ACADEMIC BUSINESS PLAN FOR NEW AND RENOVATED FACILITIES FOR THE DIVISION OF PLANT SCIENCES, INCLUDING A NEW CENTER FOR TRANSLATIONAL PLANT SCIENCES

COLLEGE OF AGRICULTURE, FOOD AND NATURAL RESOURCES

UNIVERSITY OF MISSOURI

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A. Executive Summary:

The Division of Plant Sciences (DPS) is the most diverse and extensive of the six divisions of CAFNR. DPS is the only academic unit in the state that covers the broad spectrum of teaching, research and outreach in plant production, plant protection, and plant biology. The Division has excellent programs but is hindered from reaching its full potential because current facilities are highly compartmentalized, being spread among five campus buildings, limiting the cross disciplinary collaboration that would be possible if faculty, staff, and students could work in close proximity in a facility designed to promote academic interactions.

Plant agriculture is enormously important in Missouri and DPS has a critical role in maintaining and enhancing this sector's contribution to the economy of the state. Missouri is a significant contributor to the agricultural economy of the whole nation with soybean, 7th nationally, corn, 9th, rice, 6th, hay, 2nd, winter wheat, 11th, and cotton, 10th, as examples. Of the $7.5 billion brought to Missouri's economy in 2007 by farm sales, plants accounted for $3.5 billion. Campus-based Division programs address critical research and extension programming needs for these crops across the entire state through projects located on the network of farms and centers. Many projects are led by on-campus faculty and others involve critical collaboration between on- and off-campus faculty, especially the laboratory-based programs found almost exclusively in Columbia.

This business plan provides for an increase in undergraduate and graduate student enrollment and an expanded collaborative research environment in a new Center for Translational Plant Sciences (CTPS) connected to a renovated Agricultural Sciences Building. These new and renovated facilities would serve 180 undergraduate students, 105 graduate students, and 16 postdoctoral fellows. When the facilities are fully operational, they will accommodate 80 net new undergraduate students and 22 net new graduate students.

The centerpiece of this business plan is the development of the multistory CTPS that will replace the one-story Agricultural Laboratory Building and bring together Plant Sciences faculty currently scattered in the Agricultural Sciences Building and Mumford, Waters and Curtis Halls to promote and foster integrative research and education. The current wide physical separation of the sub-disciplines of plant sciences makes interaction very difficult, if not impossible.

The CTPS will create an outstanding environment for interdisciplinary and integrative research and education that will further strengthen MU's position of leadership in the plant sciences. Gathering the group will allow the highly collaborative model envisioned when the four former departments merged to form DPS in 2005 to be achieved. The CTPS will focus on three areas of concern to contemporary society, namely plant stress biology, plant biotechnology, and sustainable production systems.

This business plan for DPS includes space for greenhouses on the roof of CTPS and expanded plant transformation and plant growth facilities on the first floor of the Agricultural Sciences Building. In so doing, this plan contributes to the 2006 Plant Growth Facilities Master Plan.

In 2008, Campus Facilities-Space Planning and Management (CF-SPM) conducted a space analysis and projections for DPS (see addendum). The analysis included estimated costs and a proposed timetable for a three-phased project: relocate the Experiment Station Chemical

Laboratory and the Diagnostic Clinics off campus (Phase A), renovate the first and third floors of the Agricultural Sciences Building (Phase B), and demolish the Agric. Lab Building and construct a new multistory CTPS (Phase C). The following table summarizes capital expenses and proposed funding sources of the three phases:

Phase	Project	Capital Cost	FY	Proposed Funding Sources (%)		
		-million-		State	Federal	Private
A	Relocate Service Functions	$5.3	09-11	90	0	10
B	Renovate Agric. Sci. Bldg.	$25	10-13	80	10	10
C	Construct CTPS	$62-$74	11-16	42.5	42.5	15

CF-SPM projected additional annual operating costs of $1.93 million when Phases A, B, and C become operational. Operating costs include expenses for utilities, maintenance, custodial, and grounds services. DPS has estimated significant increased annual revenue from greater student enrollment and extramural grant activity that will contribute to covering these increased costs. This revenue will generate additional funds for MU's general operating budget that would not occur without the new and improved research and educational facilities. The following table summarizes the increased operating costs and increased annual funding for phases A, B, and C:

Phase	Facility	Annual Operating Costs	FY	Increased Annual Funding*	
				Tuition & Fees	Grant F&A
		-million-		-million-	
A	Service Functions	$0.20	11+	$0.51	$0.63
B	Renovated Agric. Sci. Bldg.	$0.23	13+		
C	CTPS	$1.50	16+		
Totals		$1.93		$1.14	

*Data for FY16, inflationary adjustments needed for future years.

