. Besides attracting funding, both corporate and governmental, the proposed new department will have the capacity to:

- integrate research and teaching across existing departments and disciplines;
- enhance an intellectual climate in which science is collaborative and problem-based;
- open new horizons and multidisciplinary opportunities to individual faculty and students;
- build bridges between the traditional disciplines; and
- generate jobs and economic activity in the state.

Those faculty who have participated in this discussion for many years, serving on this task force and others, have developed deep bonds, and those bonds have paid off in good will and collaborative endeavor. A Department of Applied Physical Science will act as the connective tissue between the many scientific projects on campus, spawning a new era of collaborative enterprise on campus.

Our Vision

To create a sustainable and flexible framework that energizes the spirit of applied interdisciplinary science at Carolina by fostering beacons of collaborative talent to solve the world's most challenging problems, engaging and empowering the next generation of scientists to ensure the growth and vitality of the economy of North Carolina.

Our Guiding Principles

Our guiding principles for the Department of Applied Sciences are as follows:

- Impact society, making the world better.
- Exhibit recognized excellence.
- Address challenges in a problem-based, collaborative way.
- Train students in interdisciplinary science.
- Promote entrepreneurial leadership.
- Broaden and increase the slope of federal funding at Carolina.
- Enhance core disciplines.
- Foster interdisciplinary science (integration and collaboration).
- Connect with other entities in synergistic ways.
- Engage with CAS units within the liberal arts context.
- Be diversity-driven.
- Have a flexible framework – an agile, renewable structure that adapts to changing scientific priorities.
- Employ continuous strategic planning and self-evaluation, with hard benchmarks

Benefits to Carolina

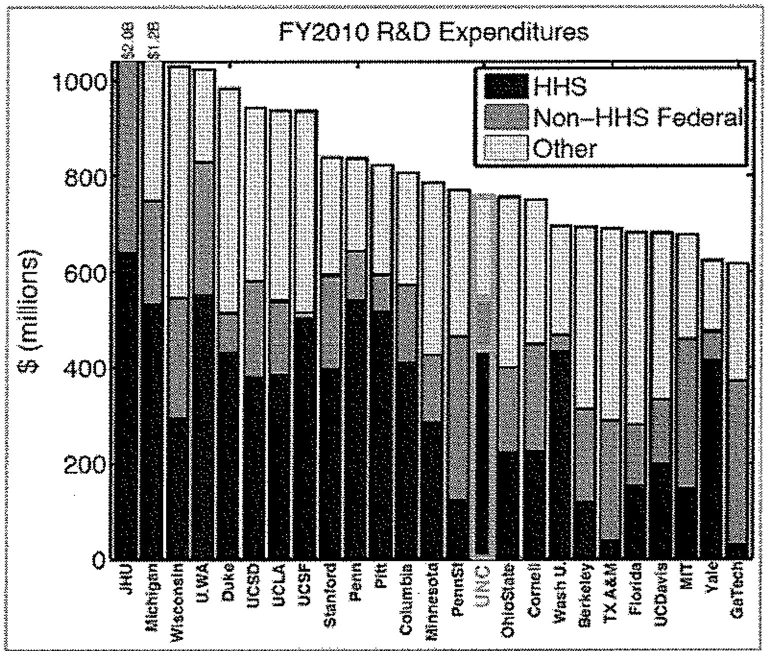
A Department of Applied Physical Science will enable Carolina to:

- Provide interdisciplinary training experience for the future scientific and technical workforce.
- Respond more rapidly to new ideas and associated grants.
- Leverage institutional, local, and state support for Federal funds.
- Attract and retain the best students and junior faculty in interdisciplinary applied research.
- Organize resources for maximum educational results, research results, and industrial outreach.
- Contribute to the Vice Chancellor for Research's stated ambition to rank in the top five public universities in research expenditures.
- Exploit new NIH funding initiatives at the health science-physical sciences interface.
- Secure a high rank among Materials Science & Engineering programs nationally.
- Catalyze an increase in research funding.
- Create vibrant, impactful educational programs critical to North Carolina's future.
- Establish collaborations with national labs and the private sector.

Section 1 - Introduction

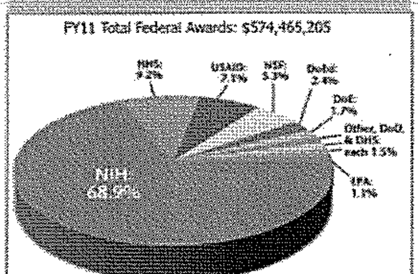
The Opportunity

The idea of supporting interdisciplinary science has been around for more than thirty years at Carolina, championed by many members of the current Task Force and also by many distinguished faculty (See Appendix 1). In the 1980s the effort to launch a formal applied physical science program was viewed as an opportunity to maximize Federal R&D revenue. However, past efforts to move in this direction were either thwarted or languished from lack of ownership and autonomy. The recommendations proposed here constitute not just a way to exploit opportunity, but a way to address problems and needs.



In FY2010, UNC Chapel Hill ranked 15th in R&D expenditures ($755M) from all sources including private, with $546M from the federal government (ranked 9th).[1] Recent trends in UNC funding, by federal agency, are presented in Appendix 2.

The top 10 universities garner 19% of the entire federal research budget. UNC is among the top 20, a cohort that gets more than 30% of the budget. (See Appendix 2)



Heavy Health Concentration - Carolina has most of its Federal revenue ($545.9 million in 2010 expenditures, $574.5 million in 2011 obligations) "in one basket"—the Health Sciences: ~80% derives from HHS (NIH), ~10% from a combination of NSF, DOE, & DoD awards, and the remainder comes from all other federal agencies combined. In contrast, only 56% of all federal R&D expenditures across higher education are by HHS ($21.1billion of $37.5 billion in

[1] http://www.nsf.gov/statistics/infbrief/nsf12313

FY2010).[2] Moreover, Carolina lags behind peers in other sources of R&D funding, relying disproportionately on federal funds (72% of all 2010 Carolina R&D expenditures, contrasted with 61% across academic institutions), reinforcing the reliance on HHS. This point is further elucidated in the plot of Industrial R&D expenditures (#71 in 2009; see Appendix 2). UNC's low NSF, DoE, DoD and Industrial revenue rankings reflect the make-up of current Carolina faculty expertise.

UNC is not eligible for ~$750 million from NSF.

Last Among Peers – Funding data suggests UNC would be last among "peers" in R&D expenditures if Berkeley had a school of medicine (See Table). Locally, UNC slightly underperforms NCSU in revenue from NSF and DoE but it garners more from DoD. But these net figures, $53.5 million at UNC versus $55.3 million at NCSU in 2010, should be considered in the following context: The 2010 NSF budget for the Engineering Directorate is $763 million. But UNC's share of NSF revenues is predominately from a limited number of Directorates: Math and Physical Sciences (FY 2010 budget $1,308 million), Biological Sciences ($712 million), Computer & Information Science & Engineering ($635 million), and the Social, Behavioral & Economic Sciences ($247 million). That is, without formal engineering or applied physical science programs, UNC is not eligible for roughly 15% of the ~$5 billion total NSF allocation[3]. The practical consequences are that UNC is not the first institution in the state that governmental units and businesses would choose to partner with in R&D involving applied research in the physical sciences.[4]

R&D Expenditures for UNC and Selected Peers

With A Little Help From Our Friends – The concomitant rise in funding earmarked for initiatives for applied interdisciplinary science by NSF, DoE, DoD, etc., over the last decade is due in part to the fact that scientific problems have grown complex and demanding of multidisciplinary, applied science approaches. As a result, this increase in funding goes not just to trained faculty researchers but to those who can demonstrate institutional support for such research. At Carolina we have tried to garner those funds by collaborating with applied science programs at other institutions, e.g., the $17 million NSF Science & Technology Center for Environmentally Benign Solvents. This Carolina-led collaboration was viable only with the strong engineering input from NCSU, UT-Austin and Georgia Tech.

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[2] Carolina ranked 56th in FY2010 R&D expenditures totaled across the NSF ($30.8M, 48th), DoD ($15.3M, 74th), and DoE ($7.5M, 66th) [National Science Foundation/ National Center for Science and Engineering Statistics, Higher Education Research and Development Survey, FY 2010]. See also Appendix 2.

[3] http://www.nsf.gov/about/congress/112/highlights/cu11_0523.jsp

[4] In 2009 the State of North Carolina expended ~ $51million on R&D; http://www.nsf.gov/statistics/infbrief/nsf12324/

Why Carolina?

Carolina is different from virtually all its peer institutions in lacking a traditional school of engineering. Internationally, Carolina was ranked 55th in overall reputation by US News and World Report and QS World University Rankings in 2011. But the natural sciences rank far lower—129th. How could this be? We are among the top twenty universities in research funding. The reason for the low ranking in natural sciences is intense competition from institutions with engineering schools. Most prominent institutions without engineering have already embarked on programs that compensate for that deficit, e.g., the School of Engineering and Applied Sciences at Harvard, the Institute for Molecular Engineering at the University of Chicago, etc. Motivating these top universities were pedagogical concerns—a trend toward group learning and collaborative problem solving—and a changing funding landscape with emphasis on multi-investigator grants focused on applied and engineering-oriented science.

