Shortening the Distance Between Discovery and Impact

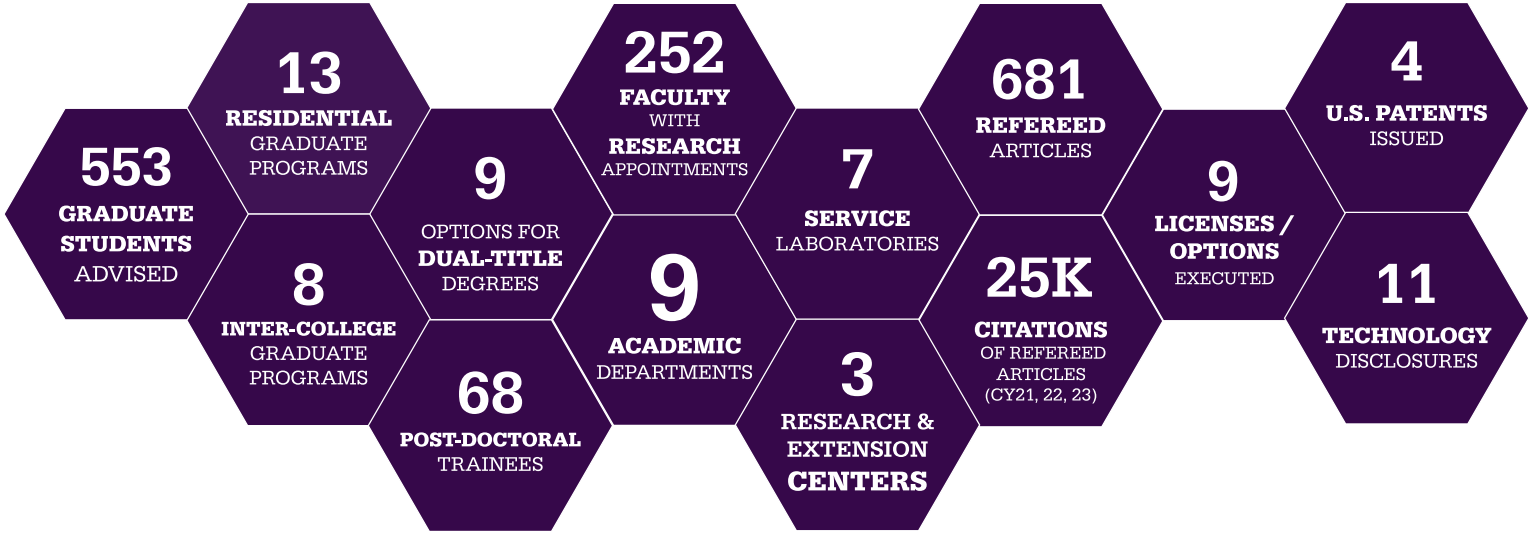
Penn State AgScience Research

PennState
College of Agricultural Sciences

Contents

The Office for Research and Graduate Education in the College of Agricultural Sciences provides critical support for advancing agricultural and natural resources research that will **uncover real-world solutions** through research and graduate education.

- The College of Agricultural Sciences **balances fundamental research** that improves our knowledge of complex biological phenomena **with applied research** focused on solving immediate needs.
- Graduate programs **prepare the next generation** of agricultural sciences researchers and practitioners to make impactful contributions to science and society.



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Shortening the distance between **discovery and impact**.

Discovery is only the beginning of our work. The College of Agricultural Sciences is at the forefront of research that addresses critical issues facing our agricultural industries, natural resources, and communities. The accomplishments we showcase work to fulfill our college mission to discover, integrate, translate, and disseminate knowledge to improve the lives of people in Pennsylvania, the nation, and the world.

As the Commonwealth's sole land-grant institution, we are responsible for administering state and federal appropriations through the Pennsylvania Agricultural Experiment Station. Leveraging these resources is critical to our current success and capacity to identify and tackle future challenges. We remain committed to harnessing the resources, excitement, and momentum that will fuel the innovation crucial to agriculture, nutritional security, and environmental protection for generations to come.

Blair D. Siegfried
Associate Dean for Research and Graduate Education
Director of the Pennsylvania Agricultural Experiment Station

USDA National Institute of Food and Agriculture
U.S. DEPARTMENT OF AGRICULTURE

The Pennsylvania Agricultural Experiment Station is supported by federal appropriations from the United States Department of Agriculture National Institute of Food and Agriculture (USDA NIFA) and matching appropriations from the Commonwealth of Pennsylvania Agricultural College Land Scrip Fund.

Climate-Smart Agricultural Systems

Adapting to a **changing climate** and **performing responsibly**

Our researchers are finding balanced solutions to sustain a growing global population. Their research seeks to effectively reduce the emissions from agricultural production while also increasing resilience and adaptability to both volatile and enduring environmental shifts.

When plants show us that they can withstand pressures of drought, disease, and pests by deploying their own natural defenses, **we can learn from them**.

- Scientists are studying how plants are already working with microbes in the soil to fight off diseases or to withstand extreme weather.
- Uncovering how plants or other insects chemically respond to dangers in their environment, both positively and negatively, also clues us into their naturally occurring defenses.
- When we understand how plants have already adapted to these pressures, we can use that knowledge to enhance and protect our future crops.

The following are highlights of our research work in Climate-Smart Agricultural Systems. Want to see more? Visit us online: **agsci.psu.edu/research/impacts**

Supporting naturally occurring microbial communities to **protect plants and improve harvests**.

Problem: **How can growers reduce the use of pesticides, which can harm beneficial insects, microbes, and the environment?**

Findings: The researchers sprayed young tomato plants with microbes gathered from the leaves of healthy tomato plants in the field and then inoculated them with a pathogen that causes bacterial speck of tomato.

- After multiple rounds of transferring these microbes, the researchers found that disease symptoms such as brown-to-black lesions on leaves began to wane.
- By the ninth round, these symptoms decreased by nearly half.

Impact: The successive passaging of microbes between tomato plants is comparable to season-to-season transfer of microbes. These findings are a step closer to using the natural ecosystems in fields to benefit farmers and prevent plant diseases.

Team: *Hanareia Ehau-Taumaunu, Constanza Bartolomeo, Beth Gugino, Kevin L. Hockett*

Partners: *Center for Infectious Diseases Dynamics; One Health Microbiome Center; The Huck Institutes of the Life Sciences; Indigo Agriculture*

Competitive Funding: *Northeast Sustainable Agriculture Research and Education; Indigo Agriculture Phytobiomes Fellowship; Fulbright New Zealand Science and Innovation Graduate Award; Ngārimu VC and 28th (Māori) Battalion Memorial Doctoral Scholarship; PA Vegetable Growers Association; Ministry of Education–New Zealand; USDA NIFA Agriculture and Food Research Initiative*

Federal and State Appropriations: *USDA NIFA Hatch Project PEN04648, Accession #1016871*

ADOBE STOCK #210620608

Team: *Pengfa Li, Leho Tedersoo, Thomas W. Crowther, Alex J. Dumbrell, Francisco Dini-Andreote, Mohammad Bahram, Lu Kuang, Ting Li, Meng Wu, Yuji Jiang, Lu Luan, Muhammad Saleem, Franciska T. de Vries, Zhongpei Li, Baozhan Wang, Jiandong Jiang*

Partners: *Nanjing Agricultural University; University of Tartu; ETH Zürich; University of Essex; Chinese Academy of Sciences; Alabama State University; University of Amsterdam*

Federal and State Appropriations: *USDA NIFA Hatch Project PEN04732, Accession #7000239*

Learning the impacts of climate change on plant-beneficial bacteria now **helps to plan for stronger, healthier plants** for the future.