Projected annual operating costs and revenues were also calculated considering the future DPS space footprint in Phases A, B, and C with total projected tuition and F&A revenue. This approach anticipates that reassignment of current DPS areas in Waters, Curtis, and Mumford Halls would allow units receiving that space to contribute to their operating costs (Phases D & E) through their enhanced programs. In this analysis, 29% of Phase A operating costs were included to reflect primary occupancy of that facility by the Experiment Station Chemical Laboratory and Phase B operating costs were increased to $0.48 million to reflect the full operating cost of the renovated DPS space in the Agricultural Sciences building. This analysis shows that projected revenues will exceed operating costs of DPS-assigned space and will contribute some funding toward other areas freed up by completion of this project. The following table summarizes these calculations:

Phase	Facility	DPS Annual Operating Costs	FY	DPS Annual Funding Sources*	
				Tuition & Fees	Grant F&A
		-million-		-million-	
A	Service Functions	$0.06	11+	$1.22	$1.03
B	Renovated Agric. Sci. Bldg.	$0.48	13+		
C	CTPS	$1.50	16+		
Totals		$2.04		$2.25	

*Data for FY16, inflationary adjustments needed for future years.

The business plan includes tables showing the calculations for the estimated income from tuition and fees, after returns and waivers, and from the campus portion of grant F&A by the Division. The assumption is made that all open DPS faculty positions will be filled and that two new senior faculty positions will be created. This yields a total of 52 DPS faculty in FY16, with 44 on campus and 8 at off-campus farms and centers. The current F&A rate (FY06-08), averaged across all DPS grants, is 6.6% for all extramural funding sources for basic and applied research, extension, and instruction. An increase to a 13% average indirect rate is projected during the period FY09-FY13 by increasing the proportion of grants receiving F&A. Two additional senior faculty positions are projected to begin in FY14 with extramural funding double the current per-FTE rate of $176,000. Starting in FY14, a 5% per year growth in extramural grant funding is assumed.

B. Vision, Values, Mission, and Scope of Operations of the Division:

Vision: As one of the largest and most complex of the six divisions of the College of Agriculture, Food and Natural Resources, the Division of Plant Sciences endorses the College's vision statement to be recognized as a customer and employee caring College that discovers and enlightens through excellence in teaching, research, extension and outreach in agriculture and natural resource programs that are socially sensitive, environmentally responsible, economically viable and efficiently productive. The Division intends to be at the national and international forefront of disciplinary and interdisciplinary research, extension and education in basic and applied aspects of plant sciences.

Values: Similarly**,** the Division of Plant Sciences endorses the principles embodied in the University of Missouri's Values Statement that anchors all the Colleges and Schools of the state's major land-grant university: to honor the public trust placed in it and to accept the associated accountability to the people of Missouri for its stewardship of that trust. Our duty is to acquire, create, transmit, and preserve knowledge, and to promote understanding. We the students, faculty, and staff of MU hold the values of respect, responsibility, discovery and excellence to be the foundation of our identity as a community. We pledge ourselves to act, in the totality of our life together, in accord with these values.

Mission: The Division of Plant Sciences has a four-fold mission in teaching, research, outreach and economic development. The Division provides leadership for plant, insect, and microbe-based research, education, and extension programs in the College of Agriculture, Food, and Natural Resources. The Division is the sole academic program in the state to address issues related to plant production, plant protection and plant biology from the laboratory to the field. Division faculty contribute to advances in conventional, sustainable and alternative production systems, plant biology, genetics and breeding, plant protection and pest management, plant-insect-pathogen interactions, plant-soil relationships and environmental quality. Plant Science Extension is dedicated to improving the well-being of Missouri's citizens by improving stewardship of the environment, providing information that allows for the production of a safe and plentiful food supply, and by enhancing the quality of life.

Scope of Operations of the Division: The Division of Plant Sciences has facilities located on and off campus. This business plan focuses on the significant need to upgrade the on-campus facilities of the Division to provide state-of-the-art new and renovated facilities connected to the Agricultural Sciences Building and in the vicinity of the Anheuser Busch Natural Resources Building and the Bond Life Sciences Center. This academic business plan is designed to consolidate divisional on-campus programs into a central location, and allow for increased interaction among faculty, staff and students than is possible currently because the programs of the Division are isolated from each other in space in five campus buildings: Waters Hall, Curtis Hall, Mumford Hall, the Agricultural Laboratory Building and the Agricultural Sciences Building. Much of this space is obsolete.

Improved and expanded on-campus research and educational facilities for the Division will enhance its extensive statewide programs by strengthening basic and applied research programs which anchor the off-campus programs of the Division. The mission of the Division includes

addressing research and extension needs of producers, agribusiness interests and extension personnel across Missouri. Significant soil, microclimatic, and cropping system differences require that unique programs be conducted within each important agricultural region. The Division contributes significantly to the Missouri Agricultural Experiment Station's network of farms and centers around the state, and provides opportunities for MU to positively and visibly impact the daily lives of many of Missouri's citizens.