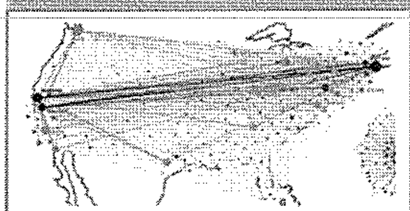
But our deficit can be made into a virtue. Carolina is not encumbered by the structure of existing engineering disciplines and so can create a structure targeted to the unique research areas most able to produce future results. Lacking the traditional means of attracting funding in applied physical science, Carolina is free to innovate in this highly competitive arena. The proposed roadmap for establishing an APS unit represents just such a creative strategy, one that is designed to change the rate of acquiring Federal R&D revenue in these areas.

AREA	RANK
Overall	55
Life Sciences	52
Social Sciences & Management	63
Arts & Humanities	73
Natural Sciences	129
Engineering & Tech.	199

QS World University Rankings
http://www.topuniversities.com/

Why Now?

There is a critical time in any scientific field when advances can be made. When that time has passed, advances continue but at a slower pace. The field of Applied Physical Science has reached that critical point of evolution, offering multiple opportunities for advances that can address eminently solvable problems. The perception that "North Carolina leads the nation in the production of tobacco and is a major producer of textiles and furniture" still overshadows the high tech aspects of manufacturing in RTP[5]. It is critical that UNC help change that perception. By highlighting and enhancing our capabilities in the physical sciences with a commitment to application-oriented teaching and research, Carolina can assume a leadership role in redefining the economy of North Carolina.



Visualization of a mathematics genealogy network. (Mucha)

Seminal scientific discoveries of the 21st century will be made at the interface between the traditional science disciplines. APS is a strategic new initiative in the College of Arts & Science that will foster cutting-edge interdisciplinary research and deliver dynamic curricula that will change practices in the sciences. Modeled after the most innovative programs in the nation, APS will educate across disciplines balancing

[5] http://www.infoplease.com/ce6/us/A0860030.html

theory and experiment to create a unique environment for learning and exploration. APS will promote flexible and responsive curricula exploiting emerging opportunities, creating world-class, hands-on, research experiences, and providing direct exposure to the entrepreneurial dimensions of its degree programs. Through collaborative research with Carolina's basic sciences and the health sciences, interactions with neighboring universities and Research Triangle Park industries, this College initiative will bring discovery and innovation directly to bear on improving the intellectual and economic life of North Carolinians.

"[Practical] problems are often more challenging than the questions fashionable among academic[s], driven as they are not by unfettered curiosity but by a conservative peer-review system — the spigot that regulates the flow of government funds."

Let's Get Practical (Nature 469, 21; 2011)

George Whitesides
Harvard

John M. Deutch
MIT

Intellectual Opportunities

While broadened federal funding is the low-hanging fruit, the benefits of an autonomous Department of Applied Physical Science far surpass financial rewards. The greatest beneficiary will be the intellectual climate of the campus. By fostering and coordinating interdisciplinary research and training communities that cut across departmental interests, a department of APS would birth new intellectual endeavors and facilities that will strengthen UNC's outstanding basic science disciplines to provide Carolina the technical depth to contribute solutions to the world's most pressing challenges in health science, energy science and natural resource science. The challenges and opportunities facing the world's population and economy know no disciplinary boundaries, and the successful universities will be the ones that respond with structures that can respond aggressively to new opportunities in research, funding and new faculty hires. This discipline-agnostic reality is highlighted in the National Academy of Engineering list of Grand Challenges:

- Make solar energy economical
- Provide energy from fusion
- Develop carbon sequestration
- Manage the nitrogen cycle
- Provide access to clean water
- Restore and improve urban infrastructure
- Advance health informatics
- Engineer better medicines
- Reverse-engineer the brain
- Prevent nuclear terror
- Secure cyberspace
- Enhance virtual reality
- Advance personalized learning
- Engineer the tools of scientific discovery

These challenges are not defined by discipline. Five challenges relate to energy and resources while four are directly related to health sciences, with another two related to national security.

The NSF has earmarked new funds for new interdisciplinary programs, e.g., Creative Research Awards for Transformative Interdisciplinary Ventures (CREATIV), launched on Nov. 14, 2011. CREATIV is a pilot grant mechanism to support high-risk, high-reward interdisciplinary

In 2011, President Obama announced the Materials Genome Initiative as a major investment in speeding the discovery and application of new materials that can have an impact in applications from industrial coatings to energy harvesting and storage to healthcare.

research. The program provides up to $1 million in total funding over a maximum of five years to unusually creative interdisciplinary proposals that don't fit into current NSF funding mechanisms.

UNC has the strength in its natural sciences to pursue these opportunities if it is able to build the connections that link its basic sciences to applications. The competition is stiff. Of the top twenty universities in research funding, UNC (15th in FY2010) and UCSF are the only ones without an engineering school.

> Of the top twenty universities in research funding, UNC and UCSF are the only ones without an engineering school.

2020 Compelling Intellectual Targets

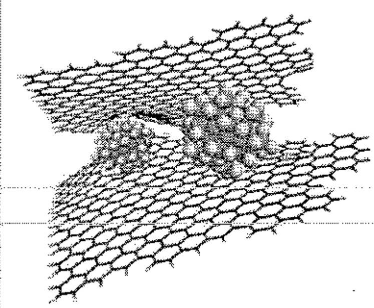
Departments are best thought of as embodying an approach to science, which they in turn direct toward a set of applications that may be in common with many departments across a campus. This wide embrace of applications within each department is one of the hallmarks of contemporary science, and has fueled a renaissance of innovation within universities. It is remarkable to note that at UNC, the Departments of Mathematics, Physics, Chemistry, Computer Science, and Biomedical Engineering all apply their approaches to both energy generation and to health care. Similarly, the faculty of the Department of Applied Physical Sciences is envisioned as a group that applies principally materials approaches to a range of critical applications that are needed by society.

> This wide embrace of applications within each department is one of the hallmarks of contemporary science, and has fueled a renaissance of innovation within universities.

Approaches —

Hard Materials:

The control of materials across scale, from atoms to molecules to organization at the meter scale has changed the enterprise of materials design and application in the past decade. This is especially true with regard to organic molecular materials, metallic, semiconducting and carbon based nanoparticles, and their combination with advanced manufacturing methods up to roll-to-roll processing. Control of functionality is being applied at the scale of individual nanoparticles for single molecule sensors up to films that would cover a rooftop for solar energy recovery. UNC has great strength in the basic science of nanomaterials and their applications including materials for energy storage, enhanced composite materials, medical imaging and imaging for homeland security.



Platinum nanoparticles on grapheme (Samulski)

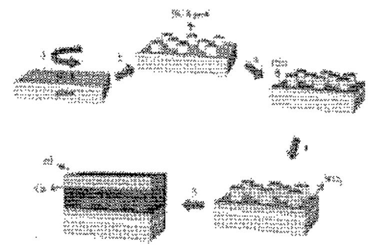
Soft Materials:

Over the past decade, the control of molecular architecture—strings of monomers (polymers), from linear chains to complex star shapes—has matured to include the complexity of controlling the sequencing of monomers along the chains. While this enterprise often employs biopolymers (DNA and Proteins) to guide self-assembly for broad materials applications, DNA also serves as a metaphor for a new approach to materials. In 2011, President Obama announced the Materials Genome Initiative as a major investment in speeding the discovery and application of new materials that can have an impact in applications from industrial coatings to energy harvesting and storage to healthcare. UNC has a solid foundation in polymer chemistry, physics and material applications including nanomedicine. This foundation will enable molecular engineering of novel complex materials that range from light-weight polymer composites for aerospace applications to drug delivery vehicles having nanometer precision.


Synthetic red blood cell mimic (DeSimone)

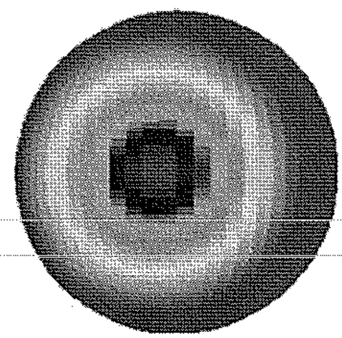
Photonics:

The control of light is at the heart of important challenges in energy, technology, imaging and therapies. The new fields of nanophotonics and plasmonics refer to the control of optical fields at the nanometer scale where geometry and material properties combine to provide extraordinary effects. Optical science and engineering research enabled the development of a wide variety of technologies that are now considered commonplace, such as fiber-optic telecommunications, data storage on compact discs, and image sensors used in digital cameras. More recent basic research developments in photonics are currently being applied to improve solar energy technologies, solid state lighting, chemical sensing, diagnostic medicine and high-performance computing. Over the next few decades, basic and applied photonics research will continue to drive growth in industry sectors from energy to healthcare, security, and communications. Importantly, optical technologies often act as a bridge between interdisciplinary research projects where the latest imaging and sensing technology is crucial for revealing new fundamental science.


Photonic crystal structure in organic solar cell (Lopez)

Modeling:

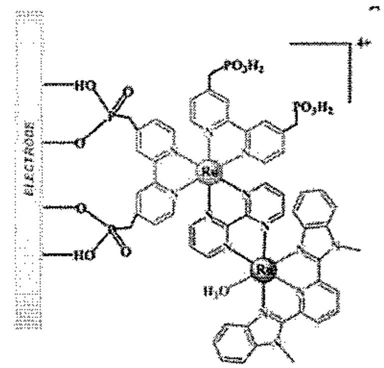
The extraordinary complexity of materials—from atomic positions, to nano-crystalline shapes to their organization within micro-scale structures—is far too vast to pursue with traditional experimental methods. Theory in the form of new analytical and computational modeling methodologies is harnessing the power of computers to provide the roadmap for materials design. Simultaneously, these efforts yield insight into the materials of life providing new perspectives on living and artificial membranes and the complex organization of the cell. These efforts will team with existing strengths on campus in Mathematics, Computer Science, Chemistry, and in Health Sciences with Pharmacy and Pharmacology.


