Office of the President

University Strategic Plan

Scholarship Domain: Discovery

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Introduction

As a land-grant university, Virginia Tech embraces the intrinsic value of research and creative scholarship. In the broader context of "discovery," cutting-edge research and innovative and creative scholarship define the university's role as a forward-looking institution. The discovery mission infuses learning and engagement with a sense of direction, fostering collaborative learning and motivating engagement with the broader community. Discovery enables Virginia Tech to invent a new and better future; it leads to progress in the material sense and to economic development and increased investments. Discovery results in a purposeful, self-reflexive enlightenment, one that takes into account the needs and perspectives of others.

Economic engines fuel the need for a focused approach to discovery at Virginia Tech, the commonwealth, the nation, and the world. A fundamental restructuring of how state-sponsored universities are funded is under way. Coupled with potential cutbacks in federal research funding associated with budget deficit reduction efforts, these changes in funding bring an enhanced sense of urgency to maximize the effective and efficient use of both current and new resources in order to reach Virginia Tech's expenditure target of $540 million per year by 2012.

The pace of change in publicly supported research funding has quickened, and expectations for return on investment have increased. It is important to develop approaches that allow needed adjustments to be made and to continue the support of core values of a major land-grant university.

The goal of $540 million in National Science Foundation (NSF)-measured research expenditures has been established in parallel to emulating Association of American University (AAU) institutions. To obtain $540 million in NSF-measured research requires externally sponsored research of $375 million in expenses by 2012, yielding a growth rate of 13.5 percent per year. (The 2012 balance, $165 million in NSF expenditures, will come from internally generated expenditures from research-related activities.)

To achieve these objectives, Virginia Tech must enhance its research portfolio with interdisciplinary, multi-college/department efforts fostered by the largest university institutes, in contrast to the single primary investigator (PI) model that has been the most prevalent form of past research. Research expansion will be strategically catalyzed by the growth of new research activities in the National Capital Region and by the continued exploration of partnerships with other institutions.

Success in all missions of the university is dependent upon the caliber and effectiveness of the faculty, but it is especially critical for success in the area of discovery. Recognizing the highly competitive nature of today's research environment, it is essential that areas of research focus be identified that show significant growth potential and build upon existing faculty strengths. It is also essential that we contextualize new discoveries, bearing in mind the global and sociopolitical landscape of the 21st century. The strengths of Virginia Tech's research capabilities include the ability of the university's largest institutes to leverage intellectual and resource capital to achieve these ambitious goals.

The university's institutes include the

- Institute for Critical Technology and Applied Science (ICTAS),
- Institute for Biomedical and Public Health Sciences (IBPHS),
- Virginia Bioinformatics Institute (VBI),
- Virginia Tech Transportation Institute (VTTI), and
- Institute for Society, Culture, and Environment.

Within this institutional context, four discovery areas of immediate strategic focus within the broad array of programs consistent with the university's comprehensive mission have been identified for emphasis during the current planning period:

- Energy, materials, and environment;
- Social and individual transformation;
- Health, food, and nutrition; and
- Innovative technologies and complex systems.

These areas take advantage of the existing strengths of the Virginia Tech faculty, including the significant contributions of the university's research faculty, post-doctoral students, and graduate students, while addressing some of the most significant issues confronting global society. There are significant overlaps at the interfaces of these four areas, and they provide a wealth of opportunities for those willing to work collectively across traditional boundaries imposed by disciplines and institutional history. In fact, the most significant opportunities will probably occur at the interfaces, with the innovative technologies and complex systems area viewed as a central, common catalyst for change. Institutions that can marshal the essential resources from a variety of sources and maintain the necessary focus will be those that will continue to progress in a highly competitive world.

Catalyzed by the goal of advancing Virginia Tech to be among the top research universities, a major strategic element of the current plan, significant effort has been

expended at the college and university levels to identify and define these four areas of investment and to begin to develop the resources and individual programs needed to successfully bring these areas to maturity. During this strategic planning period, total research expenditures, as reported to the National Science Foundation, are expected to grow to $540 million per year.

This ambitious target will require disciplined investments, responsive and aggressive pursuit of funding opportunities, and streamlined internal operations designed to remove barriers to success. The research agenda requires substantial investments in new and improved facilities, sophisticated equipment, and people.

Energy, Materials, and Environment

Much of the technical knowledge that will transform our society by advancing our understanding of complex systems and by developing technologies that promote an improved quality of life resides in the fields of *energy, materials, and environment.*

These three fields are inherently interwoven in a way that requires both intensively focused and broadly multidisciplinary research activities. This multifaceted research approach can be initiated by building on the strong technical base that already exists at Virginia Tech and that will be expanded by providing mechanisms to allow researchers to converge into multidisciplinary groups to tackle the challenges associated with complex systems within the university and in the National Capital Region (NCR).