- The Delta Center location in Portageville, for example, is one of 17 farms and centers covering more than 14,000 total acres that make up the Missouri Agricultural Experiment Station system. These outlying facilities are the field-laboratory component of a continuum that connects off-campus research and extension programs with fundamental research capabilities and extension specialists in Columbia. The Delta Center addresses needs in the Bootheel region where intensive agriculture contributes greatly to the economy of the entire state. When fully staffed, seven faculty from the Division are housed at the Delta Center in addition to support personnel and some graduate students. Each of these faculty programs depends critically on our on-campus expertise and fundamental research facilities. As an example, 80% of the nearly 50 individual projects listed by the division's soybean breeder in Portageville involve critical collaboration with one or more on-campus faculty. On-campus facilities bring advanced genetic technologies such as gene mapping, development of molecular markers, and characterization of seed proteins and metabolites to bear to maximize the impact of this breeding program.
- The Greenley Center at Novelty in northeast Missouri houses one divisional faculty member. The focus at Greenley is development and evaluation of efficient, profitable crop production systems for that region while emphasizing soil conservation, water quality and energy efficiency.
- Other off-campus facilities include the Horticulture and Agroforestry Research Center in New Franklin, the Forage Systems Research Center in Linneus, the Southwest Center in Mount Vernon, the Wurdack Farm at Cook Station, and the Bradford Research and Extension Center and South Farm. Each of these sites represents unique needs related to soil type, agricultural production system, and/or climatic conditions that Division faculty are addressing. The Turfgrass Research Center at South Farm supports applied research and extension on turf management practices pertaining to homeowners and the golf course and athletic field industry. The nearby locations, especially the Turf Center at South Farm and Bradford REC, are especially critical to DPS's undergraduate and graduate academic programs.

Additional information on these Division programs can be seen at: *http://plantsci.missouri.edu*

C. Economic Importance of Plant Sciences to the State and Nation

Research and education in the plant sciences is critical to address fundamental agricultural challenges and needs facing the state, our nation, and the world. Solutions to these challenges and needs will help our state, the nation, and the rest of the world meet long-term societal goals, including an increase in world food production, reduction in malnourishment, improvements in

environmental quality including reductions of herbicide and pesticide use, and generation of sustainable and renewable energy sources.

Plant agriculture is enormously important in Missouri and DPS has a critical role in fulfilling MU's Land Grant University mission in the state. Missouri is a significant contributor to the agricultural economy of the entire nation with soybean, 7th nationally, corn, 9th, rice, 6th, hay, 2nd, winter wheat, 11th, and cotton, 10th, as examples. Nationally, Missouri ranks second only to Texas in the number of farms, with 108,000. The agricultural sector and related industries employed almost 600,000 people in the state and paid $17.3 billion in salaries, based on 2006 values. Direct sale of agricultural products contributed $7.5 billion to Missouri's economy in 2007. Crops, including nursery and greenhouse crops, accounted for $3.5 billion of this amount. Commodity prices were even higher in 2008, and the value of crops to Missouri's economy in that year increased to $4.9 billion. In addition, feed and forage crops also contribute significantly to the more than $4 billion annual value of livestock and animal products to the state. Plant agriculture reaches every region of the state and campus-based Division programs address critical research and extension programming needs in each area through the previously-mentioned network of farms and centers.

MU has a premier program in the plant sciences that is internationally-recognized for its interdisciplinary and interactive research excellence. MU plant scientists are addressing many of Missouri's and the world's most pressing agricultural problems, including development of crops capable of tolerating drought and other abiotic stresses, crops resistant to common pests and diseases such as the soybean cyst nematode and Asian soybean rust disease, crops with greater nutritional value, herbicide-resistant crops, and development of value-added crops including, for example, improved functionality of plant proteins and oils for greater utility in food, feed and industrial markets, and the production of biodegradable plastics. The diversity of approaches being pursued and the interdisciplinary and interactive nature of our plant science programs enhance MU's ability to design unique solutions to both current agricultural problems as well as challenges yet to be recognized.

D. Need for the Center for Translational Plant Sciences

The centerpiece of this academic business plan for DPS is the development of a new multistory facility for plant sciences research and education that will replace the existing one-story Agricultural Laboratory Building. This new interdisciplinary Center for Translational Plant Sciences (CTPS) will create an outstanding environment for interdisciplinary and integrative research and education that will further strengthen MU's position at the international forefront of these mission areas in the plant sciences. The Center will provide vitally needed modern research facilities that will bring together experts from different plant science disciplines to promote and foster integrative research projects that take advantage of multidisciplinary research strategies to address important agricultural challenges, and will provide the interdisciplinary education required to train the next generations of scientists interested in solving problems in plant biology.

