WORKING GROUP PROPOSAL

TARGET AREAS FOR ENHANCED FEDERAL RESEARCH FUNDING AND MILESTONES TOWARD AN IMPROVED NATIONAL RANKING

A Blueprint for Excellence, New Jersey's long-range plan for higher education, calls upon the leadership of New Jersey's research universities, and other institutions and organizations where appropriate, to work with the representatives of the Commission on Higher Education to establish goals for increasing the state's share of federal research dollars. More specifically, the plan calls for New Jersey's ranking in aggregate share of federal research dollars for higher education to go from 21st (in 2002) to 15th by 2012 (proposed extension from original target of 2010).

During the summer, a small working group was established to (1) identify broad-based federal funding areas that are high priorities for New Jersey and (2) propose interim milestones toward achieving the goal of a significantly improved national ranking by 2012. The following proposal was prepared by the working group for review and discussion by the presidents of the four primary research universities. The proposal will then be shared with other institutions and organizations and the Commission for discussion.

Ideally, targeted areas will be finalized and milestones set by the end of the year. At that time, the research universities, and other institutions where appropriate to their mission, should develop or enhance tactical plans to increase significantly federal research dollars garnered in the target areas and set institutionally specific goals and milestones to work toward the state goal. In addition, state and private sector strategies should be discussed to support institutional efforts.

Proposed Milestones and Targets

We know that many states are now aggressively seeking to increase their share of federal research dollars. New Jersey colleges and universities ranked 21st in the aggregate share of federal research dollars in 2002, the most recent year for which data are available. The state that ranked 15th in 2002 received $448 million, which is $133 million more than that received by New Jersey institutions. Assuming that the state ranked15th increases its federal grant funds at a rate of six percent a year, its funding would grow to $806 million over a ten year period, and New Jersey institutions would need to increase at a much greater percent in order to surpass that figure over ten years. The following projected increases are recommended to achieve the goal of increasing New Jersey's rank to 15th by 2012. Actual growth amounts are not yet known for 2003 and 2004; modest growth is projected initially with more significant increases in subsequent years as indicated below:

2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
315m	334m	354m	379m	409m	446m	490m	548m	621m	708m	807m

These projected increases over a ten-year period would require significant changes in performance that will not be accomplished merely through incremental growth of existing R&D programs. High profile efforts to develop new modes of attracting research funding will be necessary.

As a first step, five key research areas are recommended as targets for New Jersey higher education institutions to focus collaborative and institution-specific efforts. Although federal research funding in all areas will increase funding toward an improved ranking, the following five areas of research represent perhaps the greatest opportunities for significantly increased funding for New Jersey. Each of the areas is particularly important to New Jersey and is likely to offer increases in overall funds available: Stem Cell Research, Biomedically-Related Nanoscience, Homeland Security, Advanced Imaging Technology, and Genomics/Bioinformatics. The areas are summarized on the following pages, including an explanation about opportunity, research focus, and current assets in each area.

STEM CELL RESEARCH

Opportunity: Stem cell research represents one of the most exciting and promising new fields of modern biomedical research. Stem cells offer direct therapeutic potential for a wide variety of major intractable diseases including Alzheimer's, Parkinson's, cancer, diabetes, cardiovascular, and neuromuscular disorders and injuries. Already, relatively crude forms of stem cell therapy (bone marrow transplantation) are accepted modalities in the treatment of a number of hematological diseases and cancer, providing proof-of-principle examples of the potential for wider and more effective application.

Stem cell research also contributes directly to basic studies of molecular and cell biology, developmental biology and genetics, physiology and neuroscience, which are all areas of strength in the state's research universities that will be significantly enhanced with increasing emphasis on stem cell research. Although there are political issues and federal limitations surrounding the study and use of stem cell therapy, they restrict only federal funding of development or experimentation with new human embryonic stem cell lines. Work with existing (approved) lines, adult stem cells, stem cells from model animals, and privately funded research, are not restricted at all. And there is strong likelihood that the federal limitations will be relieved in the future. In any event, substantial funding opportunities exist at the federal, state, and local levels, from many private donors, a growing industry relating to the technology, mature pharmaceutical and biotechnology companies, and a large number of patient advocacy groups.