The institutes at Virginia Tech will provide this mechanism for multidisciplinary collaboration; e.g., several of the research projects supported by the Institute for Critical Technology and Applied Science (ICTAS) have their roots in the fields of energy, materials, and environment.

Many of the recent and planned investments in equipment and research facilities and the clustered faculty searches have been aligned with the university's priorities within these fields. Continued efforts will be made to maintain this research foundation; to establish new, internationally recognized research programs within these fields; and to apply this technical expertise to fashion a sustainable future both nationally and globally.

Energy

In 2006, 40 percent of the U.S. energy needs are petroleum-derived, with more than 60 percent of the oil imported. With fossil fuels contributing 85 percent of our energy, combustion by-products generate significant pollution problems. Of greatest concern are greenhouse gases that have contributed to record global temperatures and the threat of climate change.

As international pressure on the U.S. mounts and with increasing awareness of the environmental costs associated with the global buildup of these pollutants, demand is growing for environmentally friendly sources of energy. Fossil fuels are also finite resources, and except for coal, economically retrievable fossil fuels will rapidly decline in this century. Remaining large oil reserves are concentrated in politically unstable parts of the world, contributing to price volatility and international tensions to assure access to these resources. Hence, efforts are needed to increase energy conversion efficiency, to reliably and securely distribute energy to meet industrial and consumer needs, and to reduce demand through the design of energy-efficient systems.

Building upon existing faculty expertise to form an energy research consortium, Virginia Tech is poised to become a national leader on energy supply, distribution, and utilization in clean coal, fuel cell, bio-renewable fuels, solar, wind, and nuclear energy. The research consortium has the potential to eventually lead the nation's research efforts on energy sources yet to be envisioned.

Although coal is a carbon-based fuel, we must rely on it for years to come, and Virginia Tech is already a national leader in clean-coal technologies and emerging research in sequestration.

There is also renewed interest both nationally and in Virginia in nuclear energy, where Virginia Tech can play a substantive role in developing safe and reliable nuclear power.

Virginia Tech has leading national expertise in the College of Natural Resources and the College of Agriculture and Life Sciences in forest, fiber, and agricultural systems and the utilization of these renewable resources.

Additionally, the university benefits from significant expertise in the College of Engineering and College of Architecture and Urban Studies, with the Myers-Lawson School of Construction, in designing and constructing efficient "green" buildings, vehicles, power systems, processes, communities, and public policies.

Potential directions for research include building virtual environments to understand energy and environmental problems, e.g., a virtual nuclear reactor, energy grid, mixed energy supply logistics, building design and construction practices, emerging energy technologies, identification and sequestration of pollutants, and mineral processing and geological issues.

Transportation issues remain a major challenge to mobility and safety throughout the U.S. and abroad. Within the U.S. we are experiencing increased congestion on roadways and within the air transportation system. In addition, the U.S. is experiencing rising fuel costs and higher numbers of crashes on our highways, resulting in an increased need for efficient and cost-effective mass-transit systems. Challenges exist related to technical issues, policy matters, and societal impacts.

Virginia Tech is a major contributor to the development of solutions for these issues. The Virginia Tech Transportation Institute (VTTI), the largest university-level research center at Virginia Tech, focuses on solving major transportation problems related to the use of technology to improve transportation safety, diminish traffic congestion, and reduce transportation infrastructure costs.

Likewise, faculty in departments across the university are addressing technical and policy matters that provide improved safety for passengers, more efficient systems for the transport of goods throughout society, and advances in technologies that will produce safer and more fuel-efficient means of transportation.

Materials

Virginia Tech has long enjoyed an international reputation in materials research with strengths in polymeric, ceramic, metallic, composite, electronic, optical, computational, and biological materials. With the *MicrON* clean room renovation, the hiring of advanced materials and nanomaterials faculty in the College of Engineering and the College of Science, and the Advanced Materials Characterization Facility in ICTAS**,** Virginia Tech is prepared to establish a research presence in inorganic nanomaterials, which complements its well earned reputation in organic nanomaterials, and to address the field of active materials.

Active materials, which encompass smart materials (such as those studied within the Center for Intelligent Material Systems and Structures) that sense and adapt to their environment, is a developing research area that Virginia Tech is uniquely positioned to fill. Applying similar techniques to biomaterials will be an important step in preventive and regenerative medicine that is critically needed for NASA's flight to Mars and for improved medical care on the battlefield.

Virginia Tech's role in the National Institute of Aerospace consortium of universities and NASA Langley Research Center will be used to broaden and support our research progress in these areas. One can envision a distributed network of nanoprobes that relay sensory data to one another, carry out data analysis to form

decisions, and initiate appropriate actions – for example, an *in-vivo* nanosensor array designed to seek out and destroy cancerous cells without interfering with an individual's quality of life.