Orientational distribution snapshot from a sheared nematic polymer flow simulation (Forest)

Applications—

Energy Sciences:

Energy has emerged as a central grand challenge with implications for the continued development of the world economy, for resource distribution and for world-wide political stability. UNC has established the Energy Frontier Research Center (EFRC) for developing renewable, carbon neutral energy sources with a focus on solar energy. Federal funding in this area is slated for doubling in the coming years. Target opportunities in this area include the chemistry and nanophysics of light/ matter interaction from the scale of individual molecules to hierarchically assembled materials, plasmonic materials for light harvesting and water-based energy strategies.



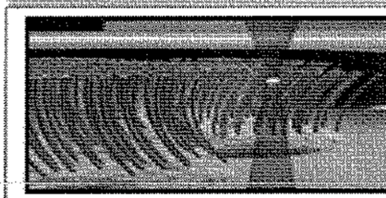
Catalyst for water oxidation (Meyer)

Resources:

The fate of populations in the developed and developing world hinges on what we now recognize as fragile sources of food, fuel and water. Over one billion people lack access to safe drinking water, and its increase of consumption has severe consequences to the health, environment and political security of nations. Food, energy and water are inextricably linked. Simply put, both the growing of food and the cooling of nuclear power plants require water, while conversely, the purification of water requires energy input. New materials and devices are playing a critical role in new membranes for water purification and fuel cells that combine energy generation with water extraction. The significance to UNC of solving the challenges posed by water launched the Water in Our World theme in 2012. Most exciting, this effort in the applied sciences of resources will join a strong community at UNC that includes the Institute for the Environment and The Water Institute in the UNC Gillings School of Global Public Health.

Nanomedicine:

The applied sciences have entered an extraordinary era where new materials and structures, experimental techniques and computational methods are providing breakthroughs in the basic science of living systems, in diagnostics, imaging and drug delivery. These contributions are coming from essentially every unit within university science programs, with a materials perspective bringing new control from polymer synthesis, nanocrystalline composites and hierarchical structures. UNC's existing strengths in basic and health sciences will be strengthened by a materials approach with partnerships formed with Physics, Chemistry, Biomedical Engineering, the new Biomedical Research Imaging Center and the Institute for Nanomedicine.



Magnetic bead attached to a cilium (Superfine)

Synergies —

With Natural Science Disciplines

The CAS has powerful research elements in place capable of assisting the launch of APS, in the basic disciplines of math, physics, and chemistry. APS can build on these strengths to attract a new breed of scientists with engineering-oriented perspectives. Besides positioning Carolina to attract interdisciplinary funding, the new unit has the power to rejuvenate and build bridges among the extant departments. Clearly, investigators in the traditional disciplines can benefit from the presence of experts in engineering applications, and applied scientists can benefit from the support of excellent fundamental science.

With Humanities, Arts, Social Sciences

The research focus areas of Applied Physical Science are aimed at global challenges with profound societal implications. A liberal education such as that provided by Carolina has value to the extent that it can bring together multiple schools of inquiry to address a single issue. The famous divide alluded to by C. P. Snow in The Two Cultures and the Scientific Revolution (1959) can be bridged by applied science in a way that neither the sciences nor the humanities alone can do. Applied physical science demonstrates the relevance of research to contemporary life, and thereby to all of the disciplines.

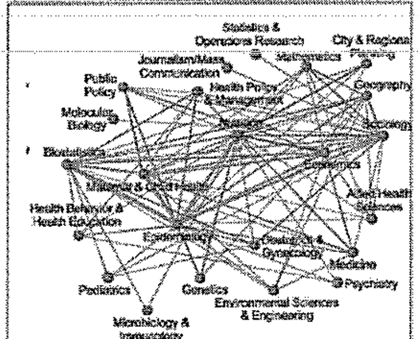
> The famous divide alluded to by C. P. Snow can be bridged by applied science in a way that neither the sciences nor the humanities alone can do.

With Other Schools in the University

There are clear synergies with The School of Medicine, The School of Public Health, and the Department of Environmental Science and Engineering. There are currently a number of innovative multi-investigator projects that can be leveraged to provide support to the proposed department of Applied Physical Science. The nano-medicine effort is one such area where synergy is anticipated. The expertise in the Department of Environmental Science and Engineering would also lend support to work being done in membrane material science.

With Other Institutions

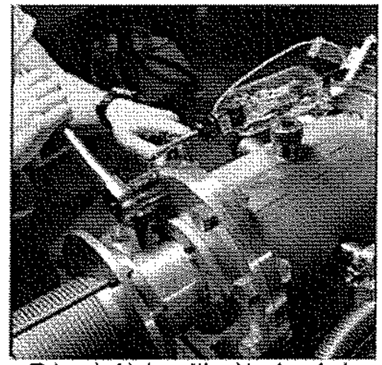
If BME were established as a formal department in the College, it could provide the APS with a natural entree to NCSU. The extant interactions between the department of chemistry and NCSU's department of chemical engineering would be enormously strengthened given the support structure of a department of Applied Physical Science. A department of Applied Physical Science would also provide a way to leverage the outstanding facility provided by David Murdoch in the Kannapolis North Carolina Research Campus, "a private/ public venture created to foster collaboration and further advancements in the fields of biotechnology, nutrition, and health." The vision of that campus is to become the world's epicenter of nutrition and disease research, and it houses one of the largest and most advanced scientific equipment collections of its kind anywhere in the world, in genomics, proteomics, metabolomics, light microscopy, and histology.



UNC research networks affiliated with CPC (Entwisle)

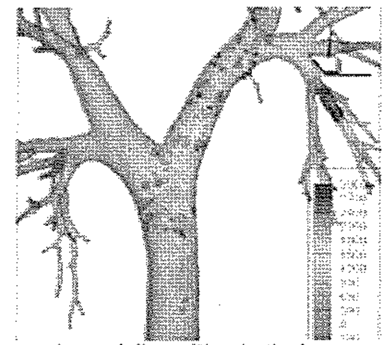
With RTP Entities

The initial focus areas of the proposed APS would naturally interface with programs at NIEHS and at the EPA. Materials science programs are already benefiting from collaborations with RTI in the area of energy sciences, and these collaborations would themselves benefit from a formal APS structure, that could extend collaborations into other focus areas. One of the biggest benefits of strengthening ties to RTP entities would be the job opportunities provided to Carolina graduates, and especially to graduates of the department of Applied Physical Science.



Triangle Universities Nuclear Lab (Champagne)

Section 2 – Launch and Structure of the New Department of APS



Aerosol disposition in the lung (Mitran)

The discipline of Applied Physical Science is inherently interdisciplinary and needs a structure that enables it to interface in a synergistic manner with traditional physical science programs. The structure needs to be agile, able to pursue new intellectual challenges and federal revenue sources without diluting academic rigor. At the same time the structure must provide a primary academic home for new APS faculty, able to grant tenure and respond to College needs. Therefore, the proposed structure is not that of a conventional disciplinary department, but rather is intended to mitigate the "silo" effect that can constellate around the disciplines. The following structural details are intended to provide such structural flexibility to the new department and its administration.

Launch of the Department

Carolina already has a large complement of faculty—probably more than fifty—working in the applied physical sciences. Identifying and coordinating this substantive, on-going effort will enable us to leverage it for increasing UNC's revenue stream and to centralize the publicizing of applied science discoveries.

Core faculty - The Dean of CAS will appoint an interim chair of the Department of Applied Physical Science who in turn will help define a process for identifying potential "core faculty." The Dean will invite this initial group of core faculty (anticipated to be < 10 members from existing faculty) to formally accept joint appointments in APS. It is anticipated that the core faculty will be constituted with, for example, representation from faculty in the sub-disciplines of Mathematics (Applied Math), Biomedical Engineering (Biomaterials), Chemistry (Synthetic Biology, Polymer and Materials), Computer Science, Physics and Astronomy (Medical & Biological Physics, Condensed Matter), Biology (Quantitative Biology), and the Institute for Advanced Materials. Many currently contribute to the graduate teaching endeavor in CASE (Curriculum in Applied Science and Engineering). Core faculty will be identified by their primary research interests and evidence of teaching cross-disciplinary, applications-oriented science topics. The chair and the core faculty make implementation plans for establishing an independent, tenure-granting unit comprising appointed current (joint) faculty and future joint and sole appointed APS hires.

Cost-neutral - The initial core faculty will be a cost-neutral confederation of existing Carolina faculty. These faculty will be offered joint appointments in APS and include faculty from the natural science disciplines, BME and current faculty with joint appointments in the Institute for Advanced Materials (IAM).

Advisory Board - To ensure that the natural science disciplines maintain and enhance their critical educational and research roles, faculty hires into APS should proceed in a judicious manner, one that leverages existing strengths in those disciplines. Hence the launch of APS will require a mechanism for acquiring external advice on how best to proceed. To that end, the APS will have its own Advisory Board at the outset appointed by the Dean of CAS. Some AB members may be drawn from the core faculty of APS and others will be chosen to ensure natural science departmental representation. The AB will identify evolving focus topics and opportunities for collaborative funding. Additionally, until APS is able to hire a full complement of faculty, the Advisory Board will provide program oversight and quality control.

