PennState
College of Agricultural Sciences

Technologies for Agriculture & Living Systems

A statewide initiative led by the Penn State College of Agricultural Sciences

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VISION

Penn State College of Agricultural Sciences offers a holistic approach — from development through adoption — to emerging and advanced technologies for agriculture and living systems that will place Pennsylvania's diverse agricultural and natural resource industries at the forefront of 21st-century integrated agroecosystems.

With the goal of establishing sustainable and resilient agroecosystems and communities that promote economic stability and minimize environmental impacts, we envision emerging and advanced technologies that will **enhance food production, health, and conservation of living systems**, spanning agricultural lands, forests, wetlands, and waterways, as well as rural and urban communities. Penn State's holistic approach embraces the diversity of the state's agricultural and natural resource value chains to position Pennsylvania as the nation's laboratory for innovation in food production, manufacturing, safety, and distribution; forest management and utilization; monitoring and conservation of ecosystem services; human health and well-being; robust workforce pipelines; and informed policy decisions that support community resilience and prosperity.

MISSION

The Technologies for Agriculture and Living Systems Initiative embodies the commitment of the land-grant university to enable resources, opportunities, and collaborations that will result in leading-edge innovation in agricultural and natural resource sectors across the state, with impacts that extend globally. This initiative will establish a framework to build and implement comprehensive and transformative solutions for healthy living systems, from agricultural production to environmental conservation and human health.

Emerging and advanced technologies can dramatically improve our ability to monitor and manage production and access to food, biodiversity and natural resources, and human health and well-being. As a part of the national land-grant system and a top 6% world-class university with a $1.2 billion research enterprise, the College of Agricultural Sciences is uniquely positioned to lead this initiative. With our extensive interdisciplinary expertise across a comprehensive portfolio of research and education, combined with our statewide Penn State Extension presence and program teams, the college is a **trusted source of science-based information and education**.

We have a long history as **an effective convener of diverse audiences**—including industry, stakeholders, academia, and government—that aligns expertise and resources to address complex issues. This expertise can provide insights into the challenges of developing, scaling, producing, and adopting technologies for the small-, medium- and large-sized farms as well as the diverse and sometimes threatened ecosystems that are representative of Pennsylvania. Moreover, we are uniquely equipped to **provide educational and training opportunities** to ensure a skilled workforce pipeline across the spectrum of food and natural resources. To realize this vision, the college will deploy a suite of interrelated functional areas to engage the breadth

of our stakeholders and amplify our collective strengths, including the launch of the **Technology for Living Systems Center** to organize the expansive research expertise at Penn State and our partnering academic institutions.

A new vision to build sustainable, resilient agroecosystems for the 21st century

Agricultural systems today are far more interconnected with other natural and engineered systems than in the past. Increases in the scale of operations and intensification of productivity create growing pressures on environmental systems, all of which are exacerbated by climate challenges, resource depletion, and biodiversity losses. We are experiencing a new revolution in technological development and availability that has the potential to entirely change not only the production of our food but also the wide ramifications of these systems for our environment. With emerging and advanced technologies, it is our opportunity to **build a new vision of agroecosystems and their supportive ecosystem services** that acknowledges the interconnectedness of these systems and aims to balance intensified production with conservation, increased profitability with responsibility, and improved resiliency with mitigation.

At the core of this revolution is the rapid development of **advanced technologies in agriculture**, such as robotics to automate harvesting and monitoring, that are transforming the industry, making it more efficient, sustainable, and resilient in the face of environmental challenges and changing global demands. On the horizon are new applications for existing technologies that incorporate artificial intelligence, including machine and deep learning, as well as material innovations in food packaging and preservation or gene editing to provide improved resilience to environmental stressors in plants and animals, all of which have the potential to dramatically shape the future of our agroecosystems.

There has been a recent proliferation of digital and precision agriculture centers created at U.S. academic institutions. A current gap within these centers is a stated mission to examine the implementation of emerging and advanced technologies at the landscape level, addressing not only production issues but also natural resource protection and community health.

The development and adoption of these technologies at other land-grant institutions has been centered primarily on large-scale farms and high value crops in midwestern and southeastern states. However, there is a pressing need for embracing the nimbleness of these technologies for different economies of scale and developing translatable and customizable solutions for small- and medium-sized farms across the nation, but especially in the northeast region of the U.S. and in Europe, where the urban-rural interface continues to grow and where large population centers provide readily accessible markets. The growing sectors of organic agriculture, controlled environment agriculture, digital agriculture, and climate-smart agriculture represent important areas for this initiative, which recognizes significant interconnections between soil health, plant diversity, and integrations with adjacent ecosystems, such as forests, wetlands, and waterways. Moreover, this holistic approach will allow us to address commodity chains and traceability, food safety, impacts on community and economic development, mitigation of greenhouse gases, or the affordability and adaptability of these technologies.

Additionally, untapped applications of precision technologies, remote sensing, and artificial intelligence to the assessment and conservation of biodiversity across plant and animal species can bring into focus more efficient responses that are crucial to the health of our ecosystems and sustainable food production. Enlisting machine and deep learning in the rapid development

of biological interventions for plant and animal health and invasive species or for computational models of climate impacts on individual fields, forest stands, or even whole watersheds can also help to reduce costs, mitigate impacts, and provide trusted evaluations of emerging applications. Using geospatial intelligence coupled with expertise in social science and demography will provide not only entrepreneurial opportunities and new insights into rural health accessibility; these tools and technologies can importantly help to target vulnerable populations for educational outreach through Extension programming or help to inform policy decisions or government investments.

Focusing on these developments from a holistic perspective will ensure that we are thinking about the interconnections of these technologies and their impacts on supply chains, communities, livelihoods, worker safety, and ecologies as much as we are thinking about increased efficiency, economic benefits, and food security.

