



Shortening the Distance Between Discovery and Impact

Penn State AgScience Research



PennState
College of Agricultural Sciences

Overview

Introduction	4
Research Areas	5
Intersections of Research Areas and Critical Issues	6
A Drive to Find Solutions.....	7

Resiliency | Characterizing and Mitigating Stressors

Protecting Against Biotic Stressors	8
Improving Soybean Yield.....	9
Identifying Stressors’ Impacts.....	10
Managing Mushroom Pests	11

Invasive Species | Detecting and Rapidly Responding to Biological Invasions

Controlling Stink Bugs.....	12
Preserving Regional Industries	13

Water Management | Reducing Soil Degradation and Minimizing Inputs

Reducing Nutrient Inputs.....	14
Curbing Emerging Contaminants.....	15

Sustainability | Responsibly Increasing Agricultural Productivity and Efficiency

Increasing Yields and Incomes.....	16
Improving Dairy Cow Health	17

Infectious Diseases | Mitigating the Spread of Vectorborne Pathogens

Editing Genes in Mosquitos.....	18
Predicting Future Tick Threats	19

Infectious Diseases | Protecting Against Infections and Decreasing Disease Incidence

Treating Wood Packaging.....	20
Making Farmers Markets Safer	21

Functional Foods | Improving Health Through Mechanisms of Bioactive Compounds

Promoting Gut Health.....	22
Upcycling Avocado Seeds	23

Biotechnology | Developing Sustainable, Value-Added Products

Replacing Plastics with Biomaterial.....	24
Mass-Producing Vitamin K	25

Rural Prosperity | Enabling Equitable Access to Knowledge and Techniques

Promoting Economic Resilience.....	26
Empowering Cambodian Women Farmers.....	27

Biodiversity | Conserving Pollinator Populations

Identifying Viruses in Pollinators	28
Predicting Local Population Extinction	29

Convergence | Connecting Beyond the College

Agricultural Engineering Building	30
Microbiome Center.....	31
Beescape.....	32
Nuru and PlantVillage.....	33

Research Report

About the College	34
Research Expenditures	35
Federal and State Appropriations.....	36
Competitive Awards	37
Award Highlights.....	38

Introduction

From improving human, plant, and animal health to ensuring food security, protecting the environment, strengthening our communities, and more, researchers across the College of Agricultural Sciences are arriving at real-world solutions that can have positive impacts on the lives of people in Pennsylvania, the nation, and the world. Because complex problems require complex solutions, the college conducts research that transcends scientific disciplines.

In order to capture this complexity, we have broadly categorized our research portfolio into six cross-cutting themes. These research areas, explained on the following page, describe a broad overview of the interdisciplinary collaboration of expertise that is needed to address the most pressing challenges facing the agricultural sciences. The stories of impact that follow range across the breadth of these areas and, at the same time, pursue the depth of the critical issues driving research inquiry.

We expect that the profound impact and reach of the work will demonstrate the significance of these solutions and continued need to fund further advancements. We are excited to share with you these projects that portray the range of promising directions and solutions discovered by our researchers over the past year.

Gary A. Thompson

*Associate Dean for Research and Graduate Education
Director of the Agricultural Experiment Station*

Research Areas



Biologically Based Materials and Products

Discovering novel approaches to using genetic systems and biological materials for value-added commercial and consumer products.



Advanced Agricultural and Food Systems

Transforming thinking and practice in agricultural and food systems to produce better foods that increase production efficiencies while using fewer resources.



Environmental Resilience

Examining the ability of natural systems to recover from disturbances and to tolerate or adapt to changing climate, nutrient pollution, forest fragmentation, and other land-use practices.



Integrated Health Solutions

Advancing and improving the health of humans, animals, and communities through preventive, corrective, diagnostic, and predictive solutions to challenges presented by foodborne pathogens, lifestyle, diseases, pests, and toxins.



Global Engagement

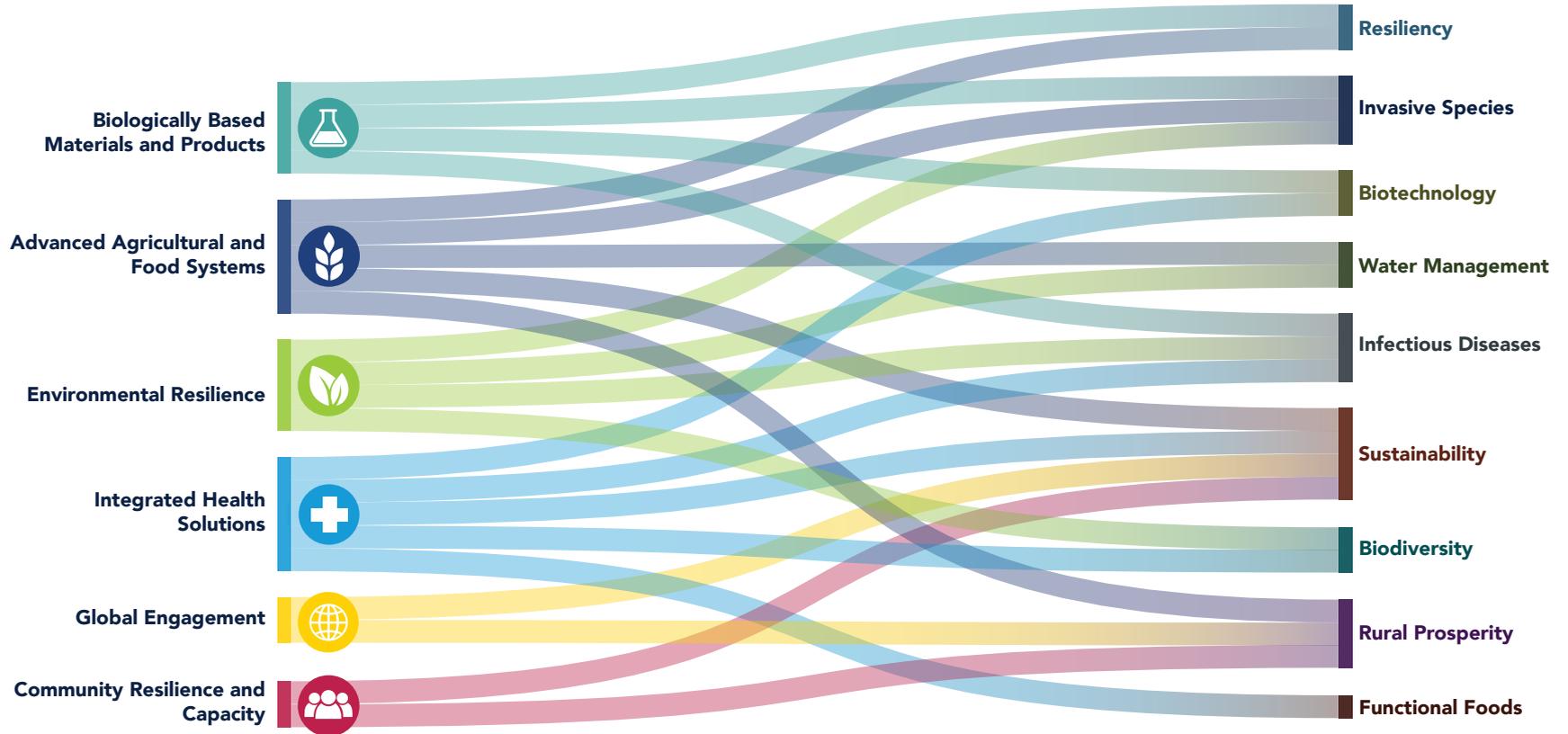
Providing global solutions to challenges in agriculture, health, and sustainability that impact the future of an interconnected world.