To achieve this and more, Virginia Tech has continued its research in computational materials with System X and the CAVE and other high performance computational systems available across campus in intelligent material design, fabrication, characterization, and manufacturing and in its cross-disciplinary/cross-college research on materials applications.

Environment

Environmental research at Virginia Tech is broadly based in that it spans multiple scales and is evident in every college and focus area of this strategic plan. As a result, this section targets additional areas of environmental research that are particular strengths and growth areas.

First, Virginia Tech has a core strength in water quality-related research from engineered treatment technologies to watershed-scale and geospatial-scale investigations. Our efforts have historically mimicked federal funding efforts, which are largely focused on short-term problems with decentralized and uncoordinated funding agendas. A recent National Research Council report, *Confronting the Nation's Water Problems: The Role of Research*, 2004, has begun to influence the funding agenda for water.

At the same time, Virginia Tech has the potential to merge many existing and new efforts focused on water quality research to meet the growing funding trends in this area. For example, the proposed establishment of a Center for Metropolitan Watersheds, a coordinated effort across five colleges, the Virginia Water Resources Research Center, and the National Capital Region, is an example of how Virginia Tech can position itself to be a leader in water quality research.

Similarly, environmental research in the atmospheric sciences has traditionally been very segregated, despite obvious overlaps between the sub-disciplines that comprise atmospheric science research. This is a growth area for Virginia Tech, and an effort is under way to develop programs and to integrate cross-disciplinary research in this area.

A substantial priority for the future is environmental health. The National Institute for Environmental Health Sciences (NIEHS) has a strong focus on environmental health, particularly through its various center efforts. Virginia Tech has a strong environmental research infrastructure and, through the School for Biomedical Engineering and Science and its collaborations with the Virginia College of Osteopathic Medicine and the Wake Forest University School of Medicine, is uniquely positioned to coordinate efforts with a focus on environmental health sciences. This focus will include a range of existing health and environment research efforts, including the developing fields of nanotoxicity and environmentally mediated neurotoxicological pathways.

Goal I. Strengthen research activities, with a focus on energy.

Strategies:

- Initiate an energy research consortium focused on energy supply (clean-coal, fuel cell, bio-renewable fuels, solar, wind, and nuclear), distribution, and utilization.
- Explore research opportunities in clean coal technologies and the emerging area of research in sequestration.
- Investigate research possibilities with a focus on nuclear energy.
- Explore the research areas of forest and fiber systems and the utilization of these renewable feedstocks.
- Collaborate on efforts that involve the designing and constructing of efficient "green" buildings, vehicles, power systems, processes, communities, and public policies.
- Develop cross-disciplinary directions for research efforts that include building virtual environments to understand energy and environmental problems, e.g., a virtual nuclear reactor; energy grid; mixed energy supply logistics; building design and construction practices; emerging energy technologies including bio-renewable fuels, identification and sequestration of pollutants, and mineral processing; and geological issues.
- Continue to address technical and policy matters that provide improved safety for passengers, more efficient systems for the transport of goods throughout society, and advances in technologies that will produce safer and more fuel-efficient means of transportation.

Goal II. Strengthen research activities with a focus on materials.

Strategies:

- Establish research initiatives in polymeric, ceramic, metallic, composite, electronic, optical, computational, and biological materials.
- Capitalize on the recently renovated *MicrON* clean room.
- Capitalize on the Advanced Materials Characterization Facility in ICTAS.
- Continue aggressive research in high-performance computational systems.
- Establish research initiatives in intelligent material design, fabrication, characterization, and manufacturing.

Goal III. Strengthen research activities with a focus on the environment.

Strategies:

- Strengthen research partnerships designed to examine water quality.
- Establish a Center for Metropolitan Watersheds.
- Establish and strengthen research initiatives in atmospheric sciences.
- Strengthen multidisciplinary research partnerships focused on environmental health, including the areas of nanotoxicity and environmentally mediated neurotoxicological pathways.

Performance Measures:

- Achieve recognition as one of the top three research institutions that focuses on cross-disciplinary and interdisciplinary research as it relates to the discovery of new technologies that lead the United States to a robust, independent, and sustainable energy supply (traditional and renewable sources) in an environment with clean air and a safe and secure water supply.
- Strengthen existing expertise and build research capacity in both inorganic and organic nanomaterials in support of the above.
- Leverage the resources, facilities, and cross-disciplinary working environment of the Institute for Critical Technology and Applied Science for the discovery of new technologies and for the shaping of emerging policy in support of the above, both in Blacksburg and the National Capital Region.

Social and Individual Transformation

The Social and Individual Transformation component of the Discovery Scholarship Domain is central to Virginia Tech's mission as a land-grant university. The dynamics of economic, social, political, technological, environmental, and cultural change are at the heart of this area of research and creative scholarship, which has application in domestic and international public policy and all aspects of community life.

