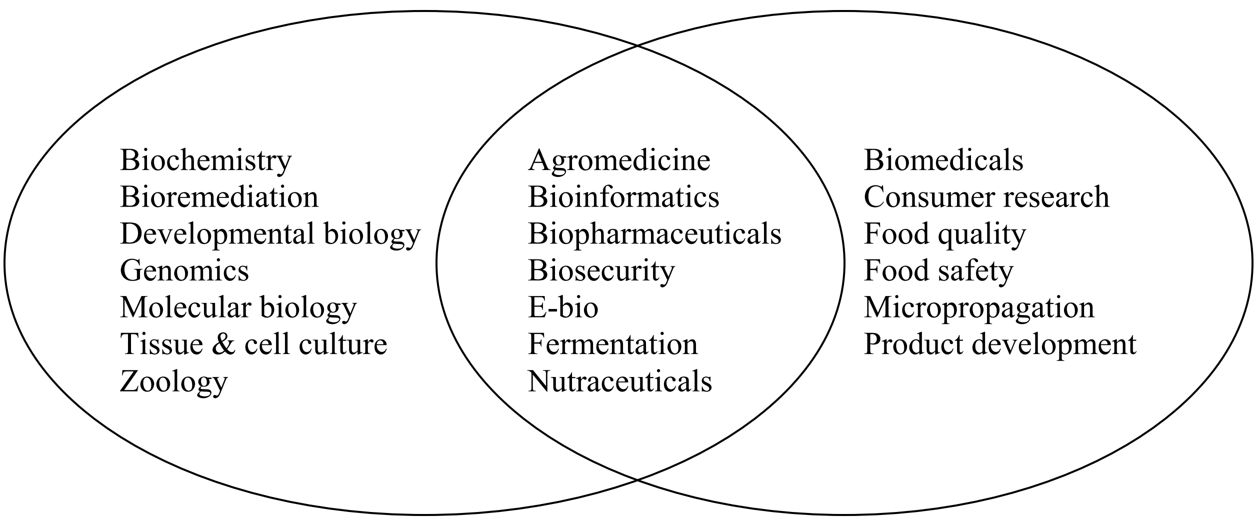
NORTH CAROLINA A&T STATE UNIVERSITY
BIOTECHNOLOGY & BIO SCIENCES CLUSTER
WHITE PAPER

Vision and Impact

The Biotechnology & Bio Sciences (BBS) research cluster is a collaboration of the Schools of Agriculture & Environmental Sciences and Technology, and the Colleges of Arts & Sciences and Engineering designed to foster development of highly productive interdisciplinary research teams in microbial, plant and animal systems and genetics with relevance to human health. Creating a research-driven infrastructure that stimulates innovation, cultivates creativity and discovery, and supports the land-grant university mission of teaching, research and extension, will fulfill this vision. This concept paper was developed in support of FUTURES, North Carolina A&T State University's strategic visioning process. Specifically, this initiative supports three goals of FUTURES: Goal 2 (interdisciplinary programs and centers); Goal 3 (responsive learning environment) and Goal 5 (enhanced and diversified resources). This concept paper is being used as part of the planning process for developing strategic partnerships as well for on-going improvements of interdisciplinary programs, and globalization.

Major areas within the BBS cluster and their connectivity are depicted below:

Biotechnology & Biosciences

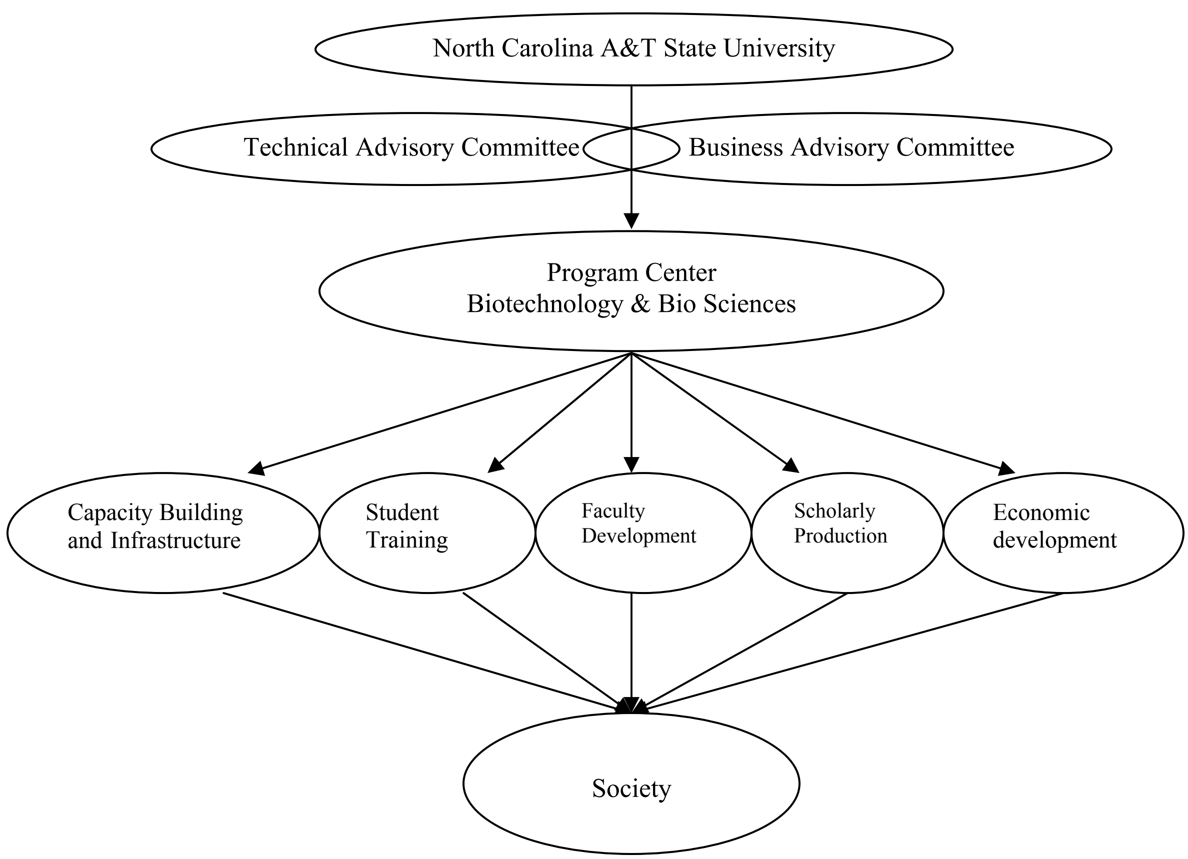


Biotechnology and genomics will impact all aspects of life in the new millennium: wellness, human resource development/training, post-secondary education, economic development, and renewable resources development strategies. Biotechnology and bioscience applications are so broad, and the advantages so compelling, that virtually every industry is impacted by the technology. Biotechnology is enabling industries to make new or better products, often with greater speed, efficiency and flexibility.

The first decade of the 21st Century will be marked largely by the solution of the human genome and the genomes of dozens of important plants, animals and microbes. Knowledge of the entire inventory of gene products within organisms and cell types will provide the foundation for much of the applied, basic agriculture and health-related research in the new century. It will also catalyze explosive growth in products derived from biotechnology. Additionally, the semiconductor industry is working to integrate biological and electronic technologies for a new generation of e-bio supported products and systems for bio-defense to ensure homeland security.

Cluster Goals and Strategies

The overall BBS cluster goal is to establish a self-sustaining program center of excellence in interdisciplinary research in biotechnology, bio and food sciences. The center will aim to reinforce intra- and inter-institutional collaborations and synergies to increase research productivity. The program center is needed to serve as the coordinating campus entity for long term strategic planning to meet the need for workforce and management talent. The program center will emphasize: (1) capacity building and infrastructure; (2) student training; (3) faculty development; (4) scholarly production and intellectual property; and (5) entrepreneurship and economic development. Preliminary plans for the center are presented in the following schematic chart.