Problem: **How can researchers temper the effects of climate change on bacterial species that benefit plants?**

» Specific bacterial species can help limit the impact of harmful pathogens, promote plant growth, and build stress resistance for many plants, including important food crops. Still, a shifting climate may threaten these plant-beneficial bacteria (PBB).

Findings: The researchers created models that predicted the effects of future climate scenarios on PBB at different latitudes. Under the model that assumed tripled greenhouse gas emissions by 2075, PBB associated with biocontrol and stress resistance declined across 80 percent of global regions.

Impact: The findings will help scientists better understand the variables that affect PBB and predict their future in a shifting climate. Researchers might leverage this knowledge to engineer crops that produce compounds that feed and nurture PBB, directly impacting crop performance.

Preventing the spread of a destructive soybean virus to **protect a valuable agricultural commodity**.

Problem: **Can we reduce the economic impacts of viruses and pests that attack soybeans, especially as climate change contributes to the proliferation of harmful pests?**

- Soybeans contribute more than $120 billion to the U.S. economy
- Soybean vein necrosis orthotospovirus (SVNV) is a viral disease that affects plant leaves and is spread by infected seeds or infected soybean thrips.

Findings: Researchers released SVNV-infected and uninfected soybean thrips onto soybean plants in the lab. They compared their life parameters separately for male and female thrips.

- They found that when soybean thrips were infected with SVNV, they tended to survive longer and reproduce better than thrips that were not infected.

Impact: The findings suggest that infected thrips grow quicker, which could enhance the spread of the virus to additional soybean plants. Because there is no cure for plants infected with the virus, knowing more about the thrips that transmit SVNV is important for designing soybean vein disease prevention programs and calculating the economic threshold of any intervention.

Team: *Asifa Hameed, Cristina Rosa, Edwin G. Rajotte*

Partners: *Ministry of Agriculture; Government of Punjab Pakistan*

Competitive Funding: *Pennsylvania Soybean Board; Fulbright Organization*

Federal and State Appropriations: *USDA NIFA Hatch Project PEN04652, Accession #1016243*

ADOBE STOCK #301265498

Team: *Jessica T. Kansman, Colleen E. Nersten, Sara L. Hermann*

Competitive Funding: *USDA NIFA Agriculture and Food Research Initiative Education and Workforce Development*

Other Funding: *Tombros Early Career Professorship; Penn State Huck Institutes of the Life Sciences*

Federal and State Appropriations: *USDA NIFA Hatch Project PEN04770, Accession #7000337; Hatch Multistate Project PEN04757, Accession #1024573*

Using ladybugs' scents to naturally repel pests and **provide sustainable crop protection**.

Problem: **How can growers protect their crops from destructive pests while reducing the use of pesticides that can negatively affect natural ecosystems and human health?**

Findings: The researchers diffused scents emitted by ladybugs into the air around plants, signaling trouble to nearby aphids, which are destructive to many crops. They found that the ladybug odors reduced the amount of time aphids consumed plant sap and dropped their population numbers by 25 percent.

Impact: This type of intervention differs from conventional pesticide applications and avoids the risk of resistance developing in pest insects, providing a sustainable solution to aphid infestations. The scent's components could also be commercially produced, making the intervention accessible to develop for the pest management market.

Nutritional and Food Security

Addressing vulnerabilities at all scales **from the microbiome to food supply chains**

Our researchers are taking a comprehensive approach to solutions that ensure the availability and access to safe, affordable, and healthy food. Their research addresses the impacts of a wide range of factors such as an unpredictable climate or socioeconomic instability that can jeopardize reliable access to nutritious food.

As our global population grows, we can expect that **our food supply will be impacted**.

- We will need to continue to do more with less–fewer inputs to protect our environment and budgets, more food on less acreage, more nutrients in each bite.
- Research is helping us find ways to enhance the nutritional value of our foods by studying how plants and animals respond to biofortification and what we can gain from those interventions.
- Discoveries in agricultural technologies are helping us to protect against climate volatility and increase the efficiency of our operations so we can continue to grow delicious foods.

The following are highlights of our research work in Nutritional and Food Security.
Want to see more? Visit us online: **agsci.psu.edu/research/impacts**

Improving the nutritional value of eggs **without impacting egg production**.

Problem: **How can farmers balance improving egg nutrition without impacting production?**

- Omega-3 fatty acids have been found to lower the risk of cardiovascular disease and cancer while positively affecting eye health and cognitive function in older, healthy adults.

Findings: The researchers assigned hens a series of diets receiving different levels of a supplement that contained a high level of a long-chain omega-3 polyunsaturated fatty acid.

- They found that due to the supplement, some of the hens produced eggs with high levels of omega-3 polyunsaturated fatty acids.
- But in hens fed the highest amounts of the supplement, egg production was greatly reduced, and some stopped laying eggs entirely.

Impact: Farmers could use the findings when designing diets for their hens that can maximize the health benefits of eggs without negatively affecting egg production. This research is also important for better understanding fatty acid nutrition and metabolism in laying hens.

Team: *Robert G. Elkin, Ahmed S. A. El-Zenary, Rebecca Bomberger, Abiel B. Haile, Evelyn A. Weaver, Ramesh Ramachandran, Kevin J. Harvatine*

Partners: *University of Sadat City*

Other Funding: *Pennsylvania Poultry Industry Egg Research Check-Off Program; Pennsylvania Soybean Board*

Federal and State Appropriations: *USDA NIFA Hatch Multistate Project PEN04680, Accession #1017794; Hatch Multistate Project PEN04664, Accession #1017181*

Team: *Pradip Poudel, Francesco Di Gioia, Joshua Lambert, Erin L. Connolly*

Competitive Funding: *Open Philanthropy*

Other Funding: *College of Agricultural Sciences Strategic Networks and Initiatives Program (SNIP)*

Federal and State Appropriations: *USDA NIFA Hatch Project PEN04723, Accession #1020664; Hatch Project PEN04708, Accession #1019852*

ADOBE STOCK #630301186

Biofortification of microgreens with zinc could help to **reduce global malnutrition**.

Problem: **How can growers help mitigate "hidden hunger" even during emergencies and catastrophes?**

- Hidden hunger is a lack of essential micronutrients (vitamins and minerals) that occurs when the food people eat does not meet their nutrient requirements for optimal growth and development.

Findings: Researchers examined how soaking seeds in different zinc sources and concentrations affected factors such as the mineral content, the beneficial compounds from plants, antioxidant activity, and antinutrient factors of microgreens.

- Soaking pea and sunflower seeds in zinc sulfate resulted in higher zinc in the microgreens. They also found that sprouting the seeds reduced an antinutrient, phytic acid, in the microgreens, allowing the zinc to become more nutritionally available.

Impact: The findings suggest that in poor regions of the world, or areas under post-catastrophic conditions, simply soaking seeds in a zinc solution could be a practical and effective strategy for producing nutrient-dense microgreens as a vital source of nutrition.

Building low-cost robotic systems that help growers to **prevent yield loss** due to extreme cold events.

Problem: **How can growers protect apple trees from spring frosts that can devastate fruit production, especially with a warming climate causing trees to blossom early?**

- Manual heating strategies are often labor-intensive and can be made ineffective by winds.

Findings: Agricultural engineers developed an automated frost protection system that makes optimized heating decisions based on real-time temperature and wind-direction data.

- The system combines an autonomous ground vehicle, drone-collected thermal data, and algorithms created by the team to identify flower stages.

Impact: Using mostly off-the-shelf parts, the team built a low-cost solution that can help address labor shortages, save on energy costs, and more effectively prevent frost damage in orchards.

- This proof of concept lays groundwork as the team works toward building a more complex automated system that could use multiple heaters guided by an aerial drone monitoring the canopy temperatures and precisely guiding the units only where heat is needed.