Community Resilience and Capacity

Helping communities improve their economic resilience, create sustainable infrastructures, and promote their local economy through value-added opportunities, new business development, and improved efficiency in established operations.

Intersections of Research Areas and Critical Issues



A Drive to Find Solutions

In order to more easily navigate through the twenty-two stories of highlighted research activity on the following pages, each project is categorized through a series of devices. The headings, highlighted phrases, and icons organize the content so that the reader may explore the information at varying levels of interest.

Critical Issues

- » Located at the top, center of each spread.
- » Illustrate the depth and significance of the research and demonstrate how different research problems can tackle the same issue.
- » Relay why the research is vital to the health and welfare of society and the environment as much as it is to the productivity of plants and animals.

Research Areas

- » Icons located in the lower corner of each page indicate the project's categorization within the six cross-cutting areas.
- » The research areas intersect with multiple critical issues, as shown in the diagram at left.

Project Details

- » **Problem:** a more specific aspect of the critical issue describing why it is important.
- » **Findings:** how the researchers approached and tackled these monumental problems.
- » **Impact:** what the potential is for this research to make a real difference in the world.

Insect-detererring compounds in sorghum may be an eco-friendly pesticide.

Problem: How do we protect plants from pests and pathogens without posing toxic risks to consumers?

Findings: Researchers discovered a group of naturally occurring compounds in sorghum—flavonoid phytoalexins—that act as natural pesticides and fungicides and studied the role of these compounds in the ability of plants to resist or deter pathogens and pests.

Impact: Through the understanding of plant genetics, this project is moving toward breeding sorghum and maize crops that use their own natural defenses to resist biotic stressors.

- » This is a nontoxic, environmentally friendly solution.
- » Use of these crops reduces the need for chemical pesticides.



Team: *Surinder Chopra, Iffa Gaffoor, Sampurna Sattar, Cullen Dixon, Nadia Frock, Juliet Moen, Gary Thompson, Consuelo De Moraes, Mark Mescher, and Rupesh Kariyat*

Federal and State Appropriations:
*Project PEN04613 and USDA NIFA
Accession #1010654*





Team: *Sally Mackenzie, Sunil Kenchanmane Raju, Mon-Ray Shao, Robersy Sanchez, Ying-Zhi Xu, Ajay Sandhu, and George Graef*

Competitive Funding: *National Science Foundation; Bill & Melinda Gates Foundation*

“Scaring” soybeans into **defensive mode** yields better plants a generation later.

Problem: How can crop yields be enhanced as drought and extreme heat increasingly jeopardize food security?

Findings: Researchers found that by silencing the expression of a critical gene in soybeans, the plants are fooled into sensing they are under stress even though they are growing in perfect conditions. The progeny of these plants, cross-bred with the original stock, remember the stress-induced responses for generations and produce more vigorous, resilient, and productive plants.

Impact: The critical gene found in soybeans is also found across all plants and could be deployed to increase yields by simply changing the way existing genes are expressed.

- » Yields increased by as much as 14 percent.
- » Because no new genes are introduced, the plant is not considered a genetically modified organism and does not require special regulatory approval.



Assessment details the impact of pests and pathogens on the **world's major food crops**.

Problem: How can the impact of pests and pathogens on the world's five major food crops be precisely measured to protect global food security?

- » Wheat, rice, maize, soybean, and potato supply 50 percent of the global human calorie intake.

Findings: An international team of plant pathologists developed an online survey to gather data on crop losses. They identified 137 specific pests and pathogens harming the five major food crops across sixty-seven countries.

- » Wheat losses = 10-28 percent
- » Rice losses = 24-41 percent
- » Maize losses = 20-41 percent
- » Soybean losses = 11-32 percent
- » Potato losses = 8-21 percent

Impact: The team's quantification of crop losses helps guide research priorities by differentiating between chronic stressors on these crops.

- » Develop resistant varieties as a long-term strategy.
- » Identify emerging or reemerging stressors that require urgent action to contain them.



Team: Paul Esker, Serge Savary, Laetitia Willocquet, Neil McRoberts, Sarah Pethybridge, and Andy Nelson

Partners: The International Society for Plant Pathology, French National Institute for Agricultural Research, University of California–Davis, Cornell University, University of Twente in the Netherlands, North Carolina State University

Competitive Funding: Pennsylvania Department of Agriculture; American Mushroom Institute

Federal and State Appropriations: Projects PEN04608 and PEN04609 and USDA NIFA Accession #1010032 and #1010058





Team: *Nina Jenkins and Tom Baker*

Competitive Funding: *Pennsylvania Department of Agriculture; American Mushroom Institute*

Federal and State Appropriations: *Projects PEN04608 and PEN04609 and USDA NIFA Accession #1010032 and #1010058*

Tackling mushroom phorid fly infestations with a **multipronged biocontrol approach.**

Problem: How can crop damages caused by mushroom phorid flies and their irritating infestations of nearby rural developments be reduced without using chemical insecticides?

- » Chester County, Pennsylvania, is the locus of the state's sixty-seven mushroom farms that produce 64 percent of domestic mushrooms.
- » The EPA banned the most commonly used pesticide for mushroom phorid flies in 2012 after finding it made the fungi toxic to humans.

Findings: Researchers tested two approaches to biologically controlling the reproduction and movement of the pests by establishing a mushroom phorid fly colony—likely the only such experimental colony in the world.