Discoveries from fundamental plant science research at MU and elsewhere increasingly provide new and innovative advances in understanding that provide the promise of greater and improved crop quality. The challenge is to translate this information into usable technologies that benefit all Missourians and, indeed, the world. Research to successfully address these goals requires close interdisciplinary collaboration and programmatic integration to complete the chain that connects basic research with production agriculture. To address the complex challenges of plant translational biology, cross-disciplinary intellectual collaboration is required among investigators in plant physiology, biochemistry, genetics, plant breeding, molecular biology, plant pathology, entomology, and biotechnology, as well as with faculty in soil science, environmental and atmospheric sciences, forestry, agricultural engineering, and computer science. Such collaboration requires intellectual exchange of knowledge and ideas among investigators on a regular basis. However, faculty expertise in the plant sciences is scattered across the MU campus, which presents a major impediment to facilitating these types of interdisciplinary collaborations.

In particular, the CTPS is critically important to fully harness the interdisciplinary research and education advantages offered by the formation of the Division of Plant Sciences at MU. The Division was formed in August, 2005, through the consolidation of the former departments of Agronomy, Entomology, Horticulture, and Plant Microbiology and Pathology. The Division provides leadership for plant, insect and microbe-based research, education and extension programs, and is the sole academic program in the state to address issues related to plant production, plant protection and plant biology from the laboratory to the field. Division faculty contribute to advances in plant biology, genetics and breeding, conventional, sustainable and alternative production systems, plant protection and pest management, plant-insect/pathogen interactions, plant-soil relationships, and environmental quality. However, most of the nearly 50 faculty members in the Division are currently distributed among several buildings including Waters Hall, Mumford Hall, Curtis Hall, the Agricultural Sciences Building, and the Agricultural Laboratory Building, and in many cases are housed in antiquated and inadequate laboratory space.

The research conducted in the CTPS will be further enhanced by colleagues from the School of Natural Resources and the Christopher S. Bond Life Sciences Center because all three buildings are in close proximity with each other. The presence in the CTPS of strong research components addressing questions in plant stress biology, plant biotechnology, and sustainable production systems will provide important resources to interface with the long-range research objectives of a variety of campus programs and initiatives including the Interdisciplinary Plant Group, the National Center for Soybean Biotechnology, the Center for Sustainable Energy, the Department of Soil, Environmental and Atmospheric Sciences, the Department of Forestry and the Agroforestry Center, the Divisions of Biochemistry, Biological Sciences, and Food Systems and Bioengineering, the Christopher Bond Life Sciences Center, and the MU Informatics Institute. Moreover, the CTPS will greatly enhance research capabilities in the state of Missouri by providing new opportunities to foster and strengthen research and training partnerships in plant science among MU investigators and those located at other institutions throughout the state, including the Donald Danforth Plant Science Center and Washington University in St. Louis, Missouri State University, Lincoln University, and Truman State University.

In addition, the DPS will play an important role in advancing the planned Missouri Innovation Center (MIC) at Blue Springs, MO. The MIC is being developed as a hub to foster research and educational collaborations between MU and the Kansas City area. The focus will be on strengthening MU ties with the multi-billion dollar animal health corridor and emerging technologies in biotechnology and nanotechnology in the region. The DPS will contribute through outreach and extension, research and development, and undergraduate and postdoctoral training in areas that relate to three of MU's Strategic Initiatives: Food for the Future, Sustainable Energy, and One Health.

E. Programs to be Housed in the Center and Scientific Collaborations Fostered

Investigators in the Center for Translational Plant Sciences will focus on three primary thematic areas:

Plant Stress Biology

Plant abiotic and biotic stresses result in major limitations to agricultural production in Missouri, the nation, and the world. Plant stresses of foremost economic importance include drought, flooding, temperature stress (cold and heat), nutrient stress (soil mineral deficiencies and toxicities), plant disease, insect damage, and the global impacts of a changing climate. Development of economical and environmentally sustainable approaches to limit the effects of plant stress on agricultural production is one of the major challenges facing plant science researchers today. To address these challenges, the Center for Translational Plant Sciences will support fundamental research in plant stress biology from the molecular to the systems level to provide a solid knowledge base from which to develop new or improved strategies for decreasing the impact of abiotic and biotic stresses on agricultural productivity and sustainability.

Notably, a research theme in plant stress biology builds and expands upon existing world-renowned research strengths at MU, ranging from drought stress physiology to plant disease resistance. The long-term goals for this thematic research area will be 1) to generate fundamental knowledge regarding the genetic, genomic, molecular, biochemical, physiological, and ecophysiological components involved in plant abiotic and biotic stress responses and adaptation; 2) to use this fundamental knowledge to develop approaches and tools to aid the improvement of agricultural plant productivity under stressful growing conditions; and 3) to develop, through biotechnology and/or conventional breeding, new plant lines or populations for improved abiotic and biotic stress resistance in agricultural plants.

To help accomplish these goals, the CTPS will serve as the home to a state-of-the-art Plant Pest and Disease Containment Facility (PPDCF). The PPDCF will provide a highly controlled and contained research environment, which will include rearing facilities and growth chambers, for research on arthropods, plant pathogens, and nematodes. In addition, the facility will provide opportunities to study emerging and invasive plant pests that cannot be studied under normal laboratory conditions because they may pose a significant threat to Missouri agriculture.