Nanomanipulator (Taylor)

Unit Charge - APS will serve as a central clearing house for applications driven research and teaching. It will gradually assume a coordinating/administrative role in the management of the IAM facilities and laboratories.

APS will administer the graduate program in materials science, its graduate student admissions, and formalizing the process of mentor selection. APS faculty will also develop relevant interdisciplinary material-oriented courses that are accessible to undergraduates as well as plan First Year Seminars in the applied sciences.

Space - The APS administrative office will be initially located in the administrative space of IAM; a long-term arrangement relies on construction of the Interdisciplinary Science Building.

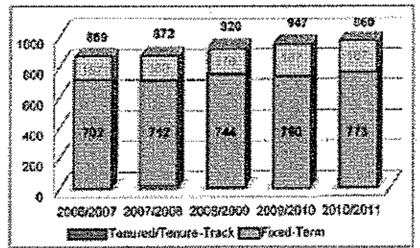
New APS research laboratory space for new hires may be drawn from existing shell space in Murray and reconfigurations in Chapman and Caudill as well as renovated lab space in Kenan. Allocation of laboratory space will be under the purview of the Dean of CAS in close collaboration with affected disciplines to ensure the development of sensible and synergistic research "neighborhoods."

Long-term Target Size

In order to be a self-sufficient, free-standing department, APS will need a critical mass of faculty to carry out its teaching and research missions. Exactly what that size is and on what timescale these faculty members should be hired remains to be determined. The University of Chicago's new Institute of Molecular Engineering provides an example. Chicago planned for twenty-four new faculty within ten years. A plausible configuration at Carolina on a timescale of 10 years might look something like the following:

- 10 full-time FTE (~ 1 new hire a year)
- 20 joint appointments (~ 5 new joint + 15 from extant faculty)

This is an aggressive hiring pace, one designed to draw attention to Carolina's intentions and commitment to applied physical sciences. Is it viable? If one looks at the rate of tenured faculty growth in the last five years (71 between 2006 and 2011), allocating 12 new FTE's for the APS would constitute ~ 8% of new faculty additions over the next decade at a comparable growth rate.

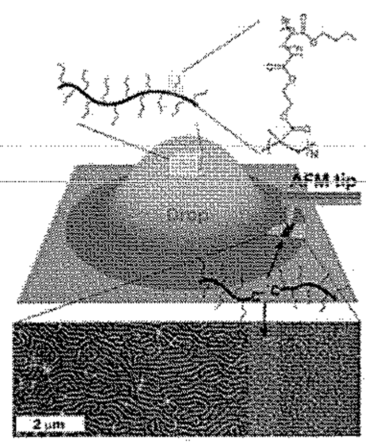


Faculty Hires

Building the applied physical sciences enterprise is the clearest, most cost-efficient way to impact our ability to compete and maintain our place amongst the best universities. An autonomous APS would enable Carolina to acquire an applications-driven faculty culture by attracting faculty with engineering skill sets who might be hesitant to join traditional physical science departments. In order to give some tangible dimension to the nature of the faculty culture that would populate APS, we tabulate some "sample faculty" attributes derived from real people in nationally recognized engineering programs. Such "composite faculty profiles" would be attracted to a vibrant department of Applied Physical Science with a compelling strategic plan for enhancing Carolina's disciplinary strengths.

Sample Applications-Oriented Faculty Profiles - The following tabulation of prospective faculty profiles spans a range of research disciplines (hard and soft materials, photonics and modeling) and application areas (energy, resources and nanomedicine). The targeted scholars come from a variety of backgrounds and home departments with the common theme of the discovery and application of new materials for the world's most challenging technical problems. As is common in today's materials research groups, most of these scientists apply multiple approaches in several application areas: for example, control of materials at the nanoscale level, from the assembly of molecular and polymeric materials as nanoscale particles ordered into 3D materials and devices, with molecular, organic and polymeric materials, and computation and modeling complements synthesis and experiments to provide design principles.

This list of sample faculty is intended only as a guide, to indicate how one might begin to build the department. Obviously, quality of research would be as important as research area for actual hires. Nevertheless, this list has been carefully designed to complement and enhance Carolina's existing research capacity. The range of disciplines brought together under these faculty profiles, from chemical, mechanical, electrical and materials engineering, highlights the advantage of a new department connecting materials and applications. The targeted applications-oriented scholars are distributed across interests in energy, in resources, and in nanomedicine:



"Brush polymers" spontaneously break under self-induced stress (Sheiko & Rubinstein)

- Mechanical and Aerospace Engineer focused on problems in fluid mechanics, Reynolds number flows, surfactants; fluid rotation & transport to complement Carolina's Virtual Lung Working Group, scientist from Physics and Astronomy, Applied Math, Chemistry and

Health Sciences working on pulmonary diseases such as cystic fibrosis.

- Chemical Engineer and Materials Scientist focused on the characterization of phase-separated polymer systems and/ or colloidal assembly of materials to adapt phase, rheological and electronic properties to advance applications based on discoveries within Carolina's DOE Energy Frontier Research Center (EFRC) and NSF Materials Research Center and Team (MIRT).

- Chemical or Biomolecular Engineer, or Applied Mathematician with an interest in modeling fluids, molecular electronics, nanocomposites, rheology, cancer invasion to advance discoveries in Applied Math, Nanomedicine, and Polymer, Analytical and Medicinal Chemistry.

- Materials Scientist or Chemical/ Biomolecular Engineer with expertise in statistical mechanical theories of polymers, colloids, nanoparticles to extend ongoing basic science efforts into applications associated with nanoparticle transport in complex polymeric and biofluid systems.

- Mechanical or Chemical Engineer working on membrane science and coupled physical, chemical, electrical and mechanical phenomena to interface fundamental separation sciences with applied water resource endeavors across campus.

- Material Scientist, Electrical Engineer or Optical Engineer dedicated to solar energy applications based on organic materials and OLED (organic light-emitting diodes) devices for third generation solar cells. Alternatively, a scientist with expertise in nano- and molecular-scale fabrication to support applications of discoveries in energy sciences and the EFRC.

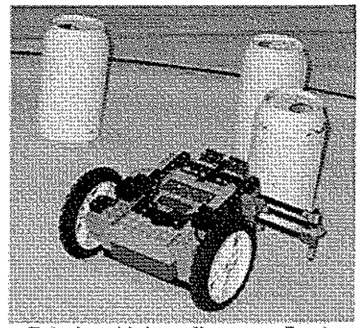
- Materials Scientist or Chemical Engineer focused on novel soft matter applications, e.g., the development of flexible, stretchable electronics and energy devices. Ideally the candidate would bring a new research focus to expand MIRT-related sciences.

- Electrical and Computer Engineer specializing in microelectromechanical systems or materials for optical and chemical applications in physical manifestations of dynamic virtual objects and people.

Synergies - The above suggested faculty profiles have synergies with some of the best research already underway at Carolina. Almost every science department in the college has faculty whose work spans physical and biological sciences and would benefit from collaboration with these scientists. At the same time, the areas of expertise represented in these profiles are currently missing from Carolina and would vastly enhance our research capabilities. Most of the prospective faculty would have appointments in multiple departments of their

Almost every science department in the college has faculty whose work spans physical and biological sciences and would benefit from collaboration with these scientists.

home institutions, demonstrating how these fields bridge academic homes. For example, some theorists would interact with Chemistry and Mathematics, while others would also find common interests with Computer Science with regard to high performance computing. Therefore, most would be difficult for Carolina to hire without a dedicated department of APS.



Robotics with Lego first year Seminar (Lastra)

Graduate Education

The initial graduate education goals would be focused on the existing graduate track in CASE namely, materials science. Only after achieving a critical faculty mass would other tracks be considered. APS would from the outset, however, serve as a central unit for coordinating graduate course offerings and content, ensuring that optimal interfacing with relevant divisions in existing divisions is carefully managed.

Undergraduate Education

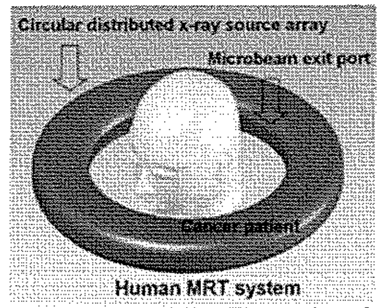
Defined undergraduate curricula would follow after attaining critical faculty size. The general goal would be to model the successful undergraduate BME major in CASE. In the long term, curricula staffed by APS faculty will be designed to foster cutting-edge interdisciplinary research in the sciences, and to deliver curricula preparing students for that research. Students joining APS will gain the knowledge needed to be at the forefront of the next technology revolution, and will develop the leadership skills required to create their own research teams and companies. APS students will be educated to address pressing technical problems confronting the world. They will learn to balance theory and experiment in fundamental and applied sciences, within a unique environment of learning and exploration.

Faculty Teaching and Responsibilities

Before curricula are established, new hires in APS would contribute unique graduate courses in domains that Carolina currently does not profess. Some of these courses are desperately needed now but the existing departments don't have the resources to offer them. For example, it is anticipated that new APS faculty would offer new graduate and advanced undergraduate teaching in the energy sciences, soft matter area, colloidal sciences and imaging sciences, as well as augment existing offerings in material science, biological physics, polymer chemistry, and biomedical engineering courses. It is also reasonable to expect new APS faculty to offer new experiences to undergraduates via the First Year Seminar program.