New Jersey has very important advantages in this regard. In addition to courageous and forward-looking state commitment to the establishment of a major stem cell research center at Rutgers/UMDNJ in New Brunswick, there is a concentration of pharmaceutical and biotech corporations, current internationally recognized stem cell research programs, and the state is the home to several recognized and very effective public spokespersons and supporters for this research, all of which enhance funding prospects. Because of widespread local political support, New Jersey's stem cell center also can serve as a center for public discourse and research in related areas of medical ethics, economics, health care delivery, and health care disparities in relation to this emerging new technology, and attract federal and other funding in this area, as well. A concentration of effort in the field of stem cell biology will not only result in enhanced state research funding but also in the location, or relocation, to the state of developed or start-up companies seeking to exploit this technology, resulting in an even larger critical mass of effort, greater competitiveness for large grants and research contracts, and economic benefit.

Research Focus: Stem cell research in New Jersey will focus in neuroscience and neurological disease and injury, an existing strength, and also in metabolic diseases, cancer, child development, and cardiovascular disease – all areas of clinical strength and interest. Our work in this field also will intersect closely with existing programs in engineering, biomaterials, surface chemistry and materials science, novel devices and nanotechnology, both in our research universities and in the local industrial base. Education and specialized training programs also will provide a stream of capable personnel in this highly technical discipline, helping to ensure continued development and investment.

Current Assets:

Stem cell research: major, recognized programs at Rutgers and UMDNJ and substantial individual-investigator funding in Princeton's Molecular Biology department. Strong clinical programs in near-term areas of application. Strong cooperation among involved institutions.
Biomaterials: existing productive collaboration among Rutgers, UMDNJ, and NJIT scientists.
Local Industrial Base: Johnson & Johnson, corollary research centers: CABM, EOHSI, DIMACS and BioMAPS, Pharmacy, CINJ, Cardiovascular Institute, Child Health Institute
Genetics and Developmental Biology: Princeton, UMDNJ, and Rutgers
Engineering and Nanotechnology: Rutgers, NJIT, and Princeton

BIOMEDICALLY-RELATED NANOSCIENCE

Opportunity: The US government is committed to spending over a billion dollars annually on nanotechnology research. The President's 2004 budget provides $847 million for the National Nanotechnology Initiative (NNI), a 9.5 percent increase over 2003. Five federal agencies are designated as NNI sponsors: NSF, DoE, NASA, NIST and EPA. The Nanotechnology Research and Development Act of 2003 authorizes these NNI agencies to spend $2.36 billion over the next three years on nanotechnology research and development. Furthermore, the 21st Century Nanotechnology Research and Development Act authorizes as yet unquantified support for nanoscience, nanoengineering, and nanotechnology research through the awarding of grants; the creation of nanotechnology research centers; and the formation of a research program to identify the ethical, legal, environmental, and other societal concerns related to nanotechnology. These legislative mandates do not even begin to describe the magnitude of nanotech-related funding opportunities for universities and research institutions, because "nanotechnology" is a gateway term that encompasses broad areas of interdisciplinary science and technology that are central to the mission of every federal funding agency. The NIH Roadmap, for example, includes an entire suite of programs in molecular science and technology as well as a program specifically dedicated to Nanomedicine.

Research Focus: The very breadth and disciplinary diversity of the nanotechnology field introduces the need to define a clearly focused mission and identity that stands out among others. New York and Pennsylvania both have several year's head start in mounting major nanotechnology initiatives fueled by hundred's of millions of dollars of state investment – and they are not clearly the leaders. New Jersey can penetrate with a focus that is unique, and the connection to the needs of the full cross-section of the state's healthcare industry is too important to be overlooked.

New Jersey has a unique opportunity in the nanotechnology field to capitalize on its competitive strengths in the very areas of research, development, engineering, IT, manufacturing, and regulatory compliance that shaped the state's world-class biopharmaceutical franchise. Here we introduce the term "Biomedically-related Nanoscience" to describe nanotechnology-related pursuits directed to either (i) solving biomedical problems or (ii) applying biological principles to the solution of environmental, industrial and/or commercial problems.

NJ's Biomedically-related Nanoscience effort will enable resolution of molecular signatures of health and disease; application-directed nanofabrication of devices of decreasing size (top-down); biomimetic assembly of molecular constructs of increasing complexity (bottom-up); and broad, transdisciplinary use of biological principles in designing efficient and effective industrial processes and systems. Commercial applications include not only healthcare and the broader life sciences marketplace, but also major industrial, environmental, public health and welfare problems whose solutions may be informed by the behavior of complex molecular ecosystems that make up biological cells, tissues, organs, and organisms. Such an endeavor will embrace all of the talents in our universities as it truly requires equal parts of molecular and cellular biology, clinical medicine, physical science, information technology, and engineering to produce functional structures that mimic, repair, replace or improve biological function.