Impact: Biopesticides can provide immediate and future solutions:

- » Short-term solutions use pheromones to confuse male flies, preventing them from mating and keeping the population from building up inside mushroom houses.
- » Long-term solutions use biopesticides that are already approved for other plants and provide a nontoxic remedy at the source of the flies.



Using native parasitic samurai wasps and pheromones to **biologically control** stink bugs.

Problem: How can the brown marmorated stink bug (BMSB) be controlled without using synthetic pesticides?

- » BMSB threatens fruits, vegetables, and ornamentals, causing millions of dollars' worth of damage.
- » Synthetic pesticides hurt beneficial insects and cause outbreaks of secondary pests.

Findings: Researchers found that the samurai wasp, a native parasitic insect, keeps BMSB in check by developing inside the stink bug's eggs. The BMSB can also be attracted to "ghost traps" baited with an aggregation pheromone.

Impact: The complementary, two-pronged approach allows some control of BMSB without pesticide applications to crops, thus also indirectly supporting the establishment of samurai wasps in and around orchards.



Team: Grzegorz Krawczyk, Hillary Peterson, Jayson Harper, Shelby Fleischer, and Claire Hirt

Competitive Funding: USDA Agricultural Research Service; USDA NIFA Specialty Crop Research Initiative; State Horticultural Association of Pennsylvania

Federal and State Appropriations: Project PEN04619 and USDA NIFA Accession #1011647





Team: Jay Stauffer, Joshua Wisor, Kyle Clark, and Sara Mueller

Competitive Funding: Pennsylvania Sea Grant College Program of the National Oceanic and Atmospheric Administration

Federal and State Appropriations: Project PEN04584 and USDA NIFA Accession #1005697

Predicting the threat of the invasive round goby to a multi-million-dollar shellfish industry.

Problem: Could the invasive round goby ruin the Chesapeake Bay's multi-million-dollar oyster industry?

Findings: In studying the diet of round gobies in northwest Pennsylvania's French Creek, researchers confirmed that the gobies feed on native freshwater mussels.

Impact: If gobies reach the Pennsylvania tributaries of the Chesapeake Bay, they pose an enormous threat to this estuary, which is one of the largest bodies of ideal oyster habitat on Earth.

- » Pennsylvania's tributaries could be a gateway for the invasive species.
- » Gobies may reach the estuary if used as bait.



Conservation dairy farming could help Pennsylvania meet Chesapeake Bay target.

Problem: Can dairy farms help minimize pollution of the Chesapeake Bay through conservation practices?

- » Animal agricultural operations contribute a significant portion of the nutrient load that pollutes the Chesapeake Bay.
- » Pennsylvania alone has more than 20,000 individual animal operations within the 64,000-square-mile watershed.

Findings: Researchers modeled nutrient and sediment loading to compare nonpoint pollution from typical and conservation farms and found that conservation-dairy-cropping scenarios improved water quality. The analyses showed reductions in sediment by 31 percent, nitrogen by as much as 53 percent, and phosphorus by as much as 45 percent. Conservation farms produce most of the cattle’s feed and forage, use no-till planting, and have continuous diverse plant cover.

Impact: If most Pennsylvania dairy farms fully adopt conservation best management practices, the state may be able to achieve its water-quality target for the Chesapeake Bay.



Team: Heather Karsten, M. G. Mostofa Amin, Douglas Beegle, Peter Kleinman, and Tamie Veith

Competitive Funding: U.S. Environmental Protection Agency; USDA Pasture Systems and Watershed Management Research Unit; USDA NIFA Northeast Sustainable Agriculture Research and Education

Federal and State Appropriations: Project PEN4600 and USDA NIFA Accession #1009362





Team: Heather Gall, Lara Fowler, Bryan Swistock, and Ray Bryant

Partners: Penn State Survey Research Center and the USDA Agricultural Research Service

Federal and State Appropriations: Project PEN04726 and USDA NIFA Accession #1020769

Citizen scientists help researchers gauge Susquehanna water quality.

- Problem:** Without regulations to control the persistence of chemicals and metabolites in surface water or the ability of wastewater treatment plants to remove them, how can these contaminants of emerging concern be reduced?
- » Pharmaceuticals, pesticides, and personal care products pose serious risks to aquatic life, such as the smallmouth bass, in Pennsylvania's Susquehanna River.
- Findings:** Researchers engaged everyday users of these products to participate in the scientific discovery process and identify potential courses of action by giving them test kits with instructions on how to use them. These citizen scientists were assigned a coordinate within the Susquehanna River watershed to sample surface water.
- Impact:** By doing this research with citizen scientists, the researchers are taking a grassroots approach to raise awareness of the potentially dangerous compounds in everyday products that can make their way to waterways. As informed consumers, participants learned how they can make a difference in water quality in their local rivers.



Cacao provides an **alternative to illicit production** of coca for Colombian farmers.

Problem: How can Colombian farmers make a sustainable living without growing illicit but profitable crops such as coca (the plant used to produce cocaine)?

- » Fifty-three years of civil war have negatively impacted the agricultural investments and growth of Colombian farms.
- » Disadvantaged farmers grew coca and marijuana either by force or because it was the only option during the conflict.

Findings: Plant scientists at Penn State are contributing their expertise on the genetics and the cultivation of the historical cacao plant to provide a road map for the postconflict agricultural development of an alternative crop that is both profitable and sustainable. Cacao, the principal ingredient in chocolate, is native to Colombia, which already produces some of the finest-flavored cocoa in the world.

Impact: Cacao provides a new opportunity to support legal agricultural development in Colombia as the global demand for chocolate is continually increasing. The Cacao for Peace initiative provides training for the difficult-to-grow crop and seeks to make Colombia a major player in world cacao markets. By mapping the genetic diversity of cacao, the team will be able to trace early species of cacao to their origins and possibly identify the genes that are responsible for disease resistance.



Team: Mark Gultinan and Siela Maximova

Partners: USDA Foreign Agricultural Service, U.S. Agency for International Development, United Nations Office of Drugs and Crime, the Peace Corps, Corporación Colombiana de Investigación Agropecuaria (AGROSAVIA), the Colombian National Federation of Cocoa (Fedecacao), and Purdue University

Competitive Funding: USDA Foreign Agricultural Service; U.S. Agency for International Development

Federal and State Appropriations: Project PEN04569 and USDA NIFA Accession #1003147





Team: Alex Hristov and Joonpyo Oh

Competitive Funding: Pancosma

Federal and State Appropriations:

Project PEN04664 and USDA NIFA

Accession #1017181

Spicing up the diets of **transition dairy COWS** has been shown to improve their health.

Problem: How can dairy farmers prevent milk yield decreases during the particularly vulnerable “transition cow” period of three weeks before and after calving?