Team: *Weiyun Hua, Paul Heinz Heinemann, Long He*

Competitive Funding: *National Science Foundation / USDA Cyber-Physical System Program*

Federal and State Appropriations: *USDA NIFA Federal Appropriations under Project PEN04822, Accession #7005925*

ADOBE STOCK #311780149

Team: *Xinyang Mu, Long He, Paul Heinemann, James Schupp, Manoj Karkee*

Partners: *Penn State Fruit Research and Extension Center (FREC); Washington State University*

Competitive Funding: *USDA-AMS Specialty Crop Multi-State Grant Program*

Federal and State Appropriations: *USDA NIFA Hatch Multistate Project PEN04653, Accession #1016510*

Helping fruit growers **reduce risks and uncertainties** with precision pollination.

Problem: **How can growers leverage technology to maximize the yield of high-quality fruits?**

- While insects have traditionally been relied on for apple pollination, research has suggested that these pollinators have not met demands as climate change threatens their populations.

Findings: The researchers used a deep-learning computer program to train a machine vision system that identifies and locates the king flowers—the blossom in the center of a cluster that opens first and usually grows the largest fruit.

- Using manual identification by the researchers to ground truth the results, the machine vision's king flower detection accuracy varied from 98.7 percent to 65.6 percent at different flowering stages.

Impact: The findings are a critical early step in developing a robotic pollination system that can efficiently and reliably pollinate apples to maximize the yield of high-quality fruit. This technology will be especially critical in regions where bee die-offs have been severe and growers will need to improve pollination services for their orchards.

Biodiversity

Promoting **mutually beneficial interactions** among all living organisms on Earth

Our researchers are coordinating a wide spectrum of expertise to ensure diversity across the genes of individuals, entire populations of species, and the ecosystems in which they live. This research is helping to regenerate and preserve the complexity that Earth's living organisms will need to adapt and withstand climate volatility, increased disease pressures, threats of invasive species, and changing land use patterns.

Diversity in living systems is strength, helping to ensure that **no single threat can break down the entire system**.

- We are only on the verge of understanding how soil microorganisms are critical to plant growth and survival.
- Scientists are using new technologies to learn how genetic diversity in different species is either thriving or in danger and using that information to provide recommendations to enhance resiliency and survival for future species.
- This research is fueling a revolution in how we think about protecting different species and helping us to better understand how biodiversity is critical at all scales of life.

The following are highlights of our research work in Biodiversity.
Want to see more? Visit us online: **agsci.psu.edu/research/impacts**

Managing microorganisms in soil to **restore ecosystem functions** that benefit plant growth.

Problem: **How can farmers and other land managers offset the loss of microbe biodiversity in managed soils?**

- Certain agricultural treatments, such as long-term inputs of synthetic fertilizers or pesticides, may reduce the diversity of microbes that provide important ecosystem services, including nutrient cycling, making nutrients available to plants, soil structure, carbon sequestration, and more.

Findings: The researchers examined the effects of reintroducing microbes to both agricultural and forest soils with experimentally reduced microbial diversity. They found that microbe diversity loss was associated with a disruption of at least certain soil functions.

- In this study, they showed a decrease in nitrification – a nutrient cycling process that occurs when bacteria convert ammonium to available nitrate. However, nitrification was restored when a highly diverse set of microbes were reintroduced to the soil.

Impact: The findings suggest that depleted soils may be affected by microbial rediversification, whether through active management or microbial recolonization from surrounding areas. This could further enhance land managers' toolkit for managing microbes in human-controlled systems to help restore depleted microbial soil functions.

ADOBE STOCK #316709001

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Competitive Funding: *USDA Organic Transitions Program; National Science Foundation Graduate Research Fellowship Program*

Federal and State Appropriations: *USDA NIFA Hatch Project PEN04651, Accession #1016233; Hatch Project PEN04710, Accession #1020049; Hatch Project PEN04571, Accession #1003346*

Team: *Ryan V. Trexler, Marc W. Van Goethem, Danielle Goudeau, Nandita Nath, Rex R. Malmstrom, Trent R. Northen, Estelle Couradeau*

Partners: *Penn State Huck Institutes of the Life Sciences; Lawrence Berkeley National Laboratory; King Abdullah University of Science and Technology; Department of Energy Joint Genome Institute*

Competitive Funding: *U.S. Department of Energy Office of Science Early Career Research Program*

Federal and State Appropriations: *USDA NIFA Hatch Project PEN04710, Accession #1020049*

Measuring microbial activity in biocrusts **provides insights to the impacts** of climate change on ecosystem services provided by soils.

Problem: **How can researchers help preserve biocrusts and prevent increased global dust emissions and deposition?**

- Biocrusts rely on a diverse community of microorganisms that stabilize the soil, preventing it from breaking down into dust.
- Climate change and land use intensification in semi-arid regions threaten to reduce Earth's biocrust coverage by up to 40 percent over the next 65 years.

Findings: Researchers sampled biocrusts in the fall after rain wetted the soil sufficiently to activate microbes. The samples were dried, stored in the dark, and rewetted later. They applied a novel method for analyzing the microbial composition, which could discern active and inactive microorganisms in the biocrusts.

Impact: These findings can pave the way for innovative technologies to uncover microbial diversity. The results could also help scientists better understand the microbial functions that support biocrust resilience during rapidly changing climate patterns and more frequent droughts. These functions include valuable ecosystem services such as taking carbon and nitrogen from the air and fixing them in the soil, recycling nutrients, and holding soil particles together and preventing dust.

Development of an innovative test can help breeders **ensure healthy herds**.

Problem: **How can dairy herd breeders improve genetic diversity in cows to reduce susceptibility to disease and early death?**

- In autumn 2020, an unusual and unknown condition was identified on two New York farms, causing weakness and early deaths of Holstein calves.

Findings: Researchers collected tissue samples from two herds in New York, a herd in Florida, and a herd in Pennsylvania, to conduct a genome-wide association using DNA markers and pedigree analysis. They identified a mutation in a gene associated with calcium channels in muscle.

- Mutations in this gene affect skeletal muscle function in other species, including humans. Analyzing pedigrees, they also identified one of the mutation's first carriers and perhaps the progenitor.

Impact: The discovery of this mutation could help prevent a potential widespread calf-welfare issue and safeguard the health of future Holstein herds. The team also developed an innovative genetic test with the private sector to commercialize the technology.

ADOBE STOCK #266812118

Team: *Chad Dechow, Elisha Frye, Fiona Maunsel*

Partners: *Cornell University; University of Florida; ABS Global*

Federal and State Appropriations: *USDA NIFA Hatch Project PEN04691, Accession #1018545*

Team: *Leilton W. Luna, Lisa M. Williams, Kenneth Duren, Reina Tyl, David P. L. Toews, Julian D. Avery*

Partners: *Penn State Eberly College of Science; Pennsylvania Game Commission*

Competitive Funding: *Pennsylvania Game Commission*

Federal and State Appropriations: *USDA NIFA Hatch Project PEN04702, Accession #1019213*

ADOBE STOCK #489861784

Using whole-genome sequencing to **guide conservation strategies** and help restore wild game bird populations.

Problem: **How can researchers help increase genetic diversity within populations of the ruffed grouse?**

» This game bird has experienced a population decline by up to 70 percent since the early 1960s.

Findings: To investigate the population health of the ruffed grouse in Pennsylvania, the researchers sequenced 54 individual bird genomes and compared each individual to every other individual that was sampled to determine whether the birds belonged to a single geographic population or different populations. They found that Pennsylvania's state bird harbors more genetic diversity than expected, revealing its ability to withstand changing environmental conditions.

Impact: The research provides critical information that can guide future conservation strategies by revealing that the game bird could be maintained in persistent numbers if appropriate protections—such as habitat protection and other management interventions—are implemented.

Identifying pollinator populations that may be **at risk under future climate scenarios** and preventing local extinction.