Program Center for Biotechnology & Bio Sciences

To accomplish this overall cluster goal, implementation of the following strategies will continue: (1) Assess on-going biotechnology activities; (2) Establish core working group across campus; (3) Conduct campus asset inventory; and (4) Develop short and long term work plans to achieve the center's five objectives.

In addition, there are four specific cluster goals.

Goal 1. Leverage collective strength and resources.

Strategies

- Promote interdisciplinary collaboration among research groups and between individual researchers to address relevant issues of biotechnology, bio and food sciences.
- Consolidate and strengthen research capabilities of existing research groups and laboratories.
- Encourage new synergistic research effort among faculty within the BBS Research Cluster.
- Seek new research partnerships with state, federal, private and international researchers in the BBS Research Cluster focus areas and strengthen existing partnerships.
- Increase the level of extramural research funding within the BBS Research Cluster by leveraging collective strengths to submit competitive research proposals.
- Increase BBS Research Cluster visibility and reputation through publication and dissemination of research findings and active participation in national and international meetings.

Success Indicators

- Solutions to Biosciences problems/issues relevant to stakeholders
- Enhanced research capabilities of NCA&T in biotechnology and bio sciences.
- Enhanced visibility and competitiveness of NCA&T in BBS research cluster focus areas.
- Contribution to local community development.
- Training of qualified graduates with research experience.
- Addressing state and national research needs

Goal 2. Strengthen research competitiveness.

Strategies

- Aggressive extramural funding and collaboration;
- Partnerships with private industry, State and Federal Laboratories;
- Professional development activities;
- Centralized resources and expertise.

Success Indicators

- Total amount of extramural funding;
- Number of extramurally funded projects;
- Number of active industry partnerships;
- Number of papers published, presentations given, and workshops attended;

- Number of meaningful collaborations within and outside the university community.

Goal 3. Provide new educational experiences.

Strategies
- Plan a new interdisciplinary MS degree program(s) in biotechnology;
- Develop new courses and enhance existing courses with current developments;
- Conduct symposia, workshops, seminars, open houses and field days;
- Seek faculty and student internship opportunities, and funding for scholarships, instrumentation and assistantships;
- Engage social scientists, agricultural educators and agricultural businesses.

Success Indicators
- Number of students in the biotechnology undergraduate certificate program;
- Number of students receiving biotechnology scholarships;
- Number of graduate students conducting thesis research (or specializing) in biotechnology;
- Number of new courses and number of existing courses incorporating new development;
- Number of experiential learning opportunities secured for faculty, staff and students.

Goal 4. Enhance outreach engagement.

Strategies
- Develop outreach material;
- Conduct seminars, workshops and field days;
- Provide expert technical service to the community and stakeholders about biotechnology related health and food safety concerns.

Success Indicators
- Printed educational materials addressing current issues;
- Demonstration sites, field days and seminars addressing current developments;
- Community reception of biotechnology.

Definitions

Biotechnology is a collection of scientific techniques that uses living cells and their molecules to make products or solve problems. Bioscience including biodiversity, or more simply the variety of living things, includes microorganisms, plants and animals that co-exist in a sustainable environment. These are natural resources we use to feed and clothe ourselves through agricultural production and processing.

Plant transformation has been defined as the stable incorporation and expression of foreign genes into plants for higher yields, improved quality, next generation of antibiotics, bio-defense, bio-sensing, bio-energy, and bio-molecular materials, etc.

Bioremediation is the use of microorganisms to biodegrade hazardous organic compounds to non-hazardous compounds or less hazardous compounds. Phytoremediation is the use of plants to remove metals or biodegrade hazardous organic compounds in contaminated soil and water.

Fermentation technology, a well-established technology, has traditionally been used to produce fermented foods, feed and pharmaceutical products. It was originally used more than two centuries ago to produce alcoholic beverages. Today, it is a branch of biotechnology that is fully integrated into food and pharmaceutical industries.

Molecular biology is the study of gene structure and function at the molecular level. These studies are integral to almost all biologically related research at the University. In the modern research laboratory, the boundaries between biochemistry, genetics, molecular biology, and biophysics have become less and less well defined. However, 'cutting edge' techniques and concepts from all of these disciplines comprise the general applications of molecular biology.