Building on strengths and accomplishments, faculty members across multiple colleges are poised to contribute in substantial ways to understanding and affecting social and individual transformation. With a strong commitment to inter- and multi-disciplinary approaches; with the use of Virginia Tech's strength in technical areas to leverage creative scholarship, research, and innovation in the humanities, arts, and social sciences; with the creation of a sharper research focus; and with the strategic investment of new and reallocated resources, the prognosis for success is high.

In today's fast-moving and highly interdependent world, the foundations of social well-being and the quality of individual and community life — employment, health, housing, education, income, security, mobility, environmental quality, and cultural expression and vitality — are more dependent than ever on the complex interactions between the flows and permanencies among capital, ideas, technology, and people.

Scholarship in this area will focus on the causes and consequences of the increased interdependence of economic, social, political, and institutional systems. Research based in social and individual transformation touches both societal and individual life, extending from public policy to personal identity and including explorations of the constructions of race, ethnicity, class, and gender. The results will assist in understanding and addressing critical and emerging issues at the societal and individual levels and contribute toward planning for a sustainable future.

Research at the intersections of individual and society requires innovative and creative thinking from multiple viewpoints and garnering the strengths of multiple disciplines. Examples of these intersections include research in cognition, brain, and behavior; the analysis of democratic systems; the transformative effects of technology on society; new media and communication technologies; language and symbolic systems; the quantitative study of society; literature, and information technology; and the interface between the humanities and sciences in the study of symbolic thinking and practical environments.

Creative scholarship and research in these and related areas require university structures that promote innovation and reward collaboration across disciplines. Making sense of and anticipating the effects of cultural, economic, and sociopolitical shifts are essential for survival and prosperity. Discovery that enables people and communities to interpret, assess, critique, create, and influence the social, economic, political, and cultural will make a difference.

Virginia Tech has a distinguished record of research in many aspects of social and individual well-being and the quality of community life and is committed to strengthening the capacity of the university to address social and individual transformation within the commonwealth and the nation as we move into an increasingly globalized, post-9/11, neoliberal era. Virginia Tech will develop cross-disciplinary and interdisciplinary approaches that are both theoretical and applied and that are of relevance at every scale, from the human body and the individual to the local community, the region, the state, the nation, and the world.

A proposed Institute for Society, Culture, and Environment (ISCE) will be organized as a university-level comprehensive research institute to foster a creative, interactive, and multidisciplinary environment for intellectually important research and creative effort in the social sciences, humanities, and arts. ISCE can build a diverse portfolio of projects in the Social and Individual Transformation area of strategic focus. This institute also will serve as the main nexus for externally funded interdisciplinary research and creative artistic endeavors.

The principal foci of applied research on social and individual transformation will capture primary concentrations of existing scholarly strength with the potential to engage in multi- and cross-disciplinary efforts to address the implications of globalization for individuals, communities, and regions. These foci are

- governance and globalization;
- community arts, built environments, and urban formations;
- human development and behavioral health;
- rhetoric, representation, and public humanities; and
- social complexity and individual risk.

The proposed institute's activities are projected to cover the Blacksburg campus and to deploy a significant fraction of its efforts in the National Capital Region (NCR). The institute will amalgamate existing strengths in the colleges to form a cohesive program, addressing critical emerging issues in society. An area of focus will be an institute in global issues, and others will be identified in an ongoing implementation process.

The Virginia Tech Alliance of Social, Political, Ethical, and Cultural Thought (ASPECT), a graduate program implemented in 2005, contributes to the development of overarching theoretical aspects of social transformation, including, for example, comparative perspectives on relationships between technology, science and democracy; theories and practices of civil society; analysis of cultural forms of neo-liberalism; migration and citizenship; class, race, gender, nationality, and ethnicity; bio-ethics and bio-power; and media and representation.

Cultural vitality is a critical component of social well-being, creative expression, and quality of life, and Virginia Tech's contributions will be focused on the local and regional scales. The construction of a new Performing and Visual Arts Center will be catalytic in developing the arts. The arts are a clear and direct expression of cultures and global interconnectedness, providing a means of access to societal and individual diversity through multiple artistic vocabularies. Theatre, music, visual art, new media, and dance are valuable tools in opening difficult conversations in societies by exploring values, self-interests, and concerns of the community.

The Virginia Tech Collaborative for Creative Technologies in the Arts and Design (CCTAD) is committed to the transformative power of the arts and to exploring the intersection between human creativity and technology, focusing on digital and interactive art. CCTAD will work closely with the Art Museum of Western Virginia to establish the New River Valley and Roanoke region as a setting for innovative, world-class art and artists.