Problem: **How can we predict which species and populations will be most vulnerable under future warmer climates?**

- Pollinators such as solitary bees are small-bodied ectotherms that rely on external conditions to maintain body temperatures, but their tolerance to temperature extremes can vary across populations.

Findings: The researchers studied how body mass, local climate, and pathogens affected heat tolerance in populations of the hoary squash bee. They found that variation in heat tolerance was influenced by size, sex, and infection status of the bees.

Impact: The findings contribute to growing evidence that small-bodied invertebrates' ability to adapt or acclimate their heat tolerance to local climate conditions depends on external factors and an individual's physical traits.

- Their research reveals how important it will be to evaluate trends in bees' tolerance of heat, both within and between different populations, to anticipate which ones may be most vulnerable to local extinction due to temperature extremes.

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Partners: *Penn State College of Earth and Mineral Sciences; Penn State Eberly College of Science*

Competitive Funding: *Pennsylvania Department of Agriculture; USDA NIFA Agriculture and Food Research Initiative Pollinator Health Program; NSF Graduate Research Fellowship Program*

Federal and State Appropriations: *USDA NIFA Hatch Project PEN04770, Accession #7000337; Hatch Multistate Project PEN04716, Accession #1020527; Hatch Project PEN04620, Accession #1011873*

ADOBE STOCK #1056982886

Team: *Darcy Gray, Sarah Goslee, Melanie Kammerer, Christina M. Grozinger*

Partners: *USDA Agriculture Research Service Pasture Systems & Watershed Management Research Unit*

Competitive Funding: *USDA NIFA AFRI Food and Agriculture Cyberinformatics and Tools Initiative*

Federal and State Appropriations: *USDA NIFA Hatch Multistate Project PEN04716, Accession #1020527*

Combining pest treatments may be key to **helping honey bees** survive the winter.

Problem: **How can beekeepers help their colonies better survive the winter, a season that often leads to many managed colonies losing up to 30 percent of their population?**

Findings: The researchers analyzed data from Pennsylvania beekeepers on pre- and post-winter colony numbers, whether and how they treated for Varroa mites, and whether and what they provided for supplemental feed. They found that beekeepers who used a combination of treatments for Varroa mites had higher winter colony survival than those who used only one type of treatment.

Impact: Beekeepers may be able to use the findings to decide how to best manage their colonies to combat these high colony losses during the winter. Understanding honeybees' relationship to the environment can also give insight into the survival of native bees, which are also threatened by habitat loss and climate change.

One Health

Encompassing **all levels** from soil health to the dynamics of human and animal diseases

Our researchers are addressing health as an integrated challenge at the intersections between people, animals, plants, and the environment they inhabit. Their research recognizes critical interconnections across systems and is uncovering interdisciplinary solutions that will enhance biosecurity, promote positive health outcomes, and sustain agricultural development.

Health **cannot not exist** in a vacuum.

- By understanding how food changes into energy in our bodies, we can develop future foods that benefit us and help us ward off avoidable diseases.
- As scientists continue to uncover how our bodies and the systems within it work, those discoveries will guide future therapies and interventions that can save lives and protect against diseases.

The following are highlights of our research work in One Health.
Want to see more? Visit us online: **agsci.psu.edu/research/impacts**

Finding **healthy and effective dietary interventions** that taste good to consumers and can contribute to disease prevention.

Problem: **Can processed cocoa used to make chocolate also be used as a healthy dietary intervention for conditions such as obesity and non-alcohol-related fatty liver disease?**

- To make cocoa products acceptable to consumers, the beans must be fermented and roasted which can affect the compounds that provide health benefits.

Findings: The researchers fed groups of mice seven different dietary supplements of cocoa powder that were prepared with varying levels of fermentation and roasting, from none to extensive.

- They found that the cocoa reduced the rate of body weight gain in both male and females by up to 57 percent, regardless of fermentation and roasting protocol. Gut permeability, which is an important contributor to development of fatty liver disease, was also reduced by up to 79 percent.

Impact: This research is important because a significant proportion of the world's population has preexisting obesity and non-alcohol-related fatty liver disease. These findings could be used to develop potentially effective dietary interventions with cocoa products that are still palatable and appealing to consumers.

Team: *Daphne K. Weikart, Vijaya V. Indukuri, Kathryn C. Racine, Kiana M. Coleman, Jasna Kovac, Darrell W. Cockburn, Helene Hopfer, Andrew P. Neilson, Joshua D. Lambert*

Partner: *North Carolina State University*

Competitive Funding: *USDA Agriculture and Food Research Initiative*

Federal and State Appropriations: *USDA Hatch Project PEN04708, Accession #1019852; Hatch Project PEN04624, Accession #1013412; Hatch Project PEN04650, Accession #1015962; Hatch Project PEN04646, Accession #1015787*

Team: *Xiaoling Chen, Andrew D. Patterson, Gary H. Perdew, Iain A. Murray, Joshua J. Kellogg*

Partners: *Penn State Huck Institutes of the Life Sciences*

Competitive Funding: *NIH National Institute of General Medical Sciences; NIH National Institute of Environmental Health Sciences; USDA NIFA Agriculture and Food Research Initiative*

Federal and State Appropriations: *USDA NIFA Hatch Project PEN04772, Accession #7000371*

Natural compound in mushrooms could **benefit animal and human health**.

Problem: **Can naturally occurring molecular mixtures in foods like white button mushrooms enhance overall gut health?**

Findings: Scientists explored how a biochemometric approach—modeling chemical and biological data together—could lead to the discovery of new components of chemical mixtures in foods.

- They identified a compound found in white button mushrooms that activates the aryl hydrocarbon receptor, which is found in mammals. When activated, it can induce a cellular response to detoxify aryl hydrocarbons, which are known carcinogens, in the gut. Further explorations of other key dietary and medicinal mushrooms are ongoing.

Impact: The findings underscore the importance of studying the roles each molecular component plays in a whole food to improve health.

- This research demonstrates how chemical mixtures could benefit gut health in mammals by activating a protective biological response. Scientists can use this unique approach to explore how these components help inhibit infectious diseases in the body.

Revealing how the body forms bile acids will help further research into developing **future therapies for chronic diseases**.

Problem: **Can researchers use discoveries of how bile acids work to create new therapies?**

- Bile acids are known to play a role in human metabolism, such as in digestive processes helping to absorb fat. Still, they are also known to be associated with diseases, including inflammatory bowel disease, certain cancers, and obesity.

Findings: Deploying recent technological advances, researchers uncovered how bacteria generate a wide variety of new bile acid species. They identified a new role for a known bacterial enzyme that modifies how mammals such as humans or mice generate bile acids in their bodies. The team found that this enzyme, which can change the configuration of the bile acids, coincides with the establishment of the gut microbiome in newborns.

Impact: This discovery by the researchers cracks open new understandings of the role of bile acids, which can act as messengers between humans and their microbiomes. As they continue to uncover other signaling functions of bile acids beyond helping to consume fat, their research provides important groundwork for new and improved therapies for bile acid-related diseases in the future.