- » Metabolic disease incidences, such as clinical mastitis, can cause losses of 5-10 pounds of milk per day at peak lactation.

Findings: Dairy nutrition researchers experimented with dietary supplements to bolster the immune systems of transition cows. *Capsicum oleoresin*, an extract from chili peppers, had the most pronounced effect.

- » Capsicum acts as antimicrobial and antiseptic with positive physiological effects on the immune response of lactating cows.
- » Research showed that capsicum can prevent clinical mastitis in 50 percent of the transition cows receiving it.

Impact: Conservative estimates for both disease incidence and adoption of capsicum use forecast large annual savings in milk yield not lost, mortality not experienced, and treatment costs foregone.

- » If only 1 percent of mastitis cases, with an average cost of \$179 per case, adopted capsicum use, the estimated savings would be more than \$2.5 million.



CRISPR-Cas9 gene editing in mosquitos promises future **control of vectorborne diseases.**

Problem: Can vectorborne diseases such as malaria, Zika, dengue fever, yellow fever, and West Nile virus be efficiently and effectively controlled?

- » A gene-editing technique called CRISPR (Clustered Regularly Interspaced Short Palindromic Repeats) provides a revolutionary way to modify an organism's genome by precisely editing a targeted region of DNA.
- » Current techniques for CRISPR in arthropod vectors require difficult and inefficient embryonic microinjections to deliver the DNA-editing enzyme (Cas9) that promotes or disables certain traits.

Findings: Entomologists designed ReMOT Control (Receptor-Mediated Ovary Transduction of Cargo) to improve CRISPR by delivering the Cas9 cargo through an easy injection into the blood of female arthropods.

- » The cargo is introduced into developing eggs via receptors in the ovary.
- » The researchers demonstrated the process by editing the eye color of mosquito offspring.

Impact: ReMOT Control is a substantial improvement over existing embryo-injection techniques, putting gene-editing capability into the reach of nonspecialist laboratories and potentially revolutionizing the broad application of functional arthropod genetics. The technique drastically reduces the cost of editing genes in arthropods.



Team: Jason Rasgon, Duverney Chaverra-Rodriguez, Vanessa Macias, Donghun Kim, Grant Hughes, Sujit Pujhari, Yasutsugu Suzuki, David Peterson, and Sage McKeand

Competitive Funding: NIH National Institute of Allergy and Infectious Diseases; National Science Foundation; Pennsylvania Department of Health using Tobacco Settlement Funds

Federal and State Appropriations: Project PEN04608 and USDA NIFA Accession #1010032





Team: Joyce Sakamoto, Steven Jacobs, and Damie Pak

Competitive Funding:
National Science Foundation; Penn State College of Agricultural Sciences; Huck Institutes of the Life Sciences

Federal and State Appropriations:
Project PEN04608 and USDA NIFA Accession #1010032

More than 100 years of historical data show **shifting tick populations.**

Problem: How can we predict new or emerging tickborne diseases?

- » The blacklegged tick (deer tick) is the most prevalent species in the eastern United States.
- » As the primary vector of Lyme disease, the deer tick is currently the biggest threat.

Findings: Entomologists studied data collected over the past 117 years to track shifts in the dominant species of ticks in Pennsylvania.

- » The team compiled data from more than 7,000 tick specimens collected at Penn State since 1900.
- » The changes correlate with climate changes and variability, shifts in land use that led to habitat loss and fragmentation, and changes in human or animal behavior that brought ticks and their hosts in closer proximity.

Impact: Combining robust surveillance with analysis of historical data helps public health officials and researchers identify high-risk areas, discover ecological trends, and develop predictive models for assessing the risk of tickborne diseases.



Energy-efficient treatment chamber may protect against destructive pests.

Problem: How can we stop the threat to forests and the wood products industry posed by insect pests transported with wood packaging material?

Findings: Researchers discovered a way to kill destructive pests, such as emerald ash borers and pinewood nematodes, in wood for pallets and other shipping materials. An energy-efficient wood treatment chamber that uses radio frequency waves could replace current methyl bromide treatment, which is toxic to workers and contributes to ozone depletion.

Impact: Use of this chamber could prevent thousands of pounds of toxic methyl bromide from being released into the atmosphere each year. About 40 percent of U.S. logs are processed into wooden shipping pallets, so it's important to the U.S. wood industry that wood packaging continue to be acceptable internationally.



Team: Kelli Hoover and John Janowiak

Competitive Funding: USDA NIFA Methyl Bromide Transitions Program; College of Agricultural Sciences Research Applications for INnovations (RAIN) Program

Federal and State Appropriations: Project PEN04576 and USDA NIFA Accession #1004464





Team: Catherine Cutter, Rama Radhakrishna, and Jonathan Campbell

Federal and State Appropriations:
Project PEN04666 and USDA NIFA
Accession #1017568

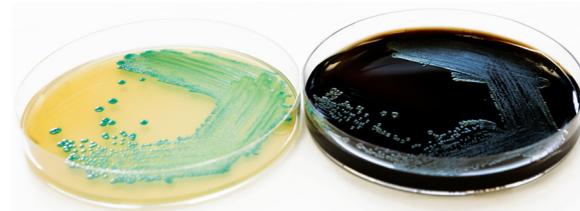
Training for farmers market vendors helps to improve food safety practices.

Problem: What can be done to help improve food safety at the more than 84,000 farmers markets in the nation?

- » Since 2008, seven major foodborne illness outbreaks and two recalls have occurred with food products from farmers markets.
- » As farmers markets have increased in size and complexity in the kinds of foods sold, so have food safety risks.

Findings: Researchers assessed samples of leafy green produce and meat sold at farmers markets in Pennsylvania and found microbiological hazards such as *Listeria* and *E. coli*.

Impact: Researchers created an app for smartphones to be used in place of traditional clipboards to improve the quality of data collection related to food safety observations. They also developed a curriculum for Penn State Extension to train farmers market vendors in food safety. A reduction of just 1 percent in the 1,280 cases per year of foodborne illness in Pennsylvania could bring about \$20,000 in health care cost savings yearly.



Broccoli may be **good for the gut.**

Problem: Can everyday foods help prevent inflammatory diseases such as colitis and Crohn's?

Findings: Researchers found that when mice ate broccoli, they were better able to tolerate digestive issues that can lead to serious disease.

Impact: Broccoli and other cruciferous vegetables, such as brussels sprouts and cauliflower, maintain a healthy balance in gut flora by strengthening the intestinal barrier that keeps out toxins and harmful microorganisms. Compounds in these vegetables may help prevent diseases such as heart disease, various cancers, and Crohn's disease.