Plant Biotechnology

Plant biotechnology holds tremendous potential for creating plants with new traits that benefit agricultural production, the environment, and human nutrition and health. The research, extension, and education programs of DPS are dedicated to the most significant global issue of our time, namely, how to nourish an increasing world population in the 21st Century and beyond. Input traits such as pest resistance, herbicide tolerance, disease resistance, and environmental stress tolerance help producers by lowering the cost of production, improving crop yields, and reducing the level of chemicals required for the control of insects, diseases, and weeds. Output traits include nutritionally enhanced foods that benefit consumers by enhancing the quality of the food and fiber products they use. Value-added traits such as the production of pharmaceuticals and vaccines in plants and insects provide new opportunities to treat human diseases. A research theme in plant biotechnology in the CTPS will enhance and expand ongoing efforts by MU plant researchers who are already leading cutting-edge plant biotechnology research efforts. For example, major efforts to engineer drought-, pest-, and disease-resistant corn and soybean, and to improve the functionality of soybean protein and oil for greater utility in food, feed and industrial markets are underway to serve the nation and the world.

The CTPS will foster interactions among a diverse group of experts and bring together scientists who are already active members in a number of plant biotechnology initiatives at MU. These include the National Center for Soybean Biotechnology, a collaborative program among more than 40 scientists at the University of Missouri, the USDA-ARS Plant Genetics Research Unit in Columbia, and the Donald Danforth Plant Science Center in St. Louis, who are working to improve soybean production and utilization through the use of biotechnology. The presence in the CTPS of a strong research component in plant biotechnology will also provide an important resource to interface with biotechnology initiatives across colleges and foster interactions with researchers in Veterinary Pathobiology, Animal Science (Swine National Resource and Research Center), Food Science, Biological Engineering, and the Medical School. Plant biotechnology also offers great promise for new joint efforts between CAFNR and the College of Engineering, which are directed at addressing critical needs in the area of bioenergy. These initiatives include the formation of the Center for Sustainable Energy, whose mission is to develop sustainable, affordable and renewable solutions to accommodate the nation's ever-growing need for energy. Partnerships with faculty housed in the CTPS will provide new opportunities to expand ongoing efforts to develop bioengineered crops for renewable energy sources and industrial uses, and the production of biofuels using lignocellulose which is degraded by insects and their gut symbionts.

To facilitate the long term goal of using biotechnology to address major problems that affect crop production and use in Missouri, the Center will house an expanded state-of-the-art Plant Transformation Core Facility to provide the necessary infrastructure and resources in the form of skilled technicians, modern equipment, and facilities to increase MU's capacity to develop transgenic plants with new traits.

Importantly, to uphold MU's commitment to education and public outreach, the CTPS will promote an increased awareness of the science and societal issues related to the adoption of agricultural biotechnology in the U.S. and internationally through education and outreach programs.

Sustainable Production Systems
Research programs that concentrate on sustainable production systems within the CTPS will complement and stimulate basic scientists to be aware of the application of their scientific findings. Furthermore, the strong extension programs in the Division of Plant Sciences will benefit from interactions among a wide array of faculty members, making technology transfer more rapid and efficient.

Never in the course of history has the development of sustainable crop, forage, fuel, and fiber production systems been more important for the U.S. and the world. Unprecedented and escalating world-wide demand for agricultural commodities to supply not only the world's food, but increasingly its fuel needs, requires MU's plant science community to develop and deploy technologies that meet this demand. Additionally, the public demands agricultural production systems that do not degrade or impair our environment. More than 20 faculty members in the Division of Plant Sciences focus on these issues.

At the core of MU's sustainable production system research programs is a commitment by faculty to develop, create, and test fundamentally new production methodologies that turn basic discoveries into real-world practice. For instance, faculty are leading strong programs in oil and cereal crop production, weed science, biofuel production, forage-livestock systems, and nutrient management. These integrated programs contend with multifaceted biological interrelationships such as plant-microbe symbiosis, plant-pathogen interactions in disease development, plant-plant, plant-animal, and plant-insect interactions, responses to environmental stresses, nutrient fluxes, and population dynamics in complex agroecological systems. Additionally, these programs are linked with agricultural industries that supply basic production inputs and processing capabilities which turn raw commodities into consumable products. These fundamental programs provide the translational connection from laboratory to deployable technology.

F. Contributions of DPS to MU's Strategic Initiatives

The Division of Plant Sciences aligns itself directly with four of the five Strategic Initiatives that MU developed and began to implement in 2009. These Mizzou Advantage initiatives are foundation stones for programmatic initiatives that position MU prominently in higher education, in economic development for the state of Missouri and beyond, and as an institution with a high quality of life and a prime destination for the future work force.