Team: *Bipin Rimal, Stephanie L. Collins, Ceylan E. Tanes, Edson R. Rocha, Megan A. Granda, Sumeet Solanki, Nushrat J. Hoque, Emily C. Gentry, Imhoi Koo, Erin R. Reilly, Fuhua Hao, Devendra Paudel, Vishal Singh, Tingting Yan, Min Soo Kim, Kyle Bittinger, Joseph P. Zackular, Kristopher W. Krausz, Dhimant Desai, Shantu Amin, James P. Coleman, Yatrik M. Shah, Jordan E. Bisanz, Frank J. Gonzalez, John P. Vanden Heuvel, Gary D. Wu, Babette S. Zemel, Pieter C. Dorrestein, Emily E. Weinert, Andrew D. Patterson*

Partners: *Penn State Eberly College of Science; Penn State Huck Institutes of the Life Sciences; Penn State College of Health and Human Development; Penn State College of Medicine; Penn State One Health Microbiome Center; Michigan Medicine Translational Tissue Modeling Laboratory, University of Michigan*

Competitive Funding: *National Institutes of Health; American Beverage Foundation for a Healthy America; Crohn's and Colitis Foundation; American Heart Association; Pennsylvania Department of Health*

Federal and State Appropriations: *USDA NIFA Hatch Project PEN04772, Accession #7000371*

ADOBE STOCK #256231990

Team: *Camilla H. K. Hughes, Olivia E. Smith, Marie Charlotte Meinsohn, Mylène Brunelle, Nicolas Gévry, Bruce D. Murphy*

Partners: *Université de Montréal; Université de Sherbrooke; Harvard Medical School*

Federal and State Appropriations: *USDA NIFA Hatch Multistate Project PEN04798, Accession #7003523*

Discovery of factor responsible for ovarian follicle reserve formation has implications for **human and cattle reproductive health and success**.

Problem: **How can researchers help create treatments for fertility issues due to depletion of the ovarian reserve, which includes a mammal's lifetime supply of egg cells?**

Findings: In a study in mice, the researchers found that a specific protein—Steroidogenic factor 1 (SF-1)—regulates the formation of the ovarian follicle reserve. In the absence of SF-1, the number of eggs in the ovarian reserve was dramatically reduced, and the ovaries themselves were much smaller.

Impact: In the future, understanding how the ovarian reserve of follicles is established may help researchers understand why people and animals have later-in-life problems with fertility when those reserves are depleted. Therapies may be devised to slow down or counteract that depletion.

Precision technologies can help **speed diagnosis of calf pneumonia and decrease antibiotics use**.

Problem: **How can farmers help protect calves against bovine respiratory disease (BRD), which often develops into pneumonia requiring antimicrobial interventions?**

- BRD is the primary cause of economic loss in the beef industry and the leading cause of death in post-weaned dairy calves.

Findings: Researchers compared data collected using lung ultrasonography against daily behavioral data collected by wearable sensors and robots placed on the calves.

- Using machine learning, they found that the precision livestock farming system data yielded 96 percent accuracy at five days before clinical pneumonia in the calves.
- A second more economical study used only one technology in the dataset and achieved an 88 percent accuracy in predicting healthy and sick calves, and 70 percent of sick calves were predicted four days prior to BRD diagnosis.

Impact: As precision technologies are becoming increasingly affordable, they offer farmers opportunities to detect animal health challenges soon enough to intervene. Research is ongoing on what producers should offer calves at earlier detection timepoints to improve disease responses while providing the opportunity to explore non-antimicrobial alternatives.

MELISSA CANTOR

Team: *Enrico Casella, Melissa C. Cantor, Simone Silvestri, Joao H. C. Costa*

Partners: *University of Kentucky; University of Guelph; University of Vermont*

Competitive Funding: *USDA NIFA Agriculture and Food Research Initiative; National Science Foundation Smart and Connected Communities*

Federal and State Appropriations: *USDA NIFA Hatch Project PEN04910, Accession #7006113; USDA Hatch Multistate Project PEN04823, Accession #7005382; USDA NIFA Hatch Project KY007100*

ADOBE STOCK #664651452

Team: *Gry Persson, Katherine H. Restori, Julie Hincheli Emdrup, Sophie Schussek, Michael Schantz Klausen, McKayla J. Nicol, Bhuvana Katkere, Birgitte Rønø, Girish Kirimanjeswara, Anders Bundgaard Sørensen*

Partners: *Evaxion Biotech A/S*

Competitive Funding: *The Innovation Fund Denmark*

Federal and State Appropriations: *USDA Hatch Project PEN04771, Accession #7000407*

Using artificial intelligence to create vaccines with **prolonged protection** against infectious diseases.

Problem: **Can vaccines be developed to provide long-lasting immunity against future emerging variants of COVID or seasonal flu?**

Findings: Researchers developed an artificial intelligence platform to generate a T-cell-based vaccine in a live viral challenge model. They challenged mice with SARS-CoV-2 and found that 87.5 percent of the vaccinated mice survived, while only 10 percent of the control-group mice survived. Additionally, all the vaccinated mice that survived cleared the infection within 14 days.

Impact: This research paves the way for possible human testing and the potential rapid design of novel T-cell vaccines against emerging and seasonal viral diseases such as influenza. The study is thought to be the first to show in vivo protection against severe COVID-19 by an AI-designed T-cell vaccine.

Human and Community Dynamics

Enhancing the **economic and social well-being** of people and the systems that sustain them

Our researchers are strengthening the development and resilience of communities and the individuals within them, especially as they face social, economic, and environmental shocks and stresses. This research analyzes existing challenges and forecasts the impacts of future disruptions to provide sustainable strategies and policy recommendations.

Change is inevitable, but what if we could be **better prepared so that communities do not suffer** from major economic shifts?

- Climate change introduces new challenges for communities, and by understanding how those challenges are being met now will help policymakers and community leaders plan for the future.
- Stabilizing incomes for farming operations is a continual challenge, especially for small and medium producers. Investigating the viability and feasibility of diversifying revenue streams will be vital to ensuring the longevity of those farms.

The following are highlights of our research work in Human and Community Dynamics. Want to see more? Visit us online: **agsci.psu.edu/research/impacts**

Equipping policymakers with information on the effects that climate change may have on **children and social support systems**.

Problem: **How can researchers predict how shifting weather patterns due to climate change will affect migration patterns in children, who have been largely absent in studies on the subject?**

- In many parts of Africa, fostering children outside their biological parents' home is a common and often informal practice that can serve several education and social support purposes.

Findings: The researchers analyzed data on 23 sub-Saharan African countries, which included temperature and precipitation records and information on the number of children fostered in or out to other families.

- They found that with shifting weather caused by climate change, especially drought and heat, households were less likely to add a foster child to their home. Among households with the most children, droughts also increased the likelihood a child would be out-fostered.

Impact: The findings provide important insights for policymakers about the effects climate change may have on children and social support systems, underscoring the need to think more critically about how climate change may affect migration and displace populations as weather patterns continue to evolve.

- The researchers' emphasis on whether and how environmental stressors can affect child fostering is important since fostering is associated with many aspects of children's well-being, including their health and education.

ADOBE STOCK #66079408

Team: *Brian C. Thiede, Sara R. Ronnkvist, Emma Barber*

Partners: *University of Wisconsin–Madison; Penn State Population Research Institute*

Competitive Funding: *NIH Eunice Kennedy Shriver National Institute of Child Health and Human Development*

Federal and State Appropriations: *USDA NIFA Multistate Research Project PEN04623, Accession #1013257*

ADOBE STOCK #317420798

Team: *Guangqing Chi, Shuai Zhou, Megan Mucioki, Jessica Miller, Ekrem Korkut, Lance Howe, Junjun Yin, Davin Holen, Heather Randell, Ayse Akyildiz, Kathleen E. Halvorsen, Lara Fowler, James Ford, Ann Tickamyer*

Partners: *Penn State Social Science Research Institute; Penn State Sustainability Institute; Cornell University; University of Alaska Anchorage; University of Alaska Fairbanks; University of Minnesota; Michigan Technological University; University of Leeds*

Competitive Funding: *NSF Navigating the New Arctic; NSF Arctic Social Science; NSF Early-Concept Grants for Exploratory Research (EAGER) Strengthening American Infrastructure; NIH Eunice Kennedy Shriver National Institute of Child Health and Human Development*

Federal and State Appropriations: *USDA NIFA Hatch Multistate Project PEN04796, Accession #7003407; Hatch Project PEN04965, Accession #7006628*

Co-developing solutions that will help Arctic Indigenous populations **adapt and become resilient** to environmental changes.