Background

North Carolina has the third largest biotechnology industry in the U.S. The state's biotechnology industry generates $4B in annual revenue, and is comprised of over 180 companies, 77 contract research organizations, and 37,000 employees. North Carolina's strategic plan for "growing the economy statewide through biotechnology" projects a biotech industry with 48,000 workers and earned revenues of $7.7B in ten years, and continued growth to 125,000 employees and $24B in twenty years. The demand for biotechnologists and bioscientists is projected to increase dramatically.

Agrifood is a multibillion-dollar industry that is vital to the US economy in general, and to the state of North Carolina in particular. In fact agrifood is a $46 billion a year industry that employs nearly 20 percent of North Carolina's work force. There are community and environmental health concerns associated with the agrifood sector that not only impact the well-being of rural producers and residents, but also impact the consumers of agricultural products. These include environmental contaminants (water and air quality), food safety, nutrition, and more recently biosecurity issues. The economic impact of these health and safety issues is very significant. Food safety and nutrition represent major sources of preventable diseases that cost the nation billions of dollars each year.

Opportunities

Due to increasing population worldwide, current agricultural production is not meeting the rising demand for food. Innovation is needed to increase this output and to conserve our planet's resources. Biotechnology is one of several complementary means of increasing production through higher yields, improving nutritional quality, and reducing the use of chemicals for pest control that are caustic to the environment. Biotechnology is also used to conserve natural resources. In addition, there is an emerging need and opportunity for the semiconductor and biotechnology industries to work together to develop a new generation of e-bio supported products and systems for bio-defense and homeland security.

The applications of biotechnology are so broad, and the advantages so compelling, that virtually every industry is using the technology. Biotechnology is enabling industries to make new or better products, often with greater speed, efficiency and flexibility. Developments in biotechnology and genomics allow us to understand the molecular processes that underlie life, revolutionizing agriculture and providing new approaches towards deciphering, protecting and utilizing this planet's rich biodiversity. Thus an unprecedented opportunity for scientific and technological development and agribusiness exists. These techno-developments provide new possibilities for rural development and challenging research and educational opportunities for environmental issues.

The representation of minorities in biotechnology and bioscience remains disproportionately low. There is great potential for major advances in education, research support, community support and economic development among this population.

Strengths

a. Technical Expertise

North Carolina A&T State University has an interdisciplinary biotechnology certificate program for undergraduate students. The interdisciplinary program, funded by the North Carolina Biotechnology Center, has enhanced our curriculum in biotechnology. Interdisciplinary collaborations among the School of Agriculture and Environmental Sciences (SAES), the College of Arts and Science (CAS), and the College of Engineering (CE) have trained graduate students in biotechnology, genomics and bioinformatics and accelerated faculty and staff development. Faculty associates in this cluster have a wide spectrum of diversified and complimentary expertise ranging from biochemistry, bioinformatics, chemical engineering, genetic engineering, genomics, microarray, molecular biology, tissue culture, to computer science and electronics.

b. Current Research

Faculty associates in SAES, CAS, and CE are currently engaged in about 30 extramurally funded projects in biotechnology, bio and food sciences cluster focused research areas: (1) Plant Tissue Culture and Transformation; (2) Bioremediation/Phytoremediation; (3) Fermentation; (4) Food Safety; (5) Molecular Biology; (6) Genomics and Bioinformatics; and (7) E-Bio supported systems. Primary funding sources are public agencies, related industries, university's investment, private foundations, and not-for-profit organizations. Some funding examples are: USDA, USDOI, USAID, US Army Core of Engineers, US Forestry Service, USDE, The University of North Carolina, University Industry Clusters, NCA&T FUTURES Venture Fund.

c. Strategic Collaborations

Collaborative research partnerships exist with scientists in federal, state, industry and community organizations such as the Southern Agbiotech Consortium for Underserved Communities (SACUC) - a partnership of eleven 1890 institutions, and partners supported by the USDA/Initiative for the Future of Agriculture and Food Systems (IFAFS) to contribute to the sustainability of rural agriculture by reducing disparities in the dispersal of science based information in biotechnology. Global partnerships are being actively sought.