Resources – Funding Strategy

To attract federal dollars, the funding strategy for an Applied Physical Science entity needs to be consistent with that of competing entities across the country. A new unit on campus will require significant resources for an effective start-up and for sustaining the unit during its growth phase. To attract great talent at the launch, an unusual burden is placed on a new unit to demonstrate the resolve of the administration. In addition, early identification of resources will be needed to obtain broad enthusiasm from the university community. The University of Chicago estimated approximately $4M per faculty member. We would expect similar numbers for early senior hires, but generally we should expect to allocate approximately $1.5M in startup costs and a competitive salary.



Microbeam Radiation Therapy based on carbon nanotubes (Zhou)

Leveraging Existing Resources

The incorporation of IAM and its assets (faculty, resources, CHANL,...) into APS along with the CASE materials science graduate program will create a research community with infrastructure for state-of-the-art curricula and instrumentation of benefit to the entire University community. Consolidation into APS will ensure coordination and integration of existing resources in a powerful organization fully able to coordinate and maximize use of existing and future resources of the interdisciplinary sciences. Current resources that APS will interface with include: i) UCRF, the University Cancer Research Fund ($50 million/ year) for new faculty hires in nanomedicine; ii) BRIC, the Biomedical Research Imaging Center for space for new nanomedicine faculty hires; iii) CCCNE, the Carolina Center of Cancer Nanotechnology Excellence for interdisciplinary faculty in cancer research with a critical linkage to clinical applications.

Attracting New Resources

Development for the future will be at the heart of the APS in a comprehensive effort designed to capture the public's concern about future technology challenges and how to face them. At the core of APS' development initiative will be a significant campaign target—a request for an Interdisciplinary Science Building—a facility to house new faculty and their associated staff and students.

Section 3 – Recommendation and Initiatives Required to Realize It

Recommendation: Establish a Department of Applied Physical Science within the College of Arts and Sciences targeting initial focus areas that build on strengths in current disciplines.

Carolina's advantage - The extensiveness of contemporary Applied Physical Sciences has even outdistanced the scope of engineering schools. Science is always changing. The Department Applied Physical Science (APS) envisioned here has the flexibility to create expertise only in select areas, as those areas evolve and develop, without having to cover every area that engineering schools must cover. The initial focus areas reflect both funding opportunities and existing areas of strengths within the College.

Initiative 1

Establish the new Applied Physical Science unit as a Department, not an interdisciplinary Program, Curriculum, Center, or other administrative body.

Create the new Applied Physical Science unit as an autonomous Department, initially with a graduate focus, capable of granting doctoral degrees and tenure. The new APS would concentrate faculty and facilities that build on existing strengths and that can secure funding in critical new areas.

An autonomous Department of Applied Physical Science would show Carolina to have a cohesive plan for attracting APS resources and would provide accountability in the use of these resources. A departmental structure would provide support for existing APS research and principal investigators, allowing them a say in future allocation of resources, and granting them credit for collaborative endeavors. A departmental structure would increase accountability by supervising APS resource allocation and by having the capacity to evaluate researchers in areas that traditional departments lack the capacity to evaluate. APS would enable more rapid response to new ideas and associated grants. And it would leverage institutional, local, and state support for Federal funding. APS would attract the best students, as well as junior faculty in interdisciplinary applied research. And a departmental structure would enable Carolina to organize facilities for maximum educational results and industrial outreach. The selectivity of the APS unit will ensure immediate prominence. Its core faculty will be able to mentor new hires and to establish a strategic plan, enabling problem-based teams of collaborators targeting the most lucrative funding areas.

The Applied Physical Science Department envisioned here has the flexibility to create expertise only in select areas, as those areas evolve and develop, without having to cover every area that engineering schools must cover.

… a departmental structure would enable Carolina to organize facilities for maximum educational results and industrial outreach.

Initiative 2

Create an interim committee, to be called the Advisory Board, to recommend select joint appointments to the Department of APS (APS) from the interested existing UNC faculty.

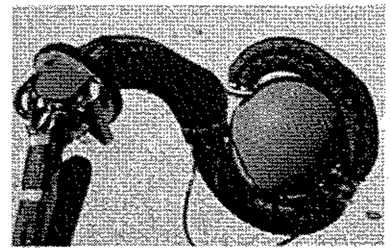
The Advisory Board constituted by the dean of CAS shall consist of key faculty practitioners in the applied sciences, and natural science department chairs or their representatives. In conjunction with the (acting) chair of the new APS, the Advisory Board will review proposed and self-nominated joint appointments to create a core faculty. In the case of joint appointments for existing faculty, the joint appointments will maintain resource allocation and F&A distributions as currently constituted. The dean, together with affected unit department heads, will consider transitioning resources between units if jointly appointed faculty wish. Current policies on faculty transfers will apply. Selection criteria should consider funding and scholarship in the initial focus areas of APS; national and international prominence of the faculty's current research programs; the individual's history of collaborative and interdisciplinary research; and teaching in the graduate CASE degrees. This Core Faculty would be the interim faculty until such time as new hires could be made to staff the APS, and should act as a multiplier for the University's recruiting power. A community of scientists capable of attracting even more world-class additions to the APS unit will emerge, one that becomes increasingly competitive for new interdisciplinary research funding programs.

The opportunity to be part of a new department, and to help create that department, is a considerable attractant for interdisciplinary-minded scientists...

Initiative 3

Charge an interim Chair of the APS appointed by the Dean to act as a single point of accountability, and initiate a nationwide search for an internationally prominent scientist to lead the new effort.

The Chair of the APS would be a revolving chair to serve for five years, selected by the Dean of the CAS. An interim Chair would be selected until such time as CAS could recruit a permanent Chair of the APS. This position would coordinate hiring into APS (ensuring that focus areas are paramount in new faculty selection criteria), oversee tenure decisions and curriculum development, and initiate PR for the program. The position would resemble a department chairmanship with the added responsibilities of ensuring a healthy relationship with the traditional disciplines, establishing corporate relationships, and providing a smooth interface with the College's strategic planning and the University's strategic planning. Benchmarks for hiring and promotion would accrue along with concerted and focused interdisciplinary Applied Physical Science research and teaching missions. The existence of a Chair provides a single point of accountability and cohesiveness in responding to national research directions. The Chair would ensure that interdisciplinary pedagogy is not left up to individual departments. Finally, this position would provide credibility and would give the University a public figure capable of participating in the setting of national objectives, providing national and international visibility for the research enterprise.



Robotic arm inspired by elephant trunk and octopus tentacles (Kier)

Initiative 4

Charge the APS with tenure-granting and doctoral-degree-granting capacity and a size goal of 20 FTEs over ten years, consisting of both joint and new faculty.

The new APS, initially staffed entirely by joint appointments, would seek exclusive new hires, as well as additional joint appointments. The long-term (10+ years) size of this new unit would be approximately 20 FTEs consisting of dedicated new hires and joint appointments that could be new hires or existing faculty. The new APS could also consider creative appointments such as joint partnerships with the private sector, providing visiting fellowship opportunities for industrial scientists. While the APS needs to be initially focused on graduate education because undergraduate education has complex extra-departmental requirements, it would immediately enrich the undergraduate curriculum via elective courses, First Year Seminars and undergraduate research opportunities. It is essential that the APS eventually have more dedicated APS faculty than merely joint appointments, in order to ensure the department's autonomy. An APS Department capable of hiring could expand the culture at Carolina to include pragmatic problem-solving and collaborative research. The funding opportunities that lie outside of the boundaries of traditional disciplines would enrich the university in ways that would spill over onto existing departments and programs.

Initiative 5

Create a necessary resource stream for the APS by allocating "already committed" resources for Applied Physical Science endeavors into an APS account.

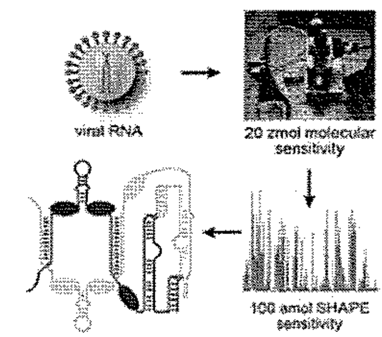
Create a resource chest for the new department with monies and resources already available and partially or wholly dedicated to Applied Physical Science endeavors, including but not limited to the following:

- $1 million from Provost that he suggested in June 1011
- Innovation Circle Applied Physical Science Professorships
- Already-committed IAM positions and resources
- Prominent positioning of APS in capital campaign

Accruing all existing Applied Physical Science resources into a single dedicated administrative unit will endow the APS with immediate start-up resources and enable it to be eligible for grants intended for Applied Physical Science centers. It will also institutionalize a collaborative culture and streamline the accountability issues. E.g., the administrative space of IAM in Chapman Hall can be used to house the administrative offices of the APS. The CAS resources allocated to the BME undergraduate major would remain independent of APS resources.

The unoccupied, unfinished space (~6000 – 8500 square feet) in the new Venable/Murray building would supply the laboratory space for approximately three new faculty hires. Additional laboratory space could be provided by the traditional laboratory departments: physics and chemistry. All of this would be an interim solution to bridge to the period when the new Interdisciplinary Sciences Building (IDS) is funded and built, at which time the entire APS would move there. Part of this initiative involves securing a commitment that the proposed IDS would have high priority in the next campaign.

Lastly, situating the APS in the Science Complex will engender collaborative research between APS faculty and faculty in the traditional scientific disciplines. It would also ensure better communication and cohesiveness in AS-related research initiatives and funding strategies.