Problem: **How can researchers learn more about how climate change affects migration patterns in the Arctic, an area in which temperatures are rising four times faster than in lower latitudes?**

Findings: The researchers analyzed previous studies on factors contributing to migration in the Arctic—including those related and not related to the climate and environment.

- They found little evidence that people were migrating out of the polar regions of Alaska and northern Canada due to climate change. Factors such as family, culture, and a sense of community led to people deciding to stay, even in the face of climate-related challenges.

Impact: The findings highlight a path forward for additional research and underscore the importance of establishing partnerships with local Arctic communities to achieve a holistic understanding of the factors driving migration or immobility.

- As critical climate tipping points are reached, threats to these communities' viability, health, and livelihoods will only increase and the need for solutions more immediate.

Balancing options for **transitioning to renewable energy options** that weighs land use and land preservation.

Problem: **How can farm owners balance the opportunities for sustainable solar energy development while also preserving valuable farmland?**

Findings: The researchers interviewed farmers and solar stakeholders from across Pennsylvania about how they made decisions and negotiated solar leases on farmland.

- They found that, in addition to greater and more stable profits, farmers described solar leases as a way to protect their land from industrial or residential development and preserve the option for the family to farm it again once the lease contract expires.
- However, certain farmland was seen as too valuable for solar development, and broader communities feel left out of these energy decision-making processes.

Impact: The findings are a stepping stone to understanding the state of solar energy development in rural communities across Pennsylvania. Identifying ways to help ensures that these development processes are mutually beneficial and equitable.

ADOBE STOCK #394150704

Team: *Kaitlyn Spangler, Erica A. H. Smithwick, Stephanie Buechler, Jennifer Baka*

Partners: *Penn State Earth and Environmental Systems Institute; Penn State Extension; Penn State College of Earth and Mineral Sciences; Penn State Ag Sciences Global*

Federal and State Appropriations: *USDA NIFA Hatch Project PEN04957, Accession #7006582; Hatch Project PEN04819, Accession #7004186*

Team: *Claudia Schmidt, Luyi Han, Arian Moghadam, Stephan J. Goetz*

Partners: *Northeast Regional Center for Rural Development (NERCRD) at Penn State; Bloomsburg University*

Competitive Funding: *USDA NIFA Agriculture and Food Research Initiative; USDA NIFA Regional Rural Development Centers*

Federal and State Appropriations: *USDA NIFA Hatch Multistate Project PEN04802, Accession #7003365*

Expanding broadband availability can help to **grow opportunities for entrepreneurship and rural economies**.

Problem: **How can farmers and other agritourism operators boost their customer base and diversify their income?**

Findings: The researchers conducted a nationwide analysis of the relationship between a county's broadband speed and the number of agritourism businesses five years later. They found that U.S. counties with broadband speeds one megabit per second above the national average in 2012 had about 5 percent more agritourism operations in 2017 than counties who stayed at or below the national average speed.

Impact: The findings boost the argument for expanding broadband availability for farm operators who want to benefit from the growing consumer interest in on-farm experiences. Diversification strategies provide farmers and ranchers the important opportunities for entrepreneurship with impacts beyond the operations toward supporting rural economies.

Integrated Ecosystems

Revealing complex interactions between **food, energy, water, and land systems** that require data-driven holistic solutions

Our researchers are harnessing and shaping the capabilities of data analytics, artificial intelligence, machine learning, remote sensing, and predictive technologies to achieve healthy and thriving agriculture, natural systems, economies, and communities. Their research is advancing data-driven solutions for better management of complex agricultural and natural resource systems.

Nature is messy and ecosystems are unavoidably complex.

- As new tools become capable of processing the many layers of information that can be extracted from these landscapes, scientists can now more quickly and efficiently analyze those interactions and even simulate different scenarios.
- Through these models, they can look into possible futures so that we can get ahead of any challenges that we may face or help us to unpack the complexity of our current ecosystems so we can more effectively intervene to preserve them.

The following are highlights of our research work in Integrated Ecosystems.
Want to see more? Visit us online: **agsci.psu.edu/research/impacts**

Novel **decision-support tool can help land managers** to increase productivity and anticipate and incentivize mitigations in water pollution stemming from agriculture.

Problem: **How can land managers find the best locations for riparian buffer strips or other pollution-reduction technology, especially in areas degraded by nutrient runoff from farmland?**

Findings: The researchers developed Cycles-L, a 3D landscape-scale agro-hydrologic model that can simulate crop and forage growth and yield, greenhouse gas emissions, and soil carbon storage, as well as how water and nitrogen move underground and over land.

Impact: Because Cycles-L uniquely simulates water and nutrient transport through all compartments within entire watersheds in 3D with far finer resolution than previous models, it can be integrated in tools for climate change scenario analysis, precision agriculture and conservation, and AI-based decision-support systems.

- This tool enables users to change management practices and climate scenarios and see how the transport of nutrients is affected, showing where interventions such as riparian buffers and cover crops or other practices should be installed and making the search for the sites easier and less expensive.

ADOBE STOCK #275949982

Team: *Yuning Shi, Felipe Montes, Armen R. Kemanian*

Competitive Funding: *U.S. Department of Energy Bioenergy Technologies Office; Environmental Protection Agency; NSF Dynamics of Coupled Natural and Human Systems; USDA NIFA Agriculture and Food Research Initiative*

Federal and State Appropriations: *USDA NIFA Hatch Project PEN04710, Accession #1020049*

ADOBE STOCK #892321240

Team: *Daniel C. Allen, James Larson, Christina A. Murphy, Erica A. Garcia, Kurt E. Anderson, Michelle H. Busch, Alba Argerich, Alice M. Belskis, Kierstyn T. Higgins, Brooke E. Penaluna, Veronica Saenz, Jay Jones, Matt R. Whiles*

Partners: *Penn State Eberly College of Science; Upper Midwest Environmental Sciences Center; Maine Cooperative Fish and Wildlife Research Unit; Charles Darwin University; University of California; University of Kansas; University of Missouri; USDA Forest Service; University of Alaska Fairbanks; University of Florida*

Competitive Funding: *NSF National Ecological Observatory Network (NEON); NSF Ecosystem Studies; NSF Macrosystems Biology and NEON-Enabled Science; NSF Population and Ecology*

Federal and State Appropriations: *USDA NIFA Hatch Project PEN04817, Accession #700372*

Understanding how energy resources flow between spatially connected ecosystems can **inform future conservation efforts**.

Problem: **How can researchers help conserve and manage important ecosystems, especially in a time of global climate change?**

Findings: The researchers analyzed data from 149 studies on energy exchanges between forest and stream ecosystems—for example, leaves fall into streams where they feed aquatic insects, which then emerge from the water and are eaten by birds and bats. In synthesizing data across seasonality, species traits, and climate, they found that aquatic and terrestrial organisms consume equal amounts of energy from the opposite ecosystem, keeping the two ecosystems in balance.

Impact: The findings are important because a lot of biodiversity loss occurs in fragmented and altered landscapes, and understanding the importance of spatially connected ecosystems via resource flows is critical to conserving and managing ecosystems.

Combining data collected in the field and the lab to **estimate the effects of climate change** on cold-blooded animals.

Problem: **How can we better predict the impacts of climate change on cold-blooded animals, which comprise most species on Earth and are strongly influenced by their environment?**

Findings: The researchers developed a novel statistical method to fuse field-collected data about the distribution and abundance of many cold-blooded animals with laboratory-derived information about temperature performance and tolerance in specific species.

- While a traditional model did not predict that any fish species would be locally driven out by climate change, the new model revealed that cold-adapted fish could be driven out of 61 percent of current habitats with rising temperatures.