Team: Gary Perdeu, Troy D. Hubbard, Iain Murray, Robert Nichols, Kaitlyn Cassel, Michael Podolsky, Guray Kuzu, Yuan Tian, Philip Smith, Mary Kennett, and Andrew Patterson

Competitive Funding: National Science Foundation; Penn State College of Agricultural Sciences; Huck Institutes of the Life Sciences

Federal and State Appropriations: Project PEN04608 and USDA NIFA Accession #1010032





Team: Joshua Lambert, Greg Ziegler, and Deepthi Dabas

Federal and State Appropriations:
Project PEN04708 and USDA NIFA
Accession #1019852

Extract shows promise as a naturally occurring **anti-inflammatory compound**.

- Problem:** What can be done to help prevent inflammatory diseases such as heart disease, strokes, and cancer?
- » Chronic inflammatory diseases are the cause of approximately three out of every five deaths worldwide and as many as seven out of ten in the United States.
 - » Health care costs associated with chronic inflammatory diseases make up approximately 90 percent of annual health care expenditures in the United States.
- Findings:** Food scientists may have found a naturally occurring source for anti-inflammatory compounds in an extract from avocado seeds.
- Impact:** Extracts from the seeds of avocados, which are considered a low-value waste product, could:
- » Help prevent these serious diseases.
 - » Return value to avocado growers and processors.
 - » Reduce hundreds of thousands of tons of seed waste dumped in landfills.



Environmentally friendly barrier coatings pose numerous applications **for curbing plastic use.**

Problem: How can we reduce the more than 29 million tons of plastic that becomes municipal waste each year in the United States?

- » It is anticipated that 10 percent of all plastic produced globally will become ocean debris, representing a significant ecological and human health threat.

Findings: Researchers developed a completely compostable material to replace ubiquitous plastic packaging.

- » Biomaterial combines inexpensive, plentiful, and renewable cellulose pulp derived from wood or cotton with chitosan from leftover shells of consumed lobster, crabs, and shrimp.
- » Applications range from manufacturing cups and bottles, to coatings for ceiling tiles and wallboard, to food coatings to seal in freshness.

Impact: Pollution could be drastically reduced if these coatings replace millions of tons of petroleum-based plastic every year. This alternative may become a barrier competitive to synthetic polymers, such as Styrofoam, solid plastic used in cups and bottles, and laminate applied to paper board.

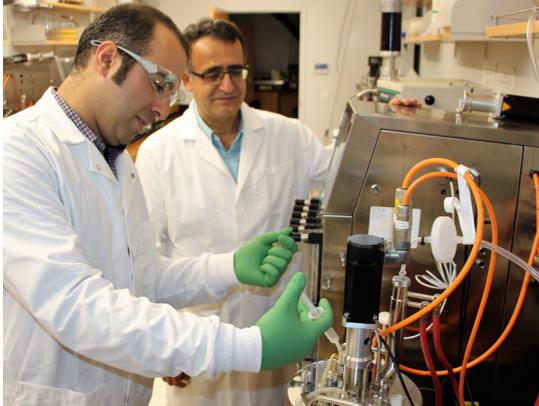


Team: Jeffrey Catchmark, Snehasish Basu, and Adam Plucinski

Partners: Southern Champion Tray (Chattanooga, Tennessee); College of Agricultural Sciences Research Applications for INnovations (RAIN) Program

Federal and State Appropriations: under Project PEN04602 and USDA NIFA Accession #1009850





Team: Ali Demirci, Ehsan Mahdinia, and Aydin Berenjia

Federal and State Appropriations
under Project PEN04561 and USDA NIFA
Accession #1002249

Biofilm reactor promises to **cut production costs** of vitamin K.

Problem: If the form of vitamin K known as Menaquinon-7, or MK-7, is known to be a natural inhibitor of serious heart conditions such as cardiovascular calcification, how can it be mass-produced for regular consumption?

- » Vitamin K can be obtained by eating cheese, sauerkraut, kale, or red meat, but these foods do not provide enough to achieve high-dose therapies.
- » Current production of MK-7 is expensive and impractical.

Findings: Researchers have developed a method to create MK-7 by agitating liquid fermentation in a biofilm reactor. The team developed an innovative composite material that is porous enough to allow the microbes to colonize but also hard enough so that the supports do not fall apart in the liquid or when agitated.

Impact: The new, promising development enhances concentrations of MK-7, potentially increasing the ability to efficiently produce large enough amounts for use in high-dose therapies to help prevent cardiovascular diseases as well as strokes, osteoporosis, and cancer.



Using lessons from successful communities to guide future growth.

Problem: How can Appalachian counties be economically resilient in the face of waning coal production?

- » Between 2005 and 2015, coal production across the thirteen states in the region fell by nearly 45 percent.
- » With a 27 percent drop in coal industry employment, nearly half of the 420 counties in the region are economically distressed or at risk.

Findings: Rural sociologists examined the relationship between a county's resilience ranking and variables associated with resilience, such as broadband availability, natural amenities, and the number of resident college graduates. Researchers identified seven common strategies adopted by counties with higher resilience scores.

- » Researchers used McKean County, Pennsylvania, as a case study of a declining community that rebounded after the 2008 recession.

Impact: By identifying the resilience-promoting factors, the team's findings will help other communities select strategies and policies to enhance their own future economic prospects.

- » As a partner with other counties under a cohesive marketing network, the Pennsylvania Wilds-McKean now benefits from a collaborative rather than competitive strategy in a crowded tourism marketplace.



Team: *Stephan Goetz, Yicheol Han, Fritz Boettner, Evan Fedorko, Evan Hansen, Christine Gyovai, Emily Carlson, Alexandria Sentilles, Alan Collins, and Brianna Zimmerman*

Partners: *Appalachian Regional Commission, Downstream Strategies of West Virginia, Dialogue + Design Associates of Virginia, Northeast Regional Center for Rural Development at Penn State, and West Virginia University*

Competitive Funding: *Appalachian Regional Commission Partnerships for Opportunity and Workforce and Economic Revitalization*

Federal and State Appropriations: *Project PEN04633 and USDA NIFA Accession #1014522*





Team: Rick Bates, Leif Jensen, Ann Tickamy, and Sovannary Huot

Competitive Funding: U.S. Agency for International Development; Kansas State University Sustainable Intensification Innovation Lab

Federal and State Appropriations: Projects PEN04569 and PEN04707 and USDA NIFA Accession #1003147 and #1019863

Agricultural diversification empowers women in Cambodia with “wild gardens.”

Problem: With approximately 1.3 billion people worldwide experiencing irregular access to nutritious or sufficient food, what can be done to help combat food shortages and malnutrition in food-insecure countries?