The DPS contributes directly to:

a. Food for the Future which builds on MU's impressive agribusiness (plant and animal) strengths, its Interdisciplinary Plant Group, and on strong relations with corporate and research partners in St. Louis (plant) and Kansas City (animal). Related strengths are programs in nutrition, aging, obesity, and other chronic health issues, and basic biological sciences, animal science, veterinary medicine, and all health disciplines.

b. One Health, One Medicine which builds on MU's interdisciplinary culture and the presence of Medicine, Animal Science, Veterinary Medicine, and Plant Science programs provides a virtually unique opportunity for research and education at the intersection of animal and human health and well being.

c. Sustainable Energy which builds on MU's many assets in the area of sustainable energy, both research and educational. The MU reactor is a strong asset for research and training in the nuclear energy, and biofuels is an area of considerable research capacity and of local agribusiness interest. The DPS is playing a central role in MU's Center for Sustainable Energy.

d. Understanding and Managing Disruptive and Transformational Technologies in areas in which existing technologies are fundamentally changing and impacting society: media, agribusiness, biomedical sciences, and energy. These changes are both transformational and disruptive. Implications of these dramatic changes need to be understood for the benefit of policy, business, and socio-cultural adaptation to changing times. Studies into all aspects of plant biotechnology at MU clearly fit into this category.

G. Student Opportunities and New Students who will be Served by the Center

The CTPS will become an important destination for MU students to learn about the many dimensions of plant sciences. Modern, energy efficient greenhouses, classrooms and labs will provide students with desperately needed teaching space on campus.

Undergraduate and graduate education are important missions of the Division of Plant Sciences. The division is committed to educating citizens of Missouri and the world about the importance of plants and agricultural crops and about plant sciences solutions to problems such as human health and nutrition, environmental degradation, global warming, and energy independence. Employment with extension and research faculty can benefit undergraduate students tremendously during their educational experience.

Undergraduate:
Because the on-campus faculty of the Division of Plant Sciences are currently scattered across five campus buildings and three greenhouse facilities, plant science undergraduate students cannot interact effectively with Division faculty, or benefit fully from all of the educational opportunities they offer. The CTPS will provide opportunities to better incorporate this expertise into the classroom and will allow better opportunities for plant science students to network with each other as well as with faculty and staff.

Graduate:
Plant, Insect, and Microbial Sciences (PIMS) Master's and Ph.D. graduate programs currently have an enrollment of 83 students. A major goal for unification of these programs into PIMS was that the whole population of students will benefit from close interaction with student colleagues and faculty across the sub-disciplines that comprise Plant Sciences. The current wide physical separation of these sub-disciplines makes such interaction very difficult, if not impossible. The CTPS will place faculty, graduate students, postdoctoral scholars and others in

close proximity to one another on a day-to-day basis to facilitate optimal educational interactions.

New Students Benefiting from the Center for Translational Plant Sciences:
New or modified programs in agricultural biotechnology are expected to increase student interest in Plant Sciences' undergraduate programs. Currently, discussions are under way with the Division of Animal Sciences of CAFNR to identify appropriate linkages and areas of opportunity to bring our state-of-the-art research programs in molecular genetic sciences to new undergraduate students in both divisions. Division of Plant Sciences faculty will teach courses in the new Viticulture and Enology Emphasis housed in the Department of Food Science. The Division is currently recruiting for several positions, including a Turf Extension Pathology Specialist as an addition to the turf research, extension and teaching faculty at MU. This addition, together with the new Turf Management research and teaching faculty member just hired in 2008, will strengthen undergraduate education in this area that is so important to the economy of Missouri and the Midwest.

H. Outreach/Technology Transfer at the Center

The CTPS will serve as an important link in the continuum from basic discoveries made in the laboratory to real-world application. Frequently, in the course of discovery research, new ideas emerge that with nurturing could produce valuable new technologies and products to enhance the state's economic health. As economic development takes greater hold as part of the fourth and newest land-grant mission, the CTPS will provide a prototype infrastructure for accelerating technology development and entry into a production environment.

In the continuum from basic discovery to real-world application, the Extension and Outreach programs in the Division of Plant Sciences provide the educational arm that links the Division to its clientele around the state. These programs enrich the lives of all Missourians by improving stewardship of the environment, by providing information that allows for economically sustainable production of safe and plentiful food, and by enhancing quality of life. Through its involvement with an extensive statewide network of Extension and Outreach experts, the Division is uniquely positioned to deliver a broad spectrum of educational programming. Signature programs of the Division include: Integrated Pest Management, Pesticide Applicator Training, Tall Fescue Toxicosis, Soil Nutrient Management, Pasture-Based Dairy Production, Weed Control, Plant Disease Management, Turfgrass Care, and the Master Gardener Program.

A major benefit of the Center for Translational Plant Sciences will be to bring together faculty, students and staff who are involved in either research or extension and outreach. This will enhance linkages among researchers who develop new products, techniques, and solutions with educators who bring the science to end-users. Conversely, extension and outreach faculty are often among the first to hear from end-users about potential problems or difficulties with existing or new technologies. The enhanced two-way flow of information is vital for solving the difficult problems that face food, fiber and fuel production in the 21st Century.