Impact: The model can be applied across almost all cold-blooded animals and presents great potential to help inform climate adaptation and management strategies.

- This research provides more realistic predictions under future climate scenarios than traditional approaches that fail to account for the tight link between environmental temperatures and how cold-blooded animals will function.

ADOBE STOCK #507315494

Team: *Tyler Wagner, Erin M. Schliep, Joshua S. North, Holly Kundel, Christopher A. Custer, Jenna K. Ruzich, Gretchen J. A. Hansen*

Partners: *U.S. Geological Survey; Pennsylvania Cooperative Fish and Wildlife Research Unit; North Carolina State University; Lawrence Berkeley National Laboratory; University of Minnesota*

Competitive Funding: *U.S. Geological Survey Midwest Climate Adaptation Science Center; NSF Macrosystems Biology and NEON-Enabled Science*

ADOBE STOCK #192379353

Team: *Lu Luan, Yuji Jiang, Francisco Dini-Andreote, Thomas W. Crowther, Pengfa Li, Mohammad Bahram, Jie Zheng, Qinsong Xu, Xue-Xian Zhang, Bo Sun*

Partners: *Penn State Huck Institutes of the Life Sciences; Chinese Academy of Sciences; Massey University; Swiss Federal Institutes of Technology; Nanjing Agricultural University; University of Tartu; Swedish University of Agricultural Sciences; Nanjing Normal University*

Competitive Funding: *National Natural Science Foundation for Excellent Young Scholars of China; National Natural Science Foundation of China; Youth Innovation Promotion Association of Chinese Academy of Sciences; China Postdoctoral Science Foundation; New Zealand Ministry of Business, Innovation and Employment Catalyst Fund*

Federal and State Appropriations: *USDA NIFA Hatch Project PEN04732, Accession #7000239*

Better prediction of soil biodiversity patterns can lead to **higher functioning microbes** for carbon storage and crop productivity.

Problem: **Can we model the distributional patterns of microbial species in soils to harness their potential for climate change mitigation and beneficial crop production outcomes?**

Findings: Researchers developed different models to fit the distribution of microbial diversity in soils and introduced soil pH, a factor previously unexplored in similar studies.

- The new models could explain some of the previously unexplained variations in the relationship between temperature and soil bacterial diversity. They then tested and validated the new models at the species, community, and global soil biodiversity levels.

Impact: The ability to predict patterns of soil biodiversity is critical to better understanding how climate change will affect soil functioning and how soil microbes will respond to shifts in temperature.

- The findings will help scientists to knowledgably employ the genomic and functional potential of soil microorganisms to enhance essential ecosystem functions, such as carbon storage, as well as the beneficial interactions of microbes and plants to enhance crop productivity.

Using diverse expertise across land-grant institutions to **develop novel sustainable solutions** to harmful pests.

Problem: **How can growers in the Northeast region combat pest insects while still protecting nontarget organisms and the environment?**

- Agriculture in the Northeast is diverse and incorporates a mix of pest management tools, ranging from biocontrol to integrated pest management to a reliance on synthetic chemical pesticides or transgenic plants to minimize crop loss.

Findings: Researchers from more than 17 land-grant universities are working together to harness the innate abilities of plants to naturally protect themselves. They emit chemicals that can ward off plant-eating insects, minimize pathogens, invite beneficial insects to protect them, or even warn neighboring plants.

Impact: By studying the chemical ecology of plants, this collaboration uses the diverse expertise of scientists from different universities to provide solutions that will help reduce reliance on pesticides and mitigate some of the risks to nontarget insects like pollinators.

ADOBE STOCK #392572378

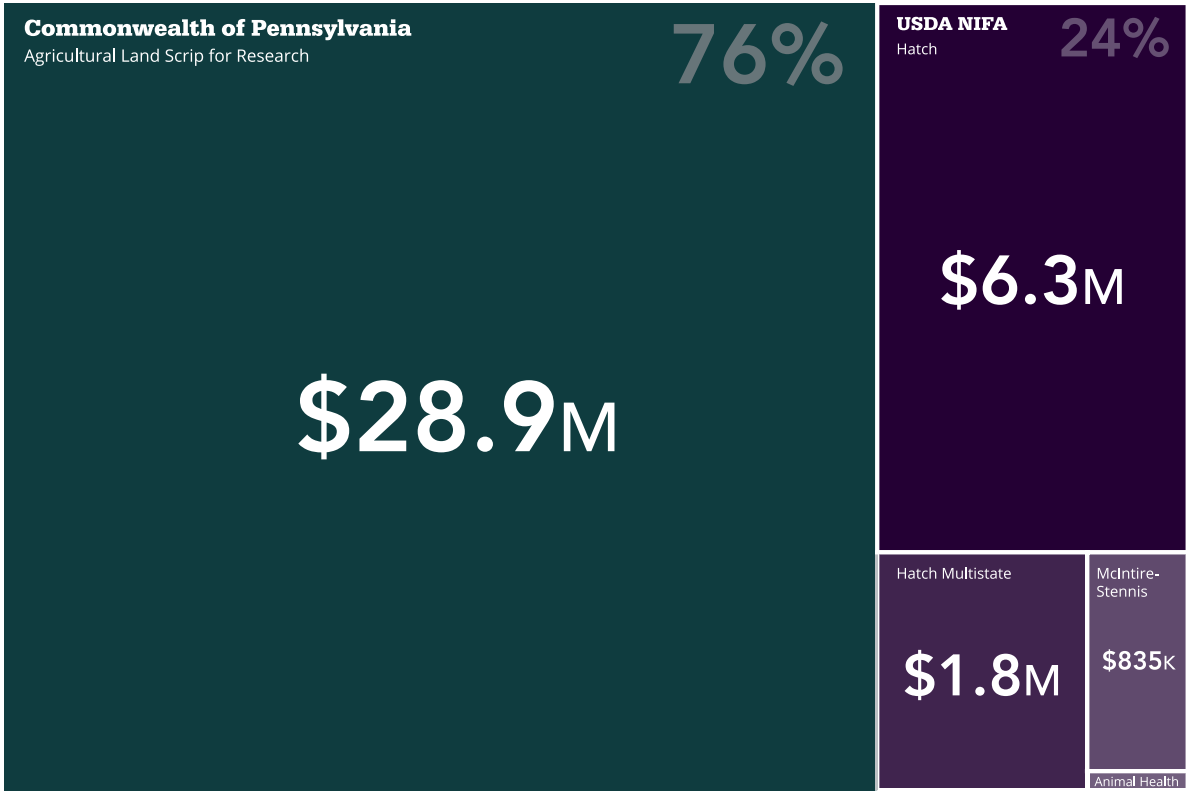
Team: *Jared Ali, Etya Amsalem, Gary Felton, Sara Hermann, Kelli Hoover, Monica Kersch-Becker, Tanya Renner, John Tooker*

Partners: *University of California; Cornell University; Cornell Cooperative Extension; Delaware Cooperative Extension; University of Illinois; Louisiana State University; University of Massachusetts; Michigan State University; University of Minnesota; Mississippi State University; University of Nebraska; University of New Hampshire; North Carolina Cooperative Extension; Purdue University; Rutgers University; University of Vermont; Virginia Tech*

Federal and State Appropriations: *USDA NIFA Multistate Hatch Project PEN04732, Accession #1024573*