Findings: Rural sociologists led a multidisciplinary project—Women in Agriculture Network (WAGN): Cambodia—to address the pressing need in the country for diversified farming systems that can improve nutrition and farm profitability.

- » Researchers gathered data from farm inventories of neglected and underutilized indigenous plants, wet- and dry-season market and price surveys, gender-focused farmer interviews, and first-time nutritional analysis of unique perennial vegetable species.
- » Produced a list of wild food plants with nutritional and marketplace value.

Impact: The research is an example of the value that practical training and applied research can have by providing Cambodian farmers, mainly women who manage small farms, with ways to diversify their operations.

- » "Wild gardens" can aid in fortifying home food security by combating hidden hunger or deficiencies of micronutrients such as vitamins and minerals.

Inexpensive technique provides a way to **identify unknown viruses** in bee populations.

Problem: How can the spread of viral pathogens among bees be prevented?
 » Pollinators are experiencing population decline around the world.

Findings: An international team of researchers collected samples of DNA and RNA from twelve bee species in nine countries and then developed a novel sequencing technique to detect viruses. Researchers detected both known and twenty-seven never-before-seen viruses belonging to at least six new families.

Impact: This inexpensive and efficient technique allows researchers to monitor bee health around the world in order to:

- » Identify additional unknown viruses in bee populations.
- » Monitor imported bee populations for potential threat of virus transmission to local bees.
- » Determine whether the viruses in infected bees are passed to crop plants.



Team: Christina Grozinger, David Galbraith, Zachary Fuller, Allyson Ray, Maryann Frazier, J. Francisco Iturralde Martinez, Harland Patch, Cristina Rosa, Joyce Sakamoto, Scott Stanley, Anthony Vaudo, and collaborators from additional institutions

Competitive Funding: National Geographic Society; USDA Animal and Plant Health Inspection Service

Federal and State Appropriations: Project #PEN4579 and USDA NIFA Accession #1004871





Team: Margarita López-Urbe, Antonella Soro, and Shalene Jha

Competitive Funding: National Science Foundation; Army Research Office

Federal and State Appropriations:
Project #PEN04619 and USDA
NIFA Accession #1011647

Bee dispersal ability may influence conservation measures.

Problem: As wild and managed pollinator populations decline due to pests, pathogens, habitat fragmentation, and climate change, how can conservation measures be planned?

- » Some pollinators adapt to these changes by dispersing, but studying dispersal of small insects is difficult.

Findings: An international team of entomologists is the first to identify two significant traits as indicators of a bee's ability to adapt to environmental changes.

- » Body size: researchers examined the breadth of the bees' diets.
- » Social behavior: researchers determined whether the bees are solitary species or work and live together as part of a group.

Impact: Because their findings confirm that these two traits can be linked to the population genetic structure, scientists can now use this research to predict which species may be at risk of local extinction.



The Agricultural Engineering Building expands our facilities to better engage in collaborative work and foster innovation with **University, government, and industry partners.**

- » Rebuilt and renovated building provides new amenities to help attract top faculty and students.
 - » Historic portion of the building originally constructed in 1938.
 - » New research and teaching laboratories, classrooms, offices, fabrication facility with 3-D printing and CNC milling capabilities, and a green roof.
- » CSL Behring Shared Fermentation Facility on the ground floor is a shared University resource available to government and industry researchers.
 - » State-of-the-art biotechnology pilot plant for production of microbial cells, recombinant proteins, and other microbial products.



Fostering Collaboration and Innovation

- » Home to the Department of Agricultural and Biological Engineering.
- » Programs in natural resource engineering and management, biological process engineering and biproducts, and agricultural engineering and production.
- » CSL Behring Shared Fermentation Facility operates as one of eleven core facilities run by Penn State's Huck Institutes of the Life Sciences.



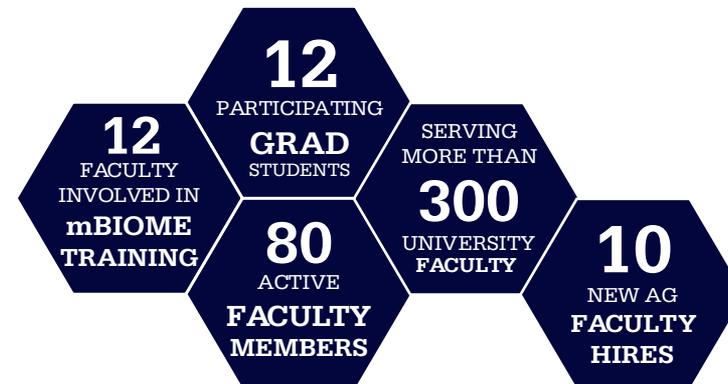


Building a National Reputation

- » Housed in the Penn State Huck Institutes of the Life Sciences.
- » Ten new faculty across five departments in the college since 2017.
- » Nineteen new microbiome faculty across eight colleges.

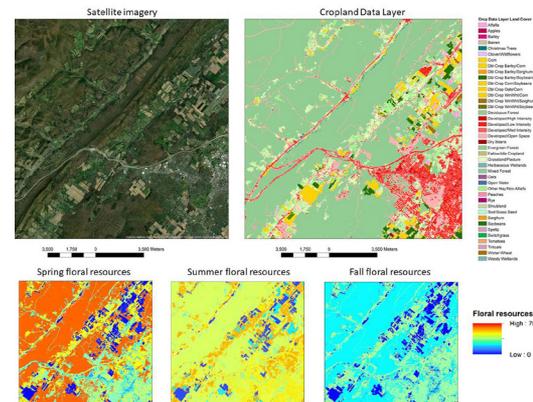
The Microbiome Center leverages our college and University resources to **advance research strengths** and build a national reputation in an emerging field.

- » An interdisciplinary collaboration of faculty from across the University.
 - » Coordinated research reveals how organisms operate in their environment as a system.
- » mBiome Graduate Student Cohort:
 - » Graduate training program in agricultural microbiomes impacts food productivity, quality, safety, and human health.
 - » Original funding for the student cohort from the college's Strategic Networks and Initiatives Program.



Beescape develops **partnerships with peer institutions** to multiply the impact of research across the nation.

- » An online tool for beekeepers, gardeners, growers, and land managers to understand how local-level stressors impact bee health.
- » Compiles publicly available data with new data collected from beekeepers on bee colony health across diverse landscapes.
 - » Allows researchers to predict how bees respond to stressors and conditions.