Shape characteristics of RNA genome (Allbritton)

Initiative 6
Formalize the Department of Biomedical Engineering's participation in the College of Arts & Sciences.

The Dean of CAS shall explore a formal extension of the Biomedical Engineering Department (BME) into the College and thereby enable the BME Department to inform the life sciences engineering foci within the CAS. It is anticipated that BME will continue to lead the undergraduate BME curricula much as the Department currently leads efforts at the graduate level in life sciences engineering. Significant synergies between the BME and APS are expected and the University as a whole will prosper from a combined department spanning the College, the School of Medicine and NCSU's College of Engineering. Such an entity can only serve to strengthen linkages across the campus and with neighboring universities. It is a natural extension to integrate the BME Department into the College enabling BME to participate in managing interdisciplinary educational and research programs. Moreover, such an arrangement will enable CAS to formally participate in the direction of the BME Department.

The Labor Department recently predicted that this engineering discipline will add jobs faster than any other sector of the economy in the years ahead.

Carolina is poised to capture biological/biomedical engineering, the fastest growing occupation and academic curriculum in the country. The Labor Department recently predicted that this engineering discipline will add jobs faster than any other sector of the economy in the years ahead[6]. This demand must be met with a steady supply of highly trained life science engineers. This need for increased education

[6] U.S. Dept. of Labor, Bureau of Labor Statistics, Occupational Employment and Wages, May 2010, www.bls.gov/oes/current/oes172031.htm

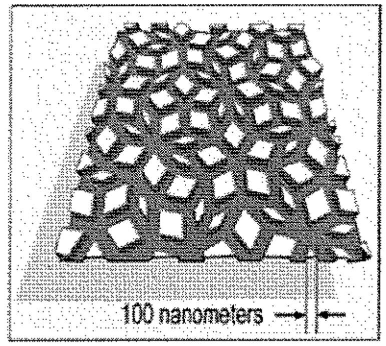
and research is being met with high levels of federal funding for both missions. For example, the FY2011 budget for the NIH's National Institute of Biomedical Imaging and Bioengineering (NIBIB) was $264 million while the National Science Foundation's Directorate for Engineering FY2011 budget was $157 million for its Division of Chemical, Bioengineering, Environmental and Transport Systems (CBET). Despite the downturn in the economy, funding for these agencies has continued to grow due to the unmet needs and the recognition of economic and health benefits from new technologies and companies in this field.

"When a research team is exposed to challenging real-world problems that require multidisciplinary and diverse expertise, the resulting problem-rich atmosphere generates inventive ideas."

Cherry A. Murray, Dean,
School of Engineering and Applied Sciences
Harvard University

Section 4 – Considerations for the Future of Applied Science

In the long term a university-wide effort that could subsume Applied Physical Sciences is essential. This goes beyond the charge of the Task Force but we include these additional ideas as a set of possible initiatives for future consideration.



Nano-scale "Penrose Tiling" (Samulski)

Consideration 1
Establish a Faculty of Applied Sciences (FAS) as a pan-University entity.

Status Quo. The totality of the UNC efforts in applied science and engineering is spread across the sciences within the College of Arts and Science and within the Schools of Medicine, Public Health, and Pharmacy amongst others. This presents a challenge to the university in the coordination of cross-cutting initiatives, educational programs, effective hiring strategies and in the marketing of UNC's efforts to the outside community.

Description. There are many applied scientists in the university as a whole, and we would recommend that consideration be given to how to leverage these other resources. UNC should develop a network of faculty engaged in applied sciences and engineering to constitute the Faculty of Applied Sciences in consultation with science leaders from across the campus. The FAS could consider the best way to facilitate coordinated research efforts on campus, including the planning of joint seminars and coordinated advisory board meetings for individual entities.

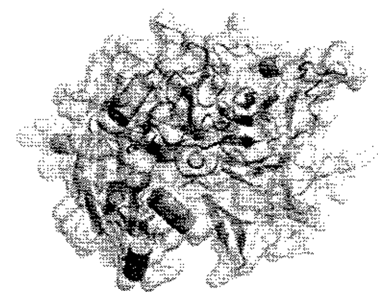
Expected Benefit. As a pan-university entity, FAS would encourage more inter-school collaborative research and teaching, better leverage fund raising from individuals and from federal sources, and provide a platform for raising the national profile of UNC in applied sciences. UNC would be more effective in hiring on the national stage if it could coordinate hiring across the various schools of the university for cluster hires that serve cross-cutting initiatives.

> UNC would be more effective in hiring on the national stage if it could coordinate hiring across the various schools of the university for cluster hires that serve cross-disciplinary initiatives.

Consideration 2
Establish a website for the FAS where faculty can communicate among themselves.

Status Quo. The community of applied scientists and engineers at UNC do not have a single way of identifying themselves within the university. The physical and administrative placement of researchers into departments does a disservice to the new ways in which science is being accomplished today—crossing departmental boundaries to build effective teams. Most important, the world outside of UNC is not aware of the breadth and depth of UNC's applied sciences and engineering activity. While many programs have national prominence of themselves, the reputation of UNC suffers because it lacks the identity of the sum of its efforts.

Description. A single website would be developed that would consolidate information about the applied scientists and engineers from across the UNC campus. Individuals would be identified, along with their appropriate UNC academic homes and research webpages. Most interestingly, the FAS could be organized along lines of challenges and application—independent of the location of the member's department. Visitors to the website would see a coordinated front of UNC Applied Physical Sciences and engineering, streamlined to provide immediate access to those collected to address particular problems. A model for this is the Materials@MIT website. While MIT has a Department of Materials Science and Engineering, the university recognizes that materials are studied in many different entities on campus, and their collective representation facilitates communication within the university and to outside visitors.



Protein involved with human pathogen Pseudomonas aeruginosa (Redinbo)

Expected Benefit. The simplest way to build the community and its visibility is through a website. Visitors, the press, students and donors could have a single portal to discover research initiatives and the power of UNC in applied sciences and engineering. Within UNC, researchers could more easily identify complementary expertise to build new teams. The website structure would represent a new ordering of faculty outside of departments, but along common research interests, and further break down barriers to interdisciplinary collaboration.

UNC would bring the world's thought leaders to Chapel Hill to discuss the Grand Challenges that affect the world.

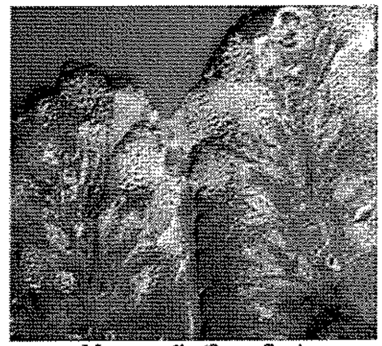
Consideration 3

Establish the Grand Challenges Lecture series and similar pan-University activities.

Status Quo. UNC's outstanding work in applied sciences and engineering needs to be clearly communicated to the state's citizens and legislature, to the nation and the world. At the same time, a vibrant community benefits from the injection of insight and resolve from the presentation of the most pressing challenges in the world, and the best examples of successful approaches to their solution.

Description. UNC would bring the world's thought leaders to Chapel Hill to discuss the Grand Challenges that affect the world. These leaders may be Nobel Prize winners or international political figures that are addressing these problems from the political sphere. These lectures may be coordinated to inform specific initiatives that are under consideration at UNC, to frame the structure of the initiative and to engage the university community. These lectures could occur as specialized lectures for academic audiences as well as public lectures for a wider audience.

Expected Benefit. Bringing the world's best science and engineering leaders to UNC serves to highlight the University's own activities in these areas, spark a dialogue across the campus for coordinated activities, and educate the public of the most critical problems of our day. The FAS Advisory Board could be charged with the planning for the topics of this series, especially in coordination with expected initiatives on campus. In this way, the prominent lectures would catalyze the conversations across the university. This will be especially effective in engaging the undergraduates in grand challenges – as they decide their courses of study – or launch new companies to address the challenges head-on.


Mucus cells (Superfine)

Consideration 4
Establish a FAS Advisory Board from across the university to plan strategic initiatives, coordinate hires and resource allocations for interdisciplinary activities.

Status Quo. The grand challenges that need to be addressed by UNC cross every boundary within the university: schools, colleges and departments. To address these challenges effectively, UNC needs to have rapid, flexible means to establish new teams, implement new investment strategies and to bring new talent to the university that will live in disparate departments across the campus. Educational programs addressing these challenges will also need to draw upon resources, courses and laboratories from across the university.

Description. A Faculty of Applied Sciences advisory board (FASAB) would collect leaders from across the campus representing the university science and engineering activities. The FASAB would consider major research and educational initiatives that should be tackled by the university in a coordinated manner. They would take into consideration the significance of the challenges to be addressed, current and emerging funding opportunities, and the position of UNC to establish or extend a leadership position.

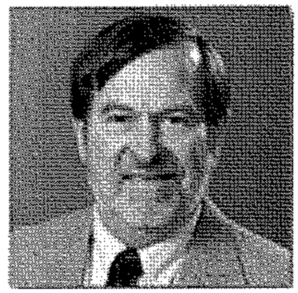
Expected Benefit. With representation from across the campus, the FASAB will be able to create a rapid response to new funding, research and educational opportunities. This will help ensure the flexibility that will set us apart from traditional engineering programs. FASAB will facilitate communication across the administrative units and the university research community to ensure that UNC has needed infrastructure and intellectual talent to address emerging challenges. This is especially important as we connect the mathematical, natural and social sciences with emerging needs of global health and resource challenges.