Current Assets: Among the state's universities, military labs, federal research facilities, and the private sector, NJ is rich in resources that fueled the growth of the state's pharmaceutical franchise and are being reinvested in new technology discovery, translation and commercialization. Core competencies within NJ universities and research institutes include:

NJIT: Biomedical engineering; molecular, cellular and tissue engineering; advanced materials, engineered nanoparticulates and nanofibers; nanoscale separation technologies; microfabrication and nanoscale fluidics; biomedical sensors, transducers and actuators; and nanoscale production, processing and monitoring technologies.

PHRI: Genomics, proteomics and microarray technology; Molecular Beacons for real-time detection of molecular and cellular events; molecular biology and molecular genetics, including molecular mechanisms of infectious diseases and cancers; public health and safety.

Princeton: Integrated photonic devices, sensors, organic/flexible devices; optoelectronic technologies for development of inexpensive, lightweight, low energy displays, large area electronics, lighting systems, solar cells and transistor circuits; nanoimprint lithography for cost-effective, high-resolution manufacture of devices such as optical displays, data storage, MEMS and semiconductor devices; DNA processing and analysis devices; organic/inorganic interfaces; self-assembly and surface patterning.

Rutgers: Nanostructured materials and nanoscale devices; inorganic/organic nanotechnology; surface modification, nanophotonics, nanoelectronics and nanosensors; bio-nano-robotic systems; nanofabrication and nanolithography; nanoscale chemistry (catalysis); critical enabling devices; multimodal sensors; smart packaging using nano-porous alumina substrates; nano-biopharmaceuticals.

Stevens: Microchemical systems, miniature power generation and safe on-demand production of critical chemicals; ultra-high heat and mass transfer; micro-volume control for chemical reactors; just-in-time production (reducing transport of hazardous materials); multifunctional surface design via thin films; micro-kinetic test beds and rate mechanisms for micro-reactor design; hierarchical models of integration from systems point of view.

UMDNJ: Bioinformatics (including genomics, proteomics, and microarray), cellular and molecular biology, signal transduction, molecular modeling, rational drug and vaccine design, protein structure/function analysis, structure, design, and molecular compatibility of biomaterials, medical imaging, medical devices, drug delivery, and cardiovascular and neurobiology research.

HOMELAND SECURITY

Opportunity: "At $803 million, the 2004 Budget for the Department of Homeland Security's (DHS) science and technology activities represents almost an eight-fold increase in funding over the 2002 Budget. DHS will develop and implement a long-term research and development program that includes investment in revolutionary capabilities with high payoff potential. DHS will harness the expertise, energy and ingenuity of the private sector, academia and government labs to develop and produce advanced technologies, systems, and procedures needed for homeland security. In 2004, $350 million in new funding is requested for vigorous research, development, test, and evaluation capabilities. In addition, funds will support the development of standards for homeland security equipment that will be used by the state and local first responder community for dealing with current and emerging threats. Finally, research and development activities will be funded to enhance the broad spectrum of missions within the Department, such as improving capabilities for inspecting cargo and processing people at our borders, and dealing with natural or man-made disasters." (OMB Budget Statement for DHS).

In addition to overt DHS funding, other agencies will fund research and development activities that support the underlying technologies for improved homeland security. As a new entity, DHS R&D funding is not already precommitted to a well established base of universities. The practical, application and standards focus of NJ's Homeland Security Technology Systems Center opens the door to immediate funding for technology evaluation and standards setting, while creating the framework to understand the research issues from the ground up.

Research Focus: The application areas for homeland security include:

- Emergency Preparedness and Response
- Defending against Catastrophic Threats
- Protecting Critical Infrastructure and Key Assets
- Border and Transportation Security
- Intelligence and Warning
- Domestic Counterterrorism

The technologies for improvement in security across each of these domains tend to be cross cutting and track the following focus areas established in the NJ Jobs Growth and Economic Development Commission study on academic research.