Multiplying Research Impact

- » College researchers are partnering with colleagues at Dickinson College, Purdue University, University of Illinois at Urbana-Champaign, University of Minnesota, University of Wisconsin, and University of California-Davis.
- » Funding provided by USDA NIFA, Foundation for Food and Agricultural Research, the National Socio-Environmental Synthesis Center (NSF), Illinois Specialty Crops Grant, and a Penn State Extension Multistate and Integrated Program Grant.



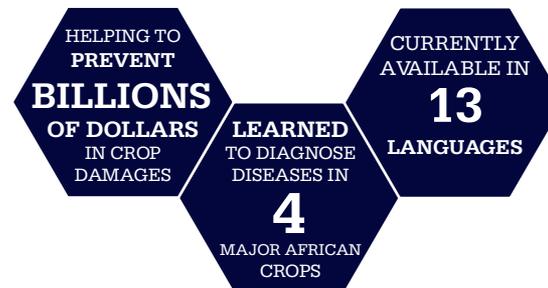


Advancing International Initiatives

- » Nuru is an add-on in the free application PlantVillage developed at Penn State and now embedded into the UN FAO mobile application.
- » The team collaborated with the Tensorflow mobile team at Google to deploy the application's machine learning capabilities.
- » Partners include the UN FAO, CGIAR, and other publicly funded institutions.

Nuru combines **entomological research and machine learning** to partner with international initiatives to fight a fast-spreading crop pest.

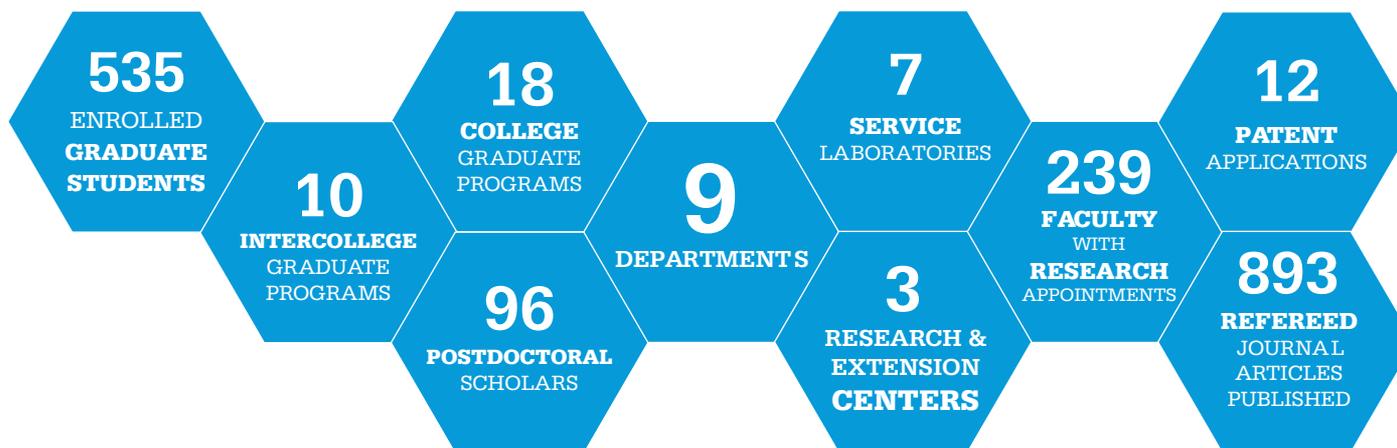
- » Free digital assistant allows sub-Saharan African farmers to use cell phones to identify invasive fall armyworm damage.
- » Uses artificial intelligence to learn to diagnose damage caused by fall armyworm and other crop diseases.
- » Integrates with a United Nations Food and Agriculture Organization (UN FAO) mobile application and global, web-based database for monitoring fall armyworm spread.
- » Works when offline in regions with spotty network availability, uploading collected data once farmers connect their device online.
- » Provides real-time, situational overview with maps of infestations and effective measures to reduce its impact.



About the College

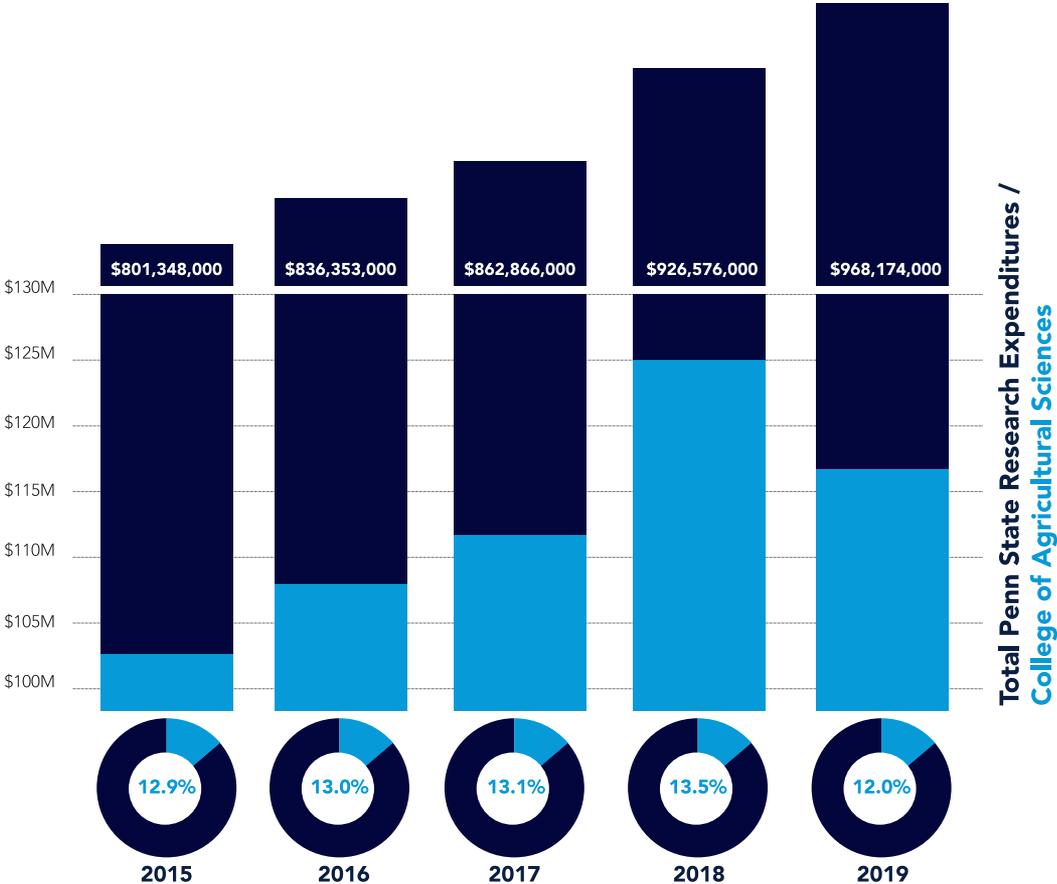
Research efforts in the College of Agricultural Sciences pursue fundamental science as the core element of discovery.