Public education, from preschool through college, represents an essential element of social transformation. Virginia Tech is positioned well to be a national leader in developing solutions to a particularly pressing problem: enhancing teaching and learning in science, technology, engineering, and mathematics (STEM). Working with public and private partners, the strengths of the university in STEM areas are increasingly being brought to bear on issues such as improvement of curriculum and pedagogy, examination of socio-cultural factors related to student success, career choice and access to curriculum, and development of best practices in the preparation of personnel as leaders and change agents.

Goal I. Establish the *proposed* Institute for Society, Culture, and Environment to foster collaboration and creative efforts in the arts, humanities, sciences, and the university's other major institutes.

Strategies:

This proposed university institute will form the nexus for interdisciplinary research efforts addressing critical emerging issues in society and will serve as a complement to the existing major university institutes on problems of mutual interest. An overarching theme in these research areas is an integration of multi-disciplinary skill sets to address crucial aspects of global and regional interdependence. While a number of existing institutes concentrate in some of these areas, the proposed institute will actively integrate researchers in the humanities, social sciences, and science.

Goal II. Strengthen the Virginia Tech Alliance of Social, Political, Ethical, and Cultural Thought (ASPECT).

Strategies:

Explore research areas that encompass comparative perspectives on relationships between technology, science, and democracy.

Engage faculty members and graduate students in examining theories and practices of civil society.

Provide opportunities for the analysis of cultural forms of neo-liberalism, market institutions, migration and citizenship, bio-ethics and bio-power, and media and representation.

Goal III. Expand the Metropolitan Institute in the National Capital Region.

Strategies:

Create opportunities to produce research on the impacts of advanced Geographic Information Systems on the economic and demographic dimensions of urban development.

Support research in the areas of suburbanization and quality of life.

Create research collaboration that examines “green,” “brown,” and “sustainable” models and practices of interlinked urban and rural development and fair growth and housing affordability.

Goal IV. Establish the Virginia Tech Performing and Visual Arts Center.

Strategies:

Construct a new Performing and Visual Arts Center that will be catalytic in developing the arts. The arts are a clear and direct expression of cultures and global interconnectedness, providing a means of access to societal and individual diversity through multiple artistic vocabularies. Theatre, music, visual art, new media, and dance are valuable tools in opening difficult conversations in societies by exploring values, self-interests, and concerns of the community.

Continue the commitment of the Virginia Tech Collaborative for Creative Technologies in the Arts and Design (CCTAD) to the transformative power of the arts and to exploring the intersection between human creativity and technology, focusing on digital and interactive art.

Goal V. Initiate PK-12 enhancements in science, technology, engineering, and mathematics (STEM).

Strategies:

Work with public and private partners to improve curriculum and pedagogy.

Examine socio-cultural factors related to student success, career choice, and access to curriculum.

Develop best practices in the preparation of personnel as leaders and change agents.

Action Items:

Invest in social science and humanities programs to address the university’s mission in supporting cultural vitality and creativity.

Invest in cross-disciplinary graduate programs that address theories and processes of economic, social, and political change and the interdependencies between science and society.

Invest in research capacity in the National Capital Region and Blacksburg campus in energy (focus on the policy, design, and environmental dimensions of international energy supply and demand); world economic system integration (focus on interdependencies of financial and intellectual capital and policy in creating new development regimes); and culture and development (focus on the dimensions and consequences of globalization on culture conflict and social transformation).

Health, Food, and Nutrition

Virginia Tech established the Institute for Biomedical and Public Health Sciences (IBPHS) in August 2003 to emphasize and expand collaborative, interdisciplinary research related to biomedical and health issues affecting humans and animals. This new institute complements and extends the capabilities of the Virginia Bioinformatics Institute (VBI).

The mission of IBPHS is to enhance the quality and quantity of research in the biomedical and public health sciences and to develop innovative cross-disciplinary research efforts in the areas that foster the development of new knowledge. This strategy aligns with the NIH Roadmap that describes major future funding to interdisciplinary research teams rather than to single investigators examining a fraction of a problem. IBPHS is currently focusing on two primary areas that build on current research strengths:

The infectious disease area concentrates on the prevention, diagnosis, treatment, and management of naturally or purposely introduced emerging and re-emerging infectious diseases.

Health, food, and nutrition areas concentrate on the prevention and treatment of obesity, with a unique comprehensive approach from development and evaluation of new functional foods through behavior change by the consumer.

Three additional areas of interest in IBPHS are *Molecular and Cellular Regulation, Genomic Science, and Neuroscience,* areas that will be more fully developed and expanded over time.

Infectious Disease

Colleges are partnering to cluster-hire faculty in the areas of infectious disease and health, food, and nutrition. These faculty members will focus on similar biomedical problems from different and complementary disciplines. The faculty clusters will share space and equipment; develop multidisciplinary graduate programs; and establish partnerships with the Virginia Bioinformatics Institute (VBI), industry, medical institutions, and other academic institutions that will assist IBPHS to achieve its

goals.