Faculty of the Division of Plant Sciences are very active in intellectual property disclosures, patents and release of improved crop varieties for use by farmers in Missouri and beyond. The development of high yielding, disease resistant, stress tolerant varieties is a key aspect of the land-grant mission of MU that fits extremely well with the translational theme of the CTPS. Varieties of winter barley, winter wheat, soybean and tall fescue have been produced by public plant breeders at MU to directly benefit producers in Missouri and regionally. New fundamental genetic knowledge and technologies combine with this applied breeding expertise to bring the impact of this investment directly to the industry. Truman, Bess and Ernie soft red winter wheat varieties are significant royalty earners at the present time. Jake, Anand and Maverick soybeans are also important to Missouri and Midwest agriculture. These research programs also provide graduate stipends to support the training of plant breeders for the future. DPS faculty are very aware of the need to serve society through research and education that will lead to innovations in plant sciences being harnessed to benefit society.

I. Facility Impact

In 2008, MU Campus Facilities-Space Planning and Management developed a five-phase plan to identify new and renovated facilities for the teaching, research, and extension programs of the Division of Plant Sciences:

Phase A: Experiment Station Chemical Laboratories (ESCL) and Diagnostic Clinics: Relocate the ESCL and the DPS Diagnostic Clinics to a new facility at Discovery Ridge to open up the footprint of the Agriculture Laboratory Building and empty the basement of Mumford Hall. This action will generate 16,500 gsf of new off-campus space at a total estimated project cost of $5.3 million, if the relocation is done in the period FY09-11. The additional operating costs for the new facility are projected to be $200,000/year.

Phase B: Agricultural Sciences Building: Renovate the third floor for research laboratories and research support services and a portion of the first floor to house the Entomology Museum and to provide a growth chamber facility. This action will generate 51,000 gsf of renovated space at an estimated total project cost of $25 million, if the work is done in the period FY10-13. The additional operating costs for the renovated facilities are projected to be $230,000/year.

Phase C: Center for Translational Plant Sciences (CTPS): Demolish the Agricultural Laboratory Building and construct the CTPS, a new multi-story building (basement plus four or five stories) on the footprint. This action will generate 120,000 to 140,000 gsf of new space at an estimated total project cost of $62-74 million, if the work is done during the period FY11-16. The additional operating costs for the new facilities are projected to be $1.5 million/year. This cost takes into account the current $300,000 operating cost of the Ag Lab building, to be eliminated as part of this phase.

Phase D: Curtis Hall: Renovate/construct space when Curtis Hall is vacated because the National Plant Genetic Security Center is available to house ARS scientists currently occupying Curtis Hall. If Phases B and C are completed with sufficient capacity for all the

DPS programs that are on-campus, including greenhouses being located on the roof of the CTPS, Curtis Hall could revert to the campus for reassignment (16,000 asf).

Phase E: Mumford Hall and Waters Hall: The completion of Phases A and C will open up space in the basement of Mumford Hall (8,600 asf) and Waters Hall (24,800 asf). This freed-up space could be made available to the Division of Applied Social Sciences in CAFNR and other campus programs in specific ways that remain to be determined.

J. Summary of Project Costs and Schedule

See page 6 of the Addendum. The 2008 Space Analysis and Projections for the Division of Plant Sciences summarizes the timing and the cost of the three phases of the DPS space upgrade project:

Phase A: Relocate off campus the Experiment Station Chemical Laboratory and the Diagnostic Clinics.
Phase B: Renovate the Third Floor and First Floor of the Agricultural Sciences Building.
Phase C: Demolish the Agric. Lab Building and construct a new multistory CTPS.

K. Summary of Proposed Sources of Funding for the One-Time Capital Improvement Costs

Phase	Project	Capital Cost	FY	Funding Sources (%)		
		-million-		State	Federal	Private
A	Relocate Service Functions	$5.3	09-11	90	0	10
B	Renovate Agric. Sc. Bldg.	$25	10-13	80	10	10
C	Construct CTPS	$62-$74	11-16	42.5	42.5	15

CAFNR will develop a strategy to seek capital funding for this DPS facility improvement project based on state, federal and private funds in the proportions indicated in the table. Initially, a major effort will be initiated by CAFNR's Office of Development to seek private funding for the project. It is essential that this project be included on MU's capital improvement list as a priority need for the campus in order to begin and be successful in this effort. It is anticipated that the project will be of significant interest to corporate donors who readily recognize the importance of investing in improved facilities for education and the types of fundamental and translational research conducted in the plant sciences at MU. Major gifts in the range of $2 million to $5 million will be sought. When the timing is appropriate to seek federal and state funding, CAFNR will coordinate efforts with the campus administration to target potential federal funding sources (e.g. USDA, DOE) and state mechanisms for funding. At present, the best prospects for state funding may come via approval by the general assembly of a bond issue to support renovation and provide new facilities at public universities in Missouri.