- » Researchers in the college continually generate new ideas that are highly competitive for extramural funding.
- » The college fosters the translation of knowledge into real-world applications through innovation and technology development.
- » Graduate programs train the next generation of scientists to be competitive and successful.



Research Expenditures

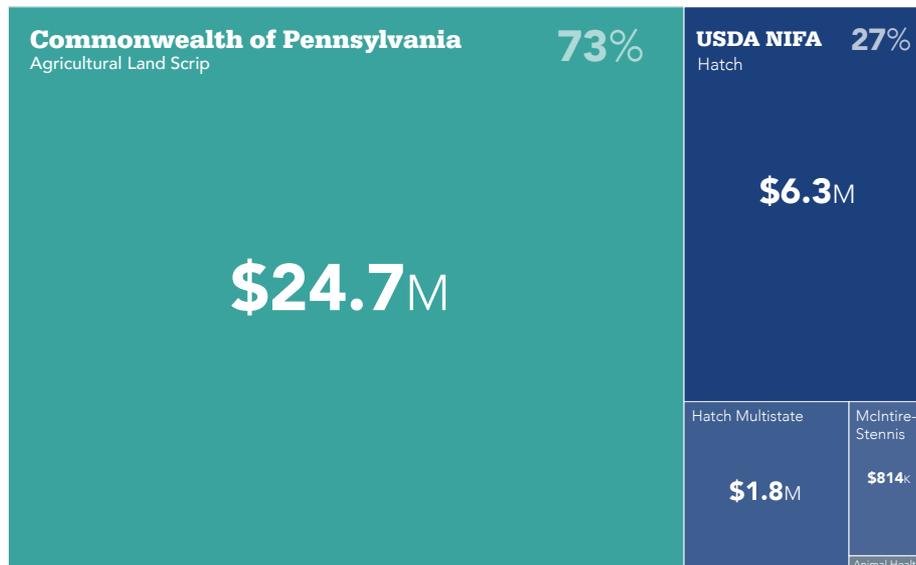
For the past five years, research expenditures by the College of Agricultural Sciences represent 12 percent or more of the total research expenditures by Penn State.



Federal and State Appropriations

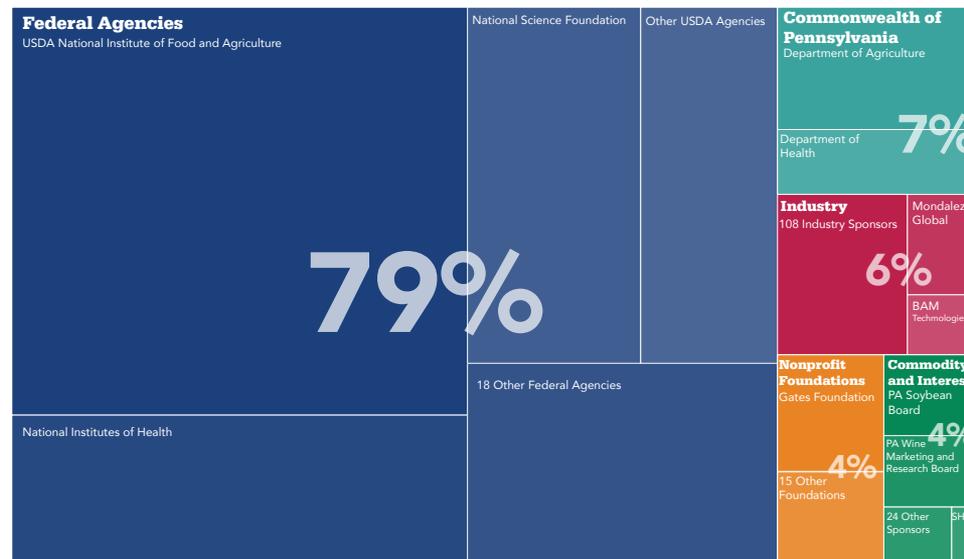
The College of Agricultural Sciences is privileged to be **the only college in the Penn State system** to receive federally appropriated funds to support faculty research.

- » The federal government has appropriated funds specifically to support agricultural research at land-grant universities since 1887.
- » The Commonwealth of Pennsylvania has exceeded the required match for federal appropriations by at least two-and-a-half times since 2008.
- » Funding from the state accounted for approximately 73 percent of the total amount of government appropriations in the 2018/2019 fiscal year.



Researchers in the College of Agricultural Sciences are awarded competitive grants to support **collaborative projects that bring together investigators** across Penn State, the nation, and the globe.

- » The college administered a total of \$98 million in extramural competitive grants.
- » Grants awarded from federal agencies accounted for approximately 79 percent of total awards.
 - » The USDA National Institute of Food and Agriculture, National Institutes of Health, and the National Science Foundation are the college's largest sponsors.



College of Agricultural Sciences faculty and graduate students were **recognized for their outstanding research** with major competitive extramural grants and fellowships.

Water for Ag

An interdisciplinary team that brings together rural sociology, soil science, biogeochemistry, and law was awarded \$7.2 million by the USDA National Institute of Food and Agriculture (NIFA) to develop a model that engages communities and stakeholders to ensure good-quality water both for and from agriculture.

Food-Energy-Water Graduate Training

A \$3 million grant from the National Science Foundation (NSF) was awarded to an interdisciplinary team in the College of Agricultural Sciences and College of Earth and Mineral Sciences to create a new graduate program. Landscape-U will use regenerative landscape design to address complex, landscape-scale challenges.

Robotic Frost Protection

The National Science Foundation Cyber-Physical Systems program awarded a team \$843,000 to develop a system that helps tree fruit growers avoid frost damage to their crops by using unmanned aerial vehicles (UAVs) and ground-based robots. The team combines disciplines across agricultural engineering, horticulture, pomology, and mechanical engineering.

Graduate Training

In the 2018-2019 academic year, seventy graduate students were awarded competitive fellowships or grants from a wide array of sponsors, including USDA NIFA, NSF, National Institutes of Health, and the Fulbright program.



PennState
College of Agricultural Sciences

Office for Research and Graduate Education
College of Agricultural Sciences
The Pennsylvania State University

Read more about these and other stories of impact from Penn State College of Agricultural Sciences at agsci.psu.edu/research/impacts.

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