Information technologies:

- Collaborative Computing & Decision Support Systems
- Data-mining & pattern recognition technologies
- Cyber Security & Intrusion Detection
- Cryptography and Steganography
- Disaster & Response Modeling & Simulation

Telecommunications

- Wireless Communications (high speed, high bandwidth, long range digital communications)

- Communications Interoperability
- Ad-hoc networking
- Remote sensor monitoring
- Asset Tracking Systems

Life Sciences & Healthcare

- Toxin & Infectious Disease Diagnosis & Treatment
- Syndromic Surveillance & Disease propagation modeling
- Mass Casualty Response

Materials

- Protective Materials for Hazardous Environments
- Novel Sensor Materials
- Toxic Chemical, Biological Agent and Fire Suppressant/Containment Materials
- Portable/Renewable Energy Sources

Sensors and Devices

- Chemical Nuclear Biological and Radiological Detection Systems for Air/Water/Land
- Robotic Systems for Inspection & Interdiction
- Biometric Identification Technologies
- Perimeter and Infrastructure Intrusion & Tampering Detection

Current Assets: Among the state's universities, military labs, federal research facilities, and the private sector, NJ is rich in resources that span all of these application and platform areas.
Information Technology: DIMACS(RU); Human Computer Interaction (NJIT); Public Health Alert System (NJDHHS & NJIT - HAN/LINCS); Collaborative Computing (Turoff/Hiltz – NJIT); Center for Advanced Information Processing (RU); Lucent Bell Labs; International Intermodal Transportation Center (NJIT)
Telecommunications: WINLAB (RU); Center for Communications & Signal Processing (NJIT); NJ Center for Wireless & Internet Security (NJIT co-Princeton & Stevens); Verizon; Lucent Bell Labs; NJN; Sarnoff Labs
Life Sciences & Healthcare: NJ Center for Biodefense (UMDNJ); NJ Center for Public Health Preparedness (UMDNJ); Public Health Research Institute (Newark); Center for Advanced Biotechnology & Medicine (RU)
Materials: Polymer Processing Institute (@NJIT); PRISM (Princeton); NJ Center for Biomaterials (RU co-UMDNJ & NJIT); Center for Membrane Technology (NJIT)
Sensors & Devices: Micro-fabrication Center (NJIT); Terahertz Imaging Lab (NJIT); NJ Center for Microflow Control (NJIT); York Center for Environmental Engineering & Science (NJIT); Center for Advanced Food Technology (RU); Princeton Plasma Physics Lab; New Jersey Nanotechnology Consortium (Bell Labs); Sarnoff

ADVANCED IMAGING TECHNOLOGY

Opportunity: Imaging has applications to medicine and biology, homeland security, engineering and materials science, nanotechnology, computer science, and many other crucial fields of science and technology. Important advances are being made in imaging hardware and software, as well as in information processing and distribution. The NIH has made a commitment to enhanced support for biomedical applications of imaging through it new director, Elias Zerhouni, himself a radiologist, because of the potential for providing immediate improvement in disease detection and diagnosis and patient care. Advanced imaging capabilities will make the state's health care institutions more competitive for large clinical grants and contracts in treatment and prevention. The Department of Homeland Security has a major interest in accurate, high speed technologies for identification of individuals at portals of entry into the nation, and surveillance of transportation routes for detection of movement of hazardous agents or weapons, areas of current research in New Jersey's research centers, among other initiatives. Related areas such as structural biology, rational drug design, cell biology and physiology, also benefit greatly from advanced imaging and image processing capabilities, and would add to the competitiveness of these New Jersey strengths in their attempts to enhance funding through large-scale, multidisciplinary and multi-institutional grants and contracts.

Research Focus: Areas of focus for New Jersey research universities include biology and medicine, including both clinical and basic research; nanotechnology, engineering and image processing, including both hardware and software development; homeland security; telecommunications; and transportation. A special emphasis will be placed on the intersection of image processing and data distribution and clinical research in biomedicine, combining many strengths of the state's universities and industrial base. An additional niche for the state's efforts in this area will be the application of advanced imaging techniques to stem cell research, a field with considerable potential.

Current Assets:

- Biological Imaging: Rutgers - Biomedical Engineering and Computer Science, structural biology, DIMACS and BioMAPS; UMDNJ - 500 and 600 MHz NMR, standard MRI and PET (position emission tomography) machines, a high resolution 3T MRI, and a PET/CT scanner; NJIT – a field emission scanning electron microscope, an Energy Dispersive X-Ray Spectroscope, an energy transmission electron microscope, an electron energy loss spectroscope, novel ultra-sonic imaging systems fabrication, and Terahertz imaging technology

- Information Processing: Rutgers - CAIP, mathematics and computer science, electrical and computer engineering; NJIT – multi-spectral image analysis, advanced pattern recognition, organ modeling, and virtual reconstruction

GENOMICS / BIOINFORMATICS

Opportunity: Biology is at a crossroads in its history. The complete genetic blueprints of a number of viruses and single-celled organisms such as bacteria and yeast are now in publicly held genome databases, and more are being added each year. The mapping of the human genome sequence, an enormous scientific undertaking and achievement, was completed in 2003. Improvements in technology in the area of structural biology have led to a virtual explosion in the number of biological molecules for which we have the 3-dimensional structure at angstrom-level resolution.