Research Scope

Biotechnology & Bio Sciences cluster research will focus on the following thrust areas: (1) Plant Tissue Culture and Transformation; (2) Bioremediation/Phytoremediation; (3) Fermentation; (4) Food Safety; (5) Molecular Biology; (6) Genomics and Bioinformatics; and (7) E-Bio supported systems.

Plant Tissue Culture and Transformation

Plant transformation technology is of great importance to many aspects of human society. It has opened the door to molecular farming, a novel system for genetic research and crop development. Plant tissue culture (micropropagation) technique has been demonstrated to be a valuable and fast means for mass production of plants with unique characteristics and values, and for rescue of endangered species. Micropropagation is also a prerequisite for genetic transformation. Generally, plants with unique quality or genetic characteristics tend to be difficult for multiplication by conventional methods. Micropropagation can fulfill the task of preserving the germplasm and maintaining the genetic diversity by rapid multiplication of the identified resource plants. Genetically modified plants (GMP) have the potential to solve many of the world's hunger and malnutrition problems, and help to protect and preserve the environment, and produce next generation of antibiotics, bio-defense agents, bio-sensors, bio-energy, and bio-molecular materials, etc. to ensure homeland security.

Bioremediation/Phytoremediation

Bioremediation and phytoremediation are rapidly advancing fields with new technologies to clean up sites contaminated with hazardous substances. While many technologies have moved from laboratory testing to the field, treating recalcitrant compounds with bioremediation technologies is difficult and significant additional research is needed. There are many sites in the United States that have been contaminated with metals, and clean-up technologies used were expensive. Phytoremediation may be a cost effective technology, but it requires longer periods, and specific plant species, and microorganisms in rhizophere. Therefore, it is important to study the interaction of rhizosphere organisms and plant roots at a specific contaminated site, so that a proper phytoremediation technology can be implemented for the site cleanup.

Fermentation

Fermentation technology, a branch of biotechnology, is currently being used to produce microorganisms, food ingredients, and pharmaceutical products. Cluster research will focus on process improvement to (1) achieve higher yields of expensive products (pharmaceuticals), (2) improve product quality and consistency (beer), and (3) improve food preservation. As applications for fermentation technology expand and become numerous, protein separation and enzyme production capability will be needed.

Food Safety

There is a need for long-term research on the benefits and health effects of genetically modified foods (GMF) to fill existing knowledge gaps and increase consumer awareness and confidence. Scientists and regulating agencies face many challenges in the areas of safety testing, regulation, international policy and food labeling. Furthermore, current regulations do not require evaluation of long-term impacts of GMF on human health. Genetically modified foods can pose serious threats to consumers with allergies and specific dietary requirements, or weakened immune systems. On the positive side, the reduced use of pesticides/herbicides in GMF yields foods with less chemical residues and thus less foodborne toxicity.

Molecular Biology

Molecular biology is the study of gene structure and function at the molecular level. These studies are integral to almost all biologically related research at the University. In the modern research laboratory, the boundaries between biochemistry, genetics, molecular biology, and biophysics have become less and less well defined. However, 'cutting edge' techniques and concepts from all of these disciplines comprise the general applications of molecular biology. The crucial insight of molecular biology is that hereditary information is passed between generations in a digital form. Molecular biology research will aim to provide an understanding of how digital code directs the creation of life.

Genomics and Bioinformatics

Genomic science, the simultaneous mapping and sequencing of all the genes within an organism, is a multidisciplinary field created by the application of automated systems and computer analysis to molecular genetics and biochemistry. This new discipline has tremendous breadth and impact to the agricultural and biomedical sciences and conservation of biodiversity. Cluster research will include overlapping studies on genome structure - functional genomics to study gene function, and comparative genomics to study the molecular basis of differences between organisms or genomic diversity. Bioinformatics, used to find and extract useful information from genomic sequence and mapping data, and analysis of DNA chip information, will aid researchers in identifying important traits such as disease and stress resistance, and yield enabling improvements in agricultural productivity and environmental quality.