Partnerships will also be developed with the Virginia Tech-Wake Forest School of Biomedical Engineering and Sciences (SBES), Carilion Health Systems/Carilion Biomedical Institute, and the Institute for Critical Technology and Applied Science (ICTAS) to build on current strengths in biomechanics, tissue engineering, imaging, and medical physics.

The first programmatic focus of IBPHS is in research on *host-pathogen-environment interaction (HPEI)-infectious disease*. Virginia has an opportunity to be a leader, both nationally and world-wide, in this important discovery area. In 2004, the commonwealth asked members of the National Academy of Sciences to evaluate a proposal to expand an evolving collaborative program for HPEI research at Virginia Tech. Following their recommendations, Virginia Tech has developed and implemented the multidisciplinary approaches that are essential for anticipating conditions under which new infectious diseases will emerge and old ones will re-emerge. Academy members rated the proposal as having a very high potential for developing nationally and internationally recognized research programs, building upon the demonstrated success of VBI as a potential world leader in bioinformatics and systems biology.

Infectious diseases, including those transmitted through wildlife vectors, pose a serious threat to local, state, and national societal welfare, including risks of tuberculosis, avian influenza, and plant diseases such as soybean rust and sudden death syndrome in oaks. Infectious diseases kill millions of people each year and contribute to the deaths of many more. The impact on biological and social systems is substantial. Public health delivery and response, national economies, and ecosystems are affected by the emergence of new diseases and by the persistence of others. These concerns will be addressed by expanding our existing research programs, including a summary-level approach to solving disease problems (see HPEI research chart) that simultaneously grows university research and spurs economic growth.

Existing expertise and infrastructure in geographic information systems and high-performance computing will contribute greatly to the modeling activities needed to predict and extrapolate disease outbreaks and risks. Achieving the HPEI research objectives and associated benefits will be returned many times over through extramurally funded research, application of findings, and resultant economic growth. World-class educational programs in microbiology must be further developed at the undergraduate and graduate levels to support these efforts.

Health, Food, and Nutrition

The second programmatic focus of IBPHS – *Health, Food, and Nutrition* – promotes and protects the public's health through scientific discovery and information dissemination. This mission will be accomplished using advanced technologies from the development of new functional foods, improved nutrition and food safety, and the adoption of health-promoting behaviors to prevent illness and reduce health costs.

A focus within this mission relates to *prevention and management of obesity.* This is one of the most pressing global public health problems, and Virginia Tech has current research strengths in this area. More than 60 percent of U.S. adults are overweight and more than 30 percent are obese. Obesity is a significant and growing cause of spiraling health costs totaling $69–117 billion per year at the national level in 2003, representing approximately 15 percent of the nation's gross domestic product. Obesity dramatically increases the risk of most chronic diseases including cardiovascular disease, diabetes, hypertension, and some cancers. Obesity and being overweight, which have rapidly increased across the past decade, are approaching smoking as the number one preventable cause of premature death and disease.

The National Institutes of Health (NIH) is developing a strategic plan for obesity research that highlights such research as a key part of its future funding agenda. IBPHS is seeking to enhance development of research initiatives in areas of the greatest scientific opportunity and challenge, including the prevention and treatment of obesity through dietary, medical, and lifestyle interventions. NIH recognizes that effectively addressing the obesity epidemic requires a research approach that *integrates* the study of behavioral causes of obesity and the study of the biological/physiological causes and has expended approximately $1 billion of its total $28 billion of funding for nutrition-related projects in 2003. The Health, Food, and Nutrition research initiative proposes an innovative approach to building research teams designed to address NIH-supported research goals.

The Health, Food, and Nutrition research program is an integrated and multidisciplinary approach that builds on and leverages the existing and developing research strengths of Virginia Tech's colleges and institutes in partnership with other academic institutions and the biomedical industry. Collaborating scientists are developing and evaluating new and more nutritious plant and animal foods, evaluating the science-based impacts of the new foods and lifestyles in preventing obesity and related chronic diseases, and analyzing the economic issues and impact of new foodstuffs and lifestyles.

The focus of the research investigates the biological mechanisms responsible for obesity and its co-morbidities including such chronic diseases as Type-II diabetes and cardiovascular disease. Investigation of causative mechanisms of obesity and their health consequences will facilitate development of foodstuffs and lifestyle intervention strategies to prevent and manage the clinically overweight and obese. Scientists working together in networks that encourage collaboration, such as that proposed for this initial focus in the Health, Food, and Nutrition program, will be needed to solve these complex issues.

Goal I. Establish research strengths in the study of infectious disease.