L. Summary of Recurring Costs to Operate the Center for Translational Plant Sciences

See the Addendum showing the 2008 Report from Campus Facilities-Space Planning and Management. On page 6 of this report is a summary of the projected additional operating costs for the three phases of the DPS space upgrade project:

Phase A: Operating the Experiment Station Chemical Laboratory and the Diagnostic Clinics at an off-campus site.
Phase B: Operating the upgraded Agricultural Sciences Building.
Phase C: Operating the Center for Translational Plant Sciences.

M. Estimated Increased Annual Income Based on the Availability of Upgraded Space in the Agricultural Sciences Building and in the New Center for Translational Plant Sciences

Increased Student Fee Income

Table 1 shows the estimated annual revenue from increased student enrollment associated with the CTPS. Shown are tuition and fee revenue estimates for the additional undergraduate and graduate students that would not be at MU without the new and improved DPS facilities. The Division of Plant Sciences will be able to increase its student enrollment with the new and improved facilities that combine areas that were previously separated.

Increased Grant Income

The CTPS will provide enhanced opportunities for collaborative and integrative research that will lead to greater opportunities for extramural funding, especially in the current funding environment where large interdisciplinary projects are encouraged and are increasingly common. In addition, funding agencies such as the USDA have established policies that promote translational research projects.

Table 2 shows the estimated annual grant income for faculty in the CTPS as projected direct and F&A grant income. The availability of improved research space, increased opportunities for collaboration, and the addition of two senior faculty will significantly increase grant income. This will lead to additional F&A income for the general operating budget of MU that would not occur without the new and improved research facilities.

Addenda

Table 1. Estimated revenue from student enrollment in the Division of Plant Sciences based on the new & renovated facilities being available for occupancy in FY16.

Table 2. Estimated annual grant F&A income based on the new & renovated facilities for the Division of Plant Sciences being available for full occupancy beginning in FY16.

Membership of *ad hoc* Committee that prepared this Academic Business Plan

2008 Report from Campus Facilities-Space Planning and Management:
Space Analysis and Projections for the Division of Plant Sciences

TABLE 1. Estimated annual revenue from student enrollment in the Division of Plant Sciences based on the new & renovated facilities being available for occupancy in FY16.*

Fiscal Year	Undergraduate		Graduate		Total Tuition and Fee Revenue	Increased Tuition and Fee Revenue over FY06-FY08
	#	$	#	$	$	$
Increase enrollment to 180 undergraduate students and to 105 graduate students						
FY06-FY08	100	594,000	83	122,000	716,000	---
FY09-FY13	100	594,000	83	122,000	716,000	---
FY14	125	743,000	93	136,000	879,000	163,000
FY15	150	891,000	105	154,000	1,045,000	329,000
FY16	180	1,070,000	105	154,000	1,224,000	508,000

* Undergraduate programs currently enroll 100 students, and we project an increase in undergraduate majors to 180 students. Plant, Insect, and Microbial Sciences (PIMS) and its component graduate programs currently enroll 83 M.S. and Ph.D. students, and we project an increase to 105 graduate students. These values assume a 20% discount on undergraduate and a 75% discount on graduate tuition.

TABLE 2. Estimated annual grant F&A income based on the new & renovated facilities for the Division of Plant Sciences being available for full occupancy beginning in FY16*.

Fiscal Year	Faculty FTE	Annual F&A		Campus Portion of Total F&A ($)	Campus Portion of Increased F&A ($)
		Total ($)	Increase over FY06-FY08 ($)		
FY06-FY08	44**	530,000	---	398,000	---
FY09-FY13	50	860,000	334,000	648,000	250,000
FY14	52	1,240,000	708,000	930,000	531,000
FY15	52	1,300,000	770,000	975,000	577,000
FY16	52	1,370,000	835,000	1,028,000	626,000

*Current annual grant expenditures are $7.76 million (FY06-FY08 average) for the Division of Plant Sciences.
The current (FY06-FY08) F&A rate averaged across all division grants is 6.6% for all external funding sources. We project an increase to a 13% average F&A rate during the period FY09-FY13, by increasing the proportion of grants receiving F&A.

** 44= Total current Division of Plant Sciences faculty (36 on campus CTPS faculty; 5 off campus; 3 LSC); 50 = Total DPS faculty assuming all open positions are filled (3 on campus, 3 off campus). 52 = Total DPS faculty assuming two new senior positions are created. Two additional senior faculty positions are projected to begin in FY14 with an increased success rate in external grant funding double the current per-FTE rate of $176,000. A 5% per year growth in external grant funding is assumed starting in FY14, based on the improved facilities.

The Division of Plant Sciences extends its great appreciation to Ms. Heiddi Davis, Director, and her team in the University of Missouri Campus Facilities, Space Planning and Management group for preparation of the Space Analysis and Projections included in this document.

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