Appendix 1. History of Applied Sciences at Carolina

Charles Holmes Herty
Dean of Applied Science (1908-11)

The Early 1900's - Dr. Charles Holmes Herty, Mary Ann Smith Professor of Chemistry and Chair of the Department, was for a time Dean of the School of Applied Physical Science (1908-11) at the University of North Carolina at Chapel Hill.

The Early 1930's - The first General Administration (GA) president of the newly consolidated UNC System, Frank Porter Graham, dismantled Carolina's nationally-ranked engineering program after agreeing with Governor O. Max Gardner's wish to locate engineering at "State College." There were financial considerations associated with redundant programs, but politics appears to have been a non-negligible consideration as well. Moreover, Graham's decision to locate engineering in Raleigh was likely influenced by an over reaction on his part: As immediate past Chancellor of Carolina, Graham did not want to appear to favor Carolina so early in his tenure as the inaugural UNC System President [1].)



Thomas J. Meyer
Chair of Chemistry (1985-1990)
Vice Chancellor, Vice Provost for Graduate Studies & Research (1994-1994)

The Eighties - Carolina and NCSU were given several professorships to jumpstart the "Microelectronics Center" (MCNC) that was being launched in Research Triangle Park. At Carolina both Chemistry and the Physics & Astronomy departments received two engineering-oriented faculty lines. These new engineering-oriented faculty hires were the foundation of an Applied Physical Sciences Curriculum which established several undergraduate major "tracks"—Computer Science, Biomedical Engineering, Materials Science, and Polymer Science. The Curriculum flourished throughout the 1980's and some undergraduate majors were subsumed into corresponding (graduate) departments, e.g., the Computer Science track. Tom Meyer persuaded Provost Charles Morrow to provide faculty positions in two focus areas, polymer science and electronic materials. Contemporaneously, Meyer in collaboration with Stuart Bondurant, Dean of the School of Medicine (1979-1994), initiated planning and creating the Program in Molecular Biology and Biotechnology (PMMB).

In the late 1980's space was a serious limitation on hiring new faculty, but Meyer negotiated with what was then Glaxo to renovate a significant part of "old Venable." When vacated, that space provided a basis for Chemistry to make a new faculty hire, and Meyer recruited Ed Samulski to create a polymer program at Carolina, to enhance the department's then nascent materials science program. That new program achieved national attention in 2007 when Carolina's "Materials Science and Engineering" program was ranked #3 in the nation according to *The Chronicle of Higher Education's* Faculty Scholarly Productivity Index.

Polymers and Materials at UNC

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Faculty Scholarly Productivity Index

Materials science and engineering - 2007

	Institution	Faculty Scholarly Productivity Index	Number of faculty	Percentage of faculty with a book publication	Books per faculty	Percentage of faculty with a journal publication	Journal publications per faculty	Percentage of faculty with journal publication cited by another work	Citations per faculty
1	Georgia Institute of Technology	1.84	37	-	-	100%	21.24	92%	169.06
2	U. of Illinois at Urbana-Champaign	1.53	27	-	-	93%	13.52	89%	151.25
3	U. of North Carolina at Chapel Hill	1.48	31	-	-	90%	10.81	87%	154.35
4	U. of California at Santa Barbara	1.42	47	-	-	89%	17.77	89%	175.29
5	Northwestern U.	1.39	23	-	-	91%	11.81	87%	93.74
6	U. of Minnesota-Twin Cities	1.26	47	-	-	91%	11.94	87%	92.66
7	U. of Minnesota-Twin Cities	1.15	47	-	-	89%	12.02	85%	94.86
8	U. of Texas at Austin	1.14	41	-	-	93%	15.17	88%	102.2
9	U. of California at Los Angeles	1.13	17	-	-	88%	14.59	88%	129.18
10	Cornell U.	1.12	40	-	-	85%	12.55	90%	118.82

The Nineties - Carolina successfully petitioned GA to have a PhD program in Materials Science, and the Applied Physical Sciences Curriculum morphed in to the Curriculum in Applied Materials Sciences (CAMS). New materials-oriented hires in Chemistry and Physics & Astronomy teamed up and successfully secured funding for interdisciplinary research on carbon nanotubes (ONR Otto Zhou, PI [3]), environmentally benign solvents (NSF Joe DeSimone, co-PI [4]), and biologically inspired materials (NASA Ed Samulski, PI [5]).

As Vice Chancellor for Graduate Studies and Research, Tom Meyer helped create an Applied Mathematics program at Carolina led by Greg Forest, a major asset to Applied Physical Sciences. Soon, planning exercises began for a Materials Science building (led by Tom Meyer, Dick Jarnagan, Royce Murray, and Ed Samulski).

When Ed Samulski became Chair of Chemistry, he wanted to create a more all-encompassing structure than just a new materials science building, and he conceived of the Science Complex to bring together all of the natural sciences in the College and exploit the interdisciplinary synergies. He obtained backing from Chancellor Hooker, and with other Carolina faculty lobbied the legislature. This led to the passage of the Bond legislation which renovated the entire campus infrastructure. Unfortunately, the space originally allocated for interdisciplinary Applied Physical Sciences reverted to the traditional disciplines, i.e., Biology, Chemistry, and Physics & Astronomy.

The Millennium - Chancellor Moeser secured additional funding for completing the Science Complex and in 2004 he agreed to jointly fund a multi-million dollar 193 nm optical lithography system ("stepper"), located in clean rooms at NCSU [2]. This was part of an effort at Carolina to bring state-of-the-art nanotechnology analytical capabilities to science students and faculty. On the Carolina campus the acquisition of the stepper complimented the newly formed multi-user instrumentation CHANL; in 2011 CHANL served nearly 300 users, principally students and faculty from Carolina, but the facility is open to users from other universities and industry as well. CHANL resides in the Institute for Advanced Materials (IAM, http://www.advancedmaterials.unc.edu) an Applied Physical Science entity established by Chancellor Moeser (in part to retain Joe DeSimone, a joint professor in Chemistry at UNC and Chemical Engineering at NCSU). IAM enabled the hiring of several Applied Physical Science-oriented faculty who could be accommodated into Carolina's traditional disciplinary units [6].

CHANL
CHAPEL HILL ANALYTICAL and NANOFABRICATION LABORATORY

The pedagogical mission of the Curriculum in Applied Materials Science (CAMS) was evaluated in view of the dominance of its BME undergraduate track. This action was coincident with the formalization of a joint UNC-NCSU graduate Biomedical Engineering program. Its umbrella organization, CAMS, was reorganized and renamed the Curriculum in Applied Science and Engineering (CASE) currently headed by Nancy Allbritton.

References and notes for Appendix 1

[1] See Chapters 9 & 10 in Warren Ashby's biography, *"Frank Porter Graham, A Southern Liberal."*

[2] January 20, 2004 NCSU Press Release "*Nanotechnology Center Advances Triangle as High-Tech Hub*".

[3] ONR MURI, *"Carbon nanotube based nanotechnology"* ~$5.5M (Otto Zhou, PI)

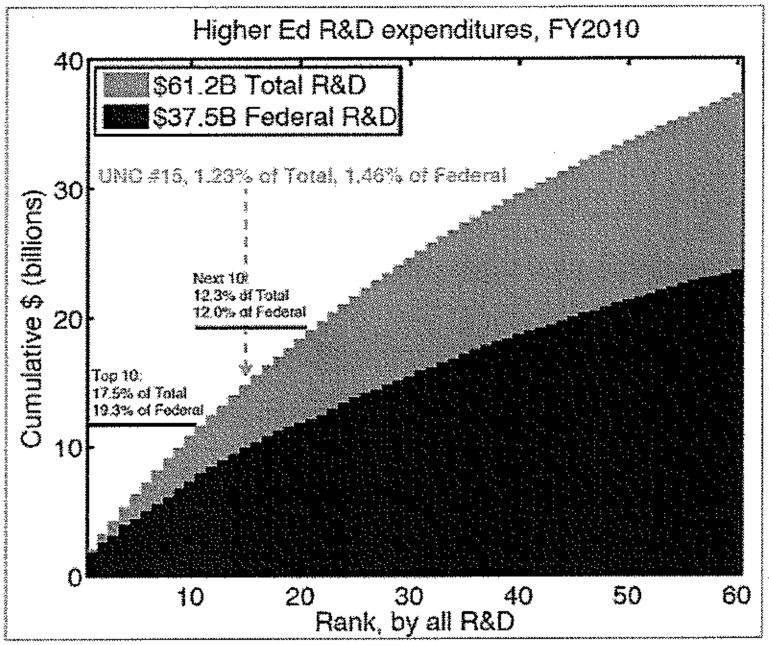
[4] NSF *"Science & Technology Center for Environmentally Benign Solvents"*; ~$17M (Joe DeSimone, co-PI)

[5] NASA URETI *"Biologically Inspired Materials for Aerospace Applications"* ~$3.4 M (Ed Samulski, PI)

[6] Institute for Advanced Materials funding has enabled Carolina to hire the following faculty as of 2011:

- Mike Ramsey (2004): "Lab-on-a-Chip" micro & nanofluidics. (Chemistry)
- Peter Mucha (2005): complex fluids and complex systems. (Mathematics)
- Tom Meyer (2005): photochemistry and energy technology. (Chemistry)
- Rene Lopez (2006): nanofabrication and optics. (Physics & Astronomy)
- Wei You (2006): organic electronic materials synthesis. (Chemistry)
- Nancy Allbritton (2007): materials science applied to biotechnology. (Chemistry/Biomedical Engineering)