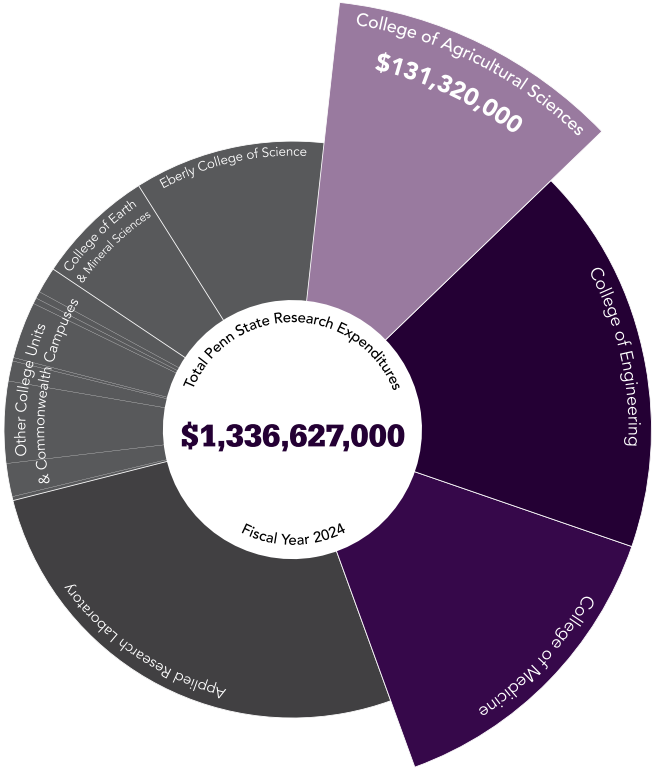
The College of Agricultural Sciences is the Commonwealth's **steward of federal and state appropriations** to support agricultural research.

» Federal and state appropriations managed through the Pennsylvania Agricultural Experiment Station provide essential base funding to maintain expertise and program support, allowing the college to quickly respond to emerging issues.



As one of more than 20 units contributing to Penn State's research expenditures, the College of Agricultural Sciences has consistently been among **the top four highest-performing college units** for the past 10 years.

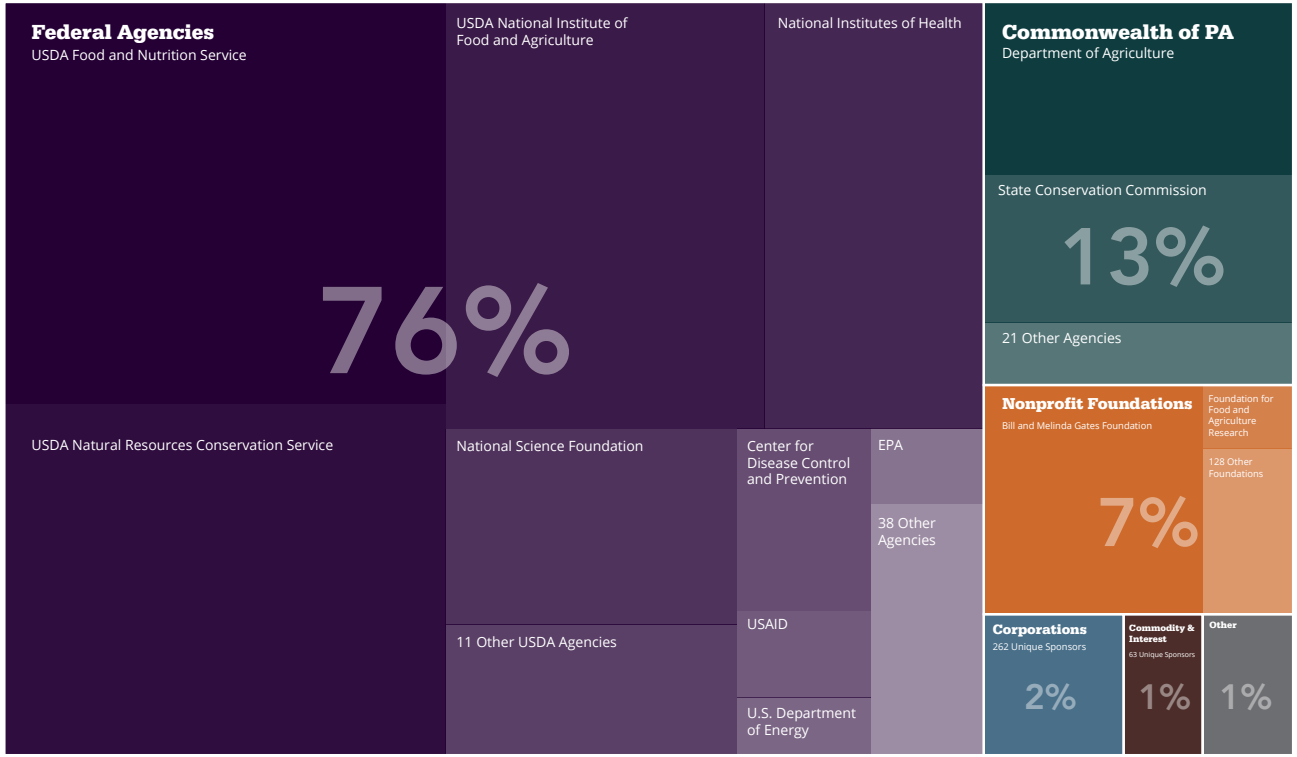
» The college increased research expenditures by 8 percent over last year and by more than 25 percent over the average of the last five years.



DATA FROM THE PENN STATE OFFICE OF THE SENIOR VICE PRESIDENT FOR RESEARCH

Researchers in the College of Agricultural Sciences support their discoveries and innovations through **a diverse portfolio of extramural grants**.

- College faculty leveraged the critical capacity of federal and state appropriations to participate in competitive grants totaling more than $160 million, a 28 percent increase over the average of the last four years for total grants.
- Research awards accounted for more than two-thirds of this funding for the college's activities.



SPONSORS OF COMPETITIVE GRANTS FOR FISCL YEAR 2024

College of Agricultural Sciences' investigators are leading large interdisciplinary teams to **propel research inquiry and discovery** in pursuit of tomorrow's solutions.

Climate-smart Agriculture that is profitable, Regenerative, Actionable, and Trustworthy (CARAT)
This $25 million pilot project funded through the historic USDA program, Partnerships for Climate-Smart Commodities, brings together faculty and Penn State Extension personnel to build trusted partnerships among scientists, dairy producers, industry organizations, climate-smart markets, and government agencies with the central aim of bringing economic value to producers along the supply chain.
(Principal Investigator: Armen Kemanian, Plant Science)

Environmental Chemical Impact on the Host-Microbiome Interaction
This $7 million award from the NIH National Institute of Environmental Health Sciences supports research on how environmental chemical exposure impacts the gut microbiome to exacerbate inflammatory conditions associated with increased risk for cancer, cardiovascular disease, and type 2 diabetes.
(Principal Investigator: Andrew Patterson, Veterinary and Biomedical Sciences)

Accelerating Bovine Tuberculosis Control in Developing Countries
The Bill and Melinda Gates Foundation supported a $6.7 million project that has the potential to transform our understanding and control of bovine tuberculosis, especially in countries with large livestock populations such as India and Ethiopia where this disease remains prevalent and traditional control strategies have been largely unfeasible.
(Principal Investigator: Vivek Kapur, Animal Science)

Focusing on Novel Pest and Disease Management Strategies for U.S. Mushroom Farms
An interdisciplinary team was awarded $3.5 million through the USDA NIFA Specialty Crops Research Initiative to develop new pest management tools for mushroom crops and create new outreach opportunities to growers, farm owners, residents, and policymakers.
(Principal Investigator: David Beyer, Plant Pathology and Environmental Microbiology)

Interdisciplinary Studies in Entomology, Computer Science and Technology NETwork (INSECT NET)
This $3 million training through the NSF Research Traineeship Program was awarded to an interdisciplinary team to establish a graduate training program that empowers students to develop solutions to the insect biodiversity crisis by creating novel monitoring systems for insect populations.
(Principal Investigator: Christina Grozinger, Entomology)

PennState
College of Agricultural Sciences

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

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

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