This avalanche of new information in genomics and structural biology poses a fundamentally new challenge for biologists who are studying the principles that drive the *integration* of information in complex biological systems. There is a need to deal with the explosion of information based on the genomic sequences of the human and all major experimental organisms. With complete genetic blueprints that will give us the identities of all biological molecules almost in hand, there is now an exciting opportunity to study how the component parts are assembled into the whole. The problem is a fundamental one, and its solution requires, in addition to existing paradigms of molecular biology, new sets of analytical tools that are likely to come from outside the discipline of biology. Biologists must seek the assistance of researchers trained in physics, chemistry, computer science, mathematics, engineering, and other fields that routinely manipulate large datasets, manage complexity, and address problems of integration, to collaborate on these solutions.

The importance of research in genomics and bioinformatics aimed at understanding the molecular basis of disease to issues of human health and well-being is obvious. Such maladies as Parkinson's disease, cancer, Pendred syndrome (deafness), tumor suppression, neurological disorders, and developmental disorders are the target of ongoing research efforts in this area. In 1989 a new National Human Genome Research Institute was established within the National Institutes of Health to specifically focus upon understanding the structure and function of the human genome and its role in health and disease. NHGRI supports the development of resources and technology that will accelerate genome research and its application to human health. Its funding level has increased significantly during its short existence, with a budget of $479 million in FY 2004. Congress has routinely treated NIH favorably in terms of appropriations, in recognition of the national priority that behavioral and biomedical research enjoys by virtue of its relevance to and impact on the long-term health of the human race. New Jersey's research institutions, with their breadth and depth of expertise in the varied disciplines that collectively contribute to the fields of genomics and informatics, are well-placed to take advantage of the anticipated continuing emphasis in terms of funding priorities - - both via the federal government and private sponsors - - to this challenging and expanding field of scientific study.

Research Focus: The applications for genomics/bioinformatics are widespread and cross-cutting, in terms of biomedical and behavioral implications. Broadly speaking, the following represent specific areas of research opportunity and potential focus:

- Genomics
- Biophysics
- Computational neurobiology
- Systems biology

- Population biology
- Quantitative genetics
- Molecular evolution
- Computational biology
- Microbial interactions

Current Assets:

Princeton: The Lewis Sigler Institute for Integrative Genomics and the Department of Molecular Biology have major research programs focusing in the following areas:

- Developing realistic and quantitative models of biological processes;
- Collecting large-scale data sets comprehensively describing biological processes.;
- Devising new and improved methods for computational analysis and display of complex models, structures and data;
- Providing applied solutions to specific biological question in the subject areas of
    - spatial patterning during development;
    - intracellular signaling and transcriptional networks, and
    - virus-host interactions.

Rutgers: Protein Data Bank (a world-wide resource for structural biology and genomics), Human Genetics Institute (one of the world's largest repositories of genetically defined cell lines and related resources, and centers for genetic analysis of human disease), BioMAPS, DIMACS, Biostatistics Center, Waksman Institute (plant genomics), Cell Biology and Neuroscience, Cook College Biotechnology Center and Agricultural Experiment Station

UMDNJ: Informatics Institute (conducts research in bioinformatics and computational approaches to biological problems using a powerful Sun Microsystems F6800 server and Dell and Silicon Graphics workstations for molecular modeling and sequence analysis); Center for Applied Genomics (multi-institutional collaboration with PHRI and NJIT develops DNA and protein chip technology for use in medical and biological research); Center for Human and Molecular Genetics (employs molecular screening technologies to study the occurrence and distribution of genetic disorders in populations), Center for Advanced Proteomic Research (provides a wide array of sophisticated instrumentation for analyzing the expression and structure of proteins), Center for Advanced Biotechnology and Medicine - jointly operated by UMDNJ and Rutgers (conducts Proteomics research)

NJIT: Micro-array and micro-analytic device technology sustained by Class-10 Micro-fabrication Center and additional support through access to NJ Nanotechnology Center SFRL. Center for Applied Genomics (multi-institutional collaboration with PHRI and NJIT develops DNA and protein chip technology for use in medical and biological research). Computational biology program in Mathematical Sciences and Sloan Foundation supported cross-disciplinary Bio-Informatics program and research teams; Directed Molecular Engineering program; Bio-chemical and bio-chemical engineering researchers..