Strategy:

Strengthen and establish significant research initiatives in host-pathogen-environment interaction (HPEI)- infectious disease prevention, diagnosis, treatment, and management of naturally or purposely introduced emerging and re-emerging infectious diseases.

Goal II. Establish research strengths in the study of health, food, and nutrition.

Strategy:

Establish research programs that explore the prevention and treatment of obesity with a unique comprehensive approach from development and evaluation of new functional foods through behavior change by the consumer.

Performance Measures:

- Maintain recruitment and hiring emphasis on interdisciplinary research teams rather than single investigators to address problems.
- Continue to develop both facility and faculty strength in HEPI – infectious diseases.
- Leverage partnerships with Virginia Tech-Wake Forest School of Biomedical Engineering and Sciences (SBES), Carilion Health Systems/Carilion Biomedical Institute, Virginia Bioinformatics Institute (VBI), the University of Maryland-Baltimore Public Health School, the Institute for Critical Technology and Applied Science, and the Virginia College of Osteopathic Medicine (VCOM) to build on current strengths in biomechanics, tissue engineering, imaging, medical physics, and public health.

Develop and evaluate functional foods in combination with consumer behavioral change as a means to prevent and manage obesity.

Innovative Technologies and Complex Systems

In its conception, Innovative Technologies and Complex Systems is placed at the center of the other three discovery research areas, with an implied role of powering progress in these areas through the use of cutting-edge technologies and the development of systems to solve complex problems.

Innovative Technologies

Innovative technologies have encompassed different specificities through time. In the past, microelectronics and advances in silicon technologies would fall within this description. At present, Virginia Tech is among the leaders in innovative technologies such as geographic information systems (GIS), wireless technologies, high performance computing (especially as it relates to grid computing), power electronics and robotics, biotechnology, and materials research. Progress in these technologies will continue to be of critical importance over the upcoming six-year planning period.

A more recent manifestation of innovative technologies is nanoscale science and engineering (nanotechnology). Nanoscience is a scientific frontier where molecular and cellular dynamics are critical and an area in which breakthroughs in discovery will take place in the years to come. Nanotechnology is a defining tool for progress if Virginia Tech aspires to scientific and technological leadership in the near future.

The importance of nanotechnology as an indispensable tool for high-impact discoveries has been recognized by funding agencies at federal and state levels. For the 2006-07 fiscal year, the National Nanotechnology Initiative (NNI), which coordinates research activities across several agencies, is requesting over $1 billion to support research. NNI estimates that resultant new technologies and products will reach $1 trillion by 2015. The Commonwealth of Virginia is considering a one-time research expenditure of $255 million for fiscal year 2006, a significant portion of which targets nanotechnology.

Industry interest in nanotechnology is growing and pervades several areas. Among these areas are the pharmaceutical industry, where drug delivery and therapies based upon cellular responses are reaching critical attention; the biomedical and biotechnology industries, where biomaterials based upon nanotechnology are on a steep growth curve; the energy industry, where fuel cells and other alternative energy sources depend upon advanced materials; and the critical technologies sector, where nanotechnology has given rise to sensing and imaging devices that enable real-time studies of cellular functions and materials characterization.

One of Virginia Tech's greatest competitive advantages is in the area of advanced computing. The development of the System X supercomputer and the continuing effort to achieve petascale computing capabilities provides researchers with the technologies to address the important issues in emerging areas of design and discovery.

Complex Systems

In broad terms, a complex system refers to any aggregate that includes self-regulation, with feedback or adaptation in its dynamics. Biological systems provide many examples of complex systems, and sophisticated computers and sensors are examples of intentionally designed complex systems. Complex systems have been studied and exploited intensely for many years. The realization that complex systems have common underlying structures despite their apparent differences has spawned the inclusion of this area in the Discovery Scholarship Domain.

The ecosystem, weather, financial systems, disease surveillance, epidemic simulation, transportation, and rocket and satellite guidance systems are examples of complex systems. As miniature sensors are developed and placed in the environment, advances in understanding the complexity of abiotic and biotic factors within a very complex ecosystem will greatly increase.

Virginia Tech has many existing strengths in complex systems. Among these are a strong program in macromolecules and interfaces; in materials research at the nanoscale level; in fabrication; in imaging and sensing; and, most important of all, in its strengths in bioinformatics, systems biology, computational science, engineering, and transportation. Strength in these areas has been significantly augmented since 2004 through a coordinated multi-disciplinary faculty recruitment effort across several colleges.

Relationships put in place recently with Wake Forest University (through the School for Biomedical Engineering and Sciences), Georgetown University, Carilion Health Systems/Carilion Biomedical Institute, the Virginia College of Osteopathic Medicine, The Institute for Genomic Research, and the University of Maryland-Baltimore County afford access to medical facilities and related resources ideal for complementary research.