E-Bio supported systems

This is an emerging field in which the semiconductor industry is working to integrate biological science to develop bio-globe position systems, biosensing, and bio-energy for biodefense/bio-offense, and agriculture and homeland security purposes.

Research Challenges

North Carolina has become a biotechnology industry leader because the state envisioned the potential of biotechnology to fuel economic growth, and in 1981, established the very first state-supported Biotechnology Center in the world to stimulate economic development. Although much success has been achieved in biotechnology, it is believed that we have only scratched the surface of North Carolina's biotechnology potential in all aspects outlined in the cluster's research focus areas.

Our challenge is to embrace this unprecedented opportunity to build on our strengths to establish and develop the Biotechnology and Bio Sciences Center as the coordinating campus entity for long term strategic planning to produce the workforce and management talent, and to help the society. The growth and development of new technologies is closely linked to strong research. The Center must be aware of trends that are five to ten years ahead so the necessary apparatus can be put in place to implement activities at the correct time. Lastly, successful economic development requires the transfer of new technologies and applications from the university to the market place.

Specific challenges include finding ways to: (1) Introduce novel and improved approaches to enhance the safety and quality of foods in globalized market; (2) Develop and characterize value added food and non-food products; (3) Contribute to the national Biosecurity effort to protect the nation's food supplies against natural and intentional contaminants, especially in the era of globalization and surging bioterrorism threats; (4) Strengthen R&D activities in the area of nutraceuticals and functional foods for health; (5) Research the use of genomics and biotechnology in the development of new and/or foods with enhanced nutritional and disease health maintenance properties; and (6) Move research outcomes from the lab to the market place through industry partnerships.

The challenge is to develop the infrastructure modeled below:

Program Center → $$$$$ → RESEARCH → Products (Technology, Company, & Quality Students)

Assets

The Biotechnology and Bio Sciences cluster will leverage existing fiscal and human resources, and assets of the university from the related disciplines, as the foundational assets of the cluster to foster and develop a competent and focused research and education environment. Resources include more than 25 faculty associates from three different schools (*SAES, CAS, and CE*), various teaching and research laboratories, and the Farm. Some representative laboratories are listed below.

- Analytical Chemistry Research Laboratory.
- Analytical Service Laboratory: Physical and Analytical Chemistry, chemical production, environmental analysis, quality control.
- Animal Biotechnology Laboratory and Bioinformatics and Microarray Facilities: Animal Biotechnology including parasitology, cell and molecular biology, genomics, and bioinformatics.
- Animal Nutrition Laboratory.
- Bacterial Physiology Laboratory: Bacterial Physiology/Metabolism of Propylene Glycol.

- Biochemistry Laboratory: spectroscopy (UV/VIS, fluorescence, and nuclear magnetic resonance -NMR-) to study the structure function of biomolecules and molecules that may have pharmaceutical applications.
- Biochemical Engineering Laboratory: Bioseparartion, biochemical and Chemical Engineering.
- Electronic Microscopy Laboratory.
- Fermentation Laboratory: Fermentation, waste management, liquid fuels production & utilization.
- Food Chemistry Laboratory: Food chemistry with emphasis on functional foods, new product development, sensory evaluation/consumer research, value-added utilization of agricultural by-products.
- Food Microbiology and Biotechnology Laboratory.
- Food Microbiology and Toxicology Laboratory: interested in oncology, biotechnology, and environmental toxicology.
- Microbiology Laboratory: Microbiology and immunology, the immune response to infectious disease, molecular biology and biotechnology, cloning microbial genes.
- Molecular Biology and Microarray Laboratory: Gene expression, microarray technology, exposure to heavy metal ion radiation.
- Mushroom Biology & Fungal Biotechnology Laboratory: Mushroom biology, fungal biotechnology, Application of fungi in bioremediation of soil pollutants and heavy metals.
- Plant Biotechnology Teaching and Research Laboratory: Plant cell, tissue and organ culture, micropropagation, genetic transformation, secondary production for pharmaceuticals and nutraceuticals, value-added crops.
- Soil Microbiology Laboratory: Soil Microbiology and Bioremediation.

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