Appendix 2. Federal R&D Revenue

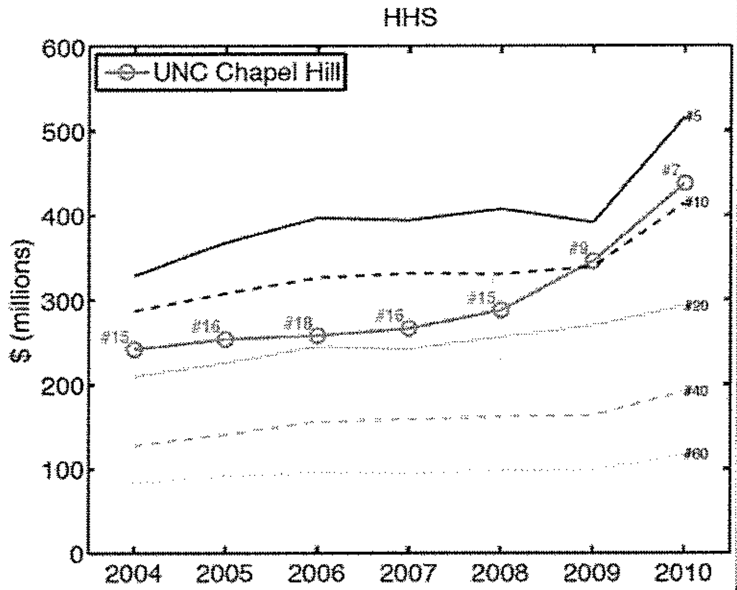


Revenue – In FY2010, UNC Chapel Hill ranked 15th in R&D expenditures ($755M) from all sources including private, with $546M from the federal government (ranked 9th).[7]

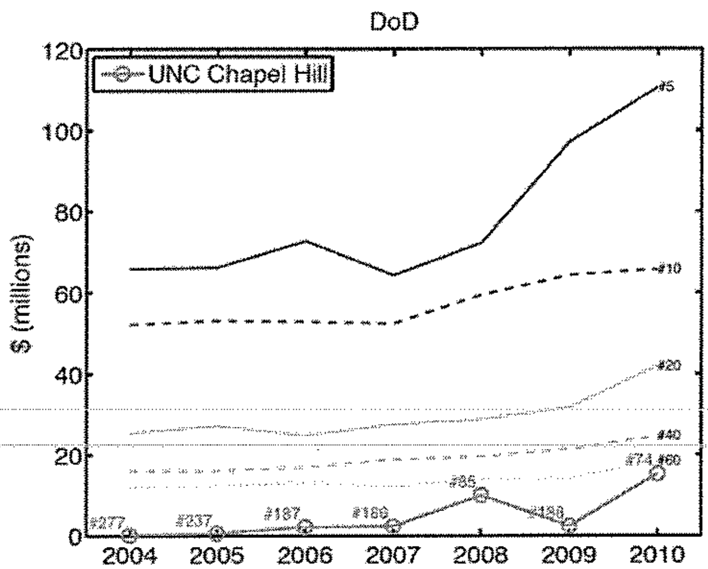
The graphs shown below in this appendix plot selected data about the recent history of Federal and Industrial R&D Expenditures at U.S. colleges and universities, available from the NSF National Center for Science and Engineering Statistics.[8] The vertical axes are millions of dollars.

[7] http://www.nsf.gov/statistics/infbrief/nsf12313

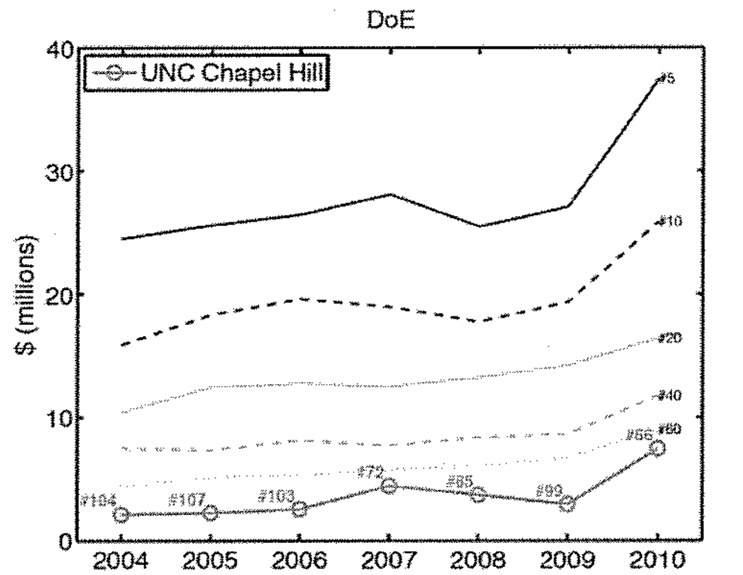
[8] *Academic Research and Development Expenditures series*, FY2004–2009 (http://www.nsf.gov/statistics/rdexpenditures), and *Higher Education Research and Development series*, FY2010 (http://www.nsf.gov/statistics/herd).



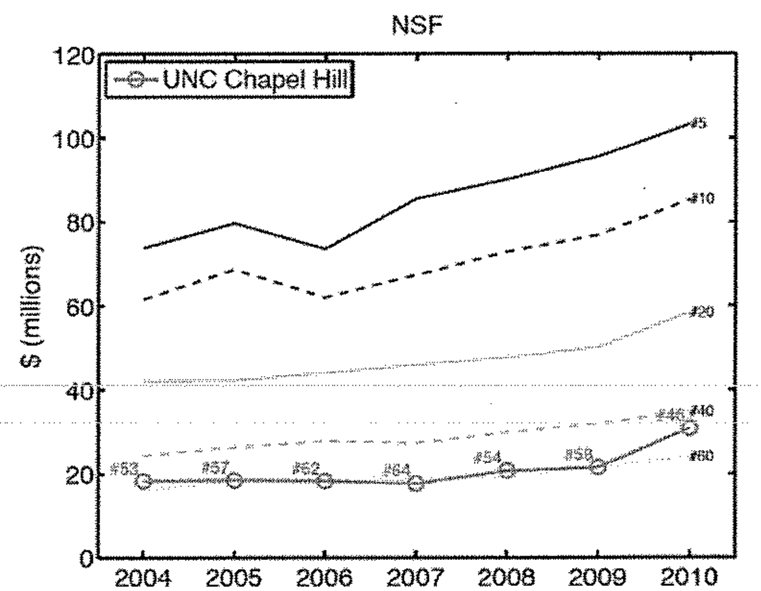
In 2009 UNC entered Top Ten ranking for HHS Revenues.



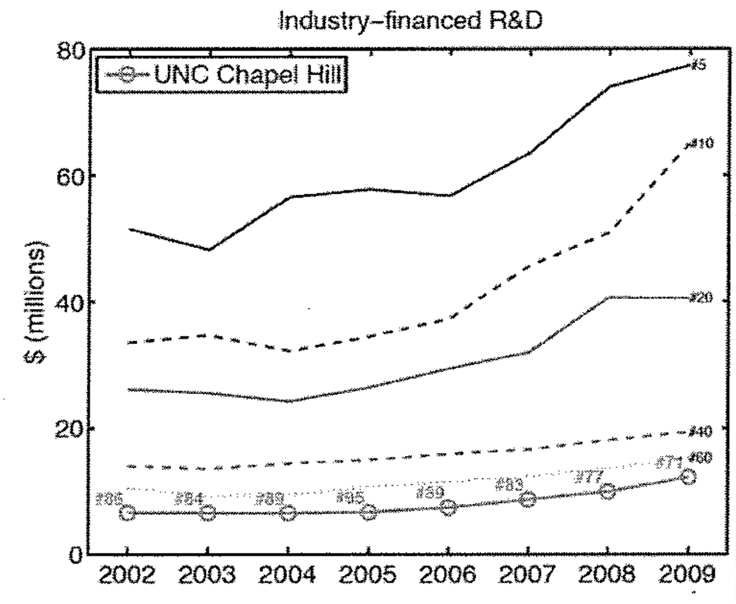
DoD Revenue has not been a high priority for UNC.



The EFRC award helped move UNC into Top Sixty only.



Carolina only recently among Top Fifty for NSF Revenue.



UNC's share of Industry Revenue is very modest.

Appendix 3. Task Force Process

Following its initial day-long meeting, the ASTF held more than a dozen additional meetings (August 2011 – June 2012) to explore ways to enhance the translation of Carolina's pool of natural science talent and knowledge into tangible leaps forward for society. Meetings included both Task Force members and selected other individuals within the College. Care was taken to ensure representation by all natural science stakeholders in the CAS. Deliberations were fully documented and democratic procedures followed.

A number of options for creating an Applied Physical Science capacity at UNC were considered. These various paths, and a summary of the Task Force findings about each, follow:

1) Hire more interdisciplinary faculty into existing departments. - This is the current *modus operandi*. It has had significant impact but has reached the point of diminishing returns.
2) Create a department of APS within CAS that interfaces with multiple departments. - This path was chosen because such a department would leverage existing science and APS strengths on campus while avoiding divided loyalties.
3) Create a School of APS. - This path was rejected as fiscally unfeasible at this time and moreover outside of the scope of this CAS-centric Task Force.
4) Create a pan-university program that draws on multiple schools. - This path was accepted as a future possibility, one that could be initiated at a low level, but that would currently be fiscally draining if pursued to the level needed to effect change.