An expanded view of complex systems builds on the successes of the Virginia Bioinformatics Institute (VBI) in systems biology and bioinformatics and leverages strengths to achieve leadership in this important area of research. The emergence of new areas of achievement within VBI in modeling and simulation of populations provides a key area for growth in the National Capital Region in alignment with defense and homeland security initiatives.

Virginia Tech has invested significantly in several institutes to nurture the activities within the area of Innovative Technologies and Complex Systems. Four of these institutes have prominence within the university and are already contributing to the production of knowledge and research in innovative technologies and complex systems. ICTAS, IBPHS, VBI, and VTTI are making significant contributions. ICTAS and VBI are securing developments in innovative technologies including nanotechnology, advanced information technology, high performance computing, and bioinformatics. IBPHS is tackling critical issues in that quintessential complex system, the health and well-being of humans and animals. VTTI continues to be a national leader in addressing transportation-related issues. The proposed institute within social and individual transformation is targeted to research broad-reaching and complex systems that impact the entire globe.

Each of Virginia Tech's eight colleges is investing in innovative technologies and complex systems. Recent cluster hires of faculty members have resulted in the addition of almost 100 new faculty members interested in enhancing the use of technology and advanced science for the purposes of expanding and understanding complex systems.

Nanoscience and nanotechnology are approaching a maturity that raises the issue of disciplinary recognition through the awarding of academic degrees. Institutions elsewhere have put in place such undergraduate and graduate degree programs. ICTAS and IBPHS are the appropriate entities to supply the coordination of the research infrastructure for Virginia Tech to reach its goals. The implementation of academic degree programs could be achieved through creation of a School for Nanotechnology.

Virginia Tech's existing research strengths and recent hiring decisions position the university to foster vibrant programs at the nexus of innovative technologies and complex systems. The other three Discovery foci: energy, materials, and environment; social and individual transformation; and health, food, and nutrition will benefit from a pervasive, strategic commitment to innovative technologies and complex systems. Virginia Tech is poised to take a leadership role in each key area and to achieve the ultimate goal of being among the elite institutions of higher education in the world.

Goal I and Strategy. Achieve research strength in the areas of innovative technologies and complex systems through the strategic integration and support of critical research areas:

Nanotechnology

Bioinformatics

Biotechnology

High performance computing

Power electronics and robotics

Wireless and optical technologies

Geographic information systems (GIS).

Performance Measures:

Power developments in the complex systems represented by the three other discovery domains using the technology made possible by discoveries in the sciences and engineering.

Provide the context for activities for all five of the major research institutes within Virginia Tech and the attendant academic programs for students across all colleges.

Focus specifically and immediately on nanotechnology, culminating in a proposed School for Nanotechnology that brings together these elements in a cohesive whole.

Position Virginia Tech to be competitive in securing the significant comprehensive grants and procurements to lead the university to the level of prominence that is the ultimate aim of the Strategic Plan.

Leverage research strength to expand research presence in the National Capital Region.

University Level Benchmarks: Goals, Proposed Metrics, and Assessment Procedures

Projected Outcomes:

Reaching $540 million in university research expenditures by 2012.

Expenditure growth in both individual college base and college research supported by institutes and centers.

Twenty-seven affiliated National Academy members by 2012.

Growth in faculty awards and post-doctoral appointees.

Roadmap to $540 million in expenditures (chart)

Indicators of Performance:

Using American Association of Universities (AAU) criteria, measurements of the following:

Proposals submitted (count and dollar value)

Proposals awarded (count and dollar value)

Research expenditures

National Academy members

Faculty awards

Postdoctoral appointees

Note: Institute contributions will be linked back to colleges and their faculty.

Annual Performance Goals:

Discovery Domain Assessment Procedures:

	Current	*2006*	*2007*	*2008*	*2009*	*2010*	*2011*	*2012*
1) College direct ($M)	117.8	125.1	132.8	141.0	149.7	159.0	168.8	179.2
2) Institute related ($M)	37.7	46.2	57.5	71.8	90.8	116.5	151.9	196.1
3) Internally generated ($M)	135.0	139.1	143.2	147.5	151.9	156.5	161.2	166.0
4) Total NSF expenditures ($M)	290.5	310.4	333.5	360.3	392.4	432.0	481.9	541.3
5) National Academy members	13	14	16	18	21	22	24	27

Evaluation:

Monthly reports on research proposals, awards, and expenditures by Office of Vice President for Research.

Biannual reports on academy members, faculty awards, and post-doctoral appointees.

Annual reviews of college research performance.

Annual reviews of the contributions of centers and institutes to increased scholarship.

Planning:

Annual reassessment of university and college goals and strategies to reach those goals.

Annual review of performance and planning with board of visitors Committee on Research.

Implementation:

Evaluation and planning outcomes inform annual budget process.