The nation's laboratory for living systems

Pennsylvania is geographically, demographically, and economically situated to become an important testbed and creative pulse for the nation in the implementation of these technologies at multiple scales and across a range of agricultural and ecological systems. With access to various commodity and specialty crops, dairy, poultry, beef, and swine producers as well as hundreds of thousands of acres of public and private forests, all situated within multiple critical watersheds, **Pennsylvania's diverse agricultural and natural resources sectors provide a living laboratory** to examine the utility, viability, and ecological impact of new and established technologies on living systems.

This diversity of sectors, combined with Pennsylvania's commitment to revitalize both rural and urban communities through economic and workforce development, presents immense potential for the Commonwealth to lead the nation in establishing a holistic vision for sustainable agroecosystems and supportive ecosystem services that are made possible by emerging and advanced technologies. Being at the interface of rural-urban populations with access to this nearly complete spectrum of the agroecosystem chain, Pennsylvania can operate as a microcosm for the nation and for the global community. Our college is uniquely positioned to partner with academic, industry, government and other stakeholder groups for testing, formalizing, and implementing sustainable pathways to integrating these technologies to help reach this potential.

A comprehensive portfolio of expertise as a foundation

Since its beginnings as the Farmers' High School of Pennsylvania in the mid-nineteenth century, **Penn State has centered its efforts on responding to the needs of the state's agricultural and natural resources industries**, systematically building a comprehensive portfolio of expertise that can underpin this initiative's holistic vision. The college provides core strengths in fundamental agricultural, environmental, and social sciences as well as innovative applications of robotics and automation, sensors, computational modeling, decision support tools, and biotechnologies.

The Penn State College of Agricultural Sciences routinely combines research, education, and extension activities across a wide range of programs and institutions and actively pursues partnerships with industry to leverage complementary strengths. The success of this initiative in addressing the complex challenges of climate change, community vitality and health, and food security will require coordination within Penn State and across partnering academic institutions to develop and implement technologies and address attendant concerns around socio-economic and cultural adoption, technical assistance and training, life cycle analyses, biodiversity, resiliency, policy, and more.

Penn State's research enterprise reached a record $1.2 billion in 2023. Faculty in the college have established collaborations across multiple colleges and campuses at Penn State, which have resulted in diverse federal and state grant funding that supports basic and applied research, graduate student training, and intellectual property development. As this initiative develops, there is an opportunity to expand the network of researchers at Penn State to also include faculty participating in relevant centers and institutes.

An effective and trusted convener

The strength of this initiative will be in the formation of collaborations that are built around Penn State's agricultural, environmental, and engineering expertise. A prime example of how such collaborations can be effectively leveraged is the Pennsylvania in the Balance initiative convened by the college to coordinate partnerships with federal and state government agencies, academia, the Chesapeake Bay Foundation, industry sectors, and NGOs in a solution-oriented, small-working-groups format to help Pennsylvania meet agricultural water quality goals. The initiative resulted in a unique collaboration that collectively developed strategic solutions and secured extensive funding to implement effective conservation practices on farms. A further outcome of this effort is the establishment of the Center for Ag Conservation Assistance Training, a Penn State Extension-led partnership to increase capacity to train the current workforce, as well as recruit and train tomorrow's conservation professionals.

The college will deploy a suite of functional areas around this initiative to organize a statewide effort and provide a framework for building partnerships within and beyond Penn State. At the core of these operational areas is the newly formed **Technology for Living Systems Center**, which brings together the domain expertise of the college in research and training and organizes collaborations across the entire Penn State academic system, as well as with partnering academic institutions in the state. The center will facilitate the engagement of expertise across the college and University to form interdisciplinary teams that can compete for large-scale federal grants and attract complementary collaborations from peer institutions, industry, and government agencies. Integrated with the research is novel programming to support a multi-pronged approach to workforce education in technology applications for living systems, including graduate and undergraduate courses that prepare students with high-level skills in tech-driven agricultural and conservation careers, as well as graduate certificates and industry internships that increase the marketability of these students as future employees. Additionally, partnering with the Penn State Center for Science and Technology in the Schools and Penn State Extension 4-H and county-based 4-H extension educators to develop K-12 programming, the center will contribute opportunities to build awareness earlier in the pipeline and instill enthusiasm for pursuing careers that develop innovative technologies and applications for agriculture and living systems.

Unique among our academic peer institutions within Pennsylvania is **Penn State Extension**, which has a presence in all 67 counties, providing stakeholders with vital information on best management farming and forestry practices, environmental stewardship, youth education, community development, and many other critical topics. For this initiative, Penn State Extension provides the well-established platforms and networks to organize train-the-trainer programs for Extension educators. These programs provide training for producers along with the agricultural or conservation workforce, helping to increase the rate of technology adoption as well as gain understanding of the challenges that may arise in real-world scenarios to provide critical metrics that will enhance and expedite research to address these issues. Penn State Extension can also provide stackable educational credentials in industry sector-specific apprenticeships or training programs (both online and in person), providing ongoing workforce development and skilled labor

pipelines. For example, a collaboration with the Penn State Center for Immersive Technologies could build immersive environments in which trainings for farm safety, for accessibility for differently abled workers, for skilled careers such as butchers, or for using specialized equipment could be conducted primarily off-site, saving costs and providing opportunities for dynamic adjustments that enhance learning outcomes.

Engagement with industry is vital to the research, training, and outreach components of this initiative. Alignment with the needs of industry partners can spark creativity in the direction of research programs, can drive the design of training programs and internships, and can direct efforts for socializing the utility of technologies for increasing adoption. This initiative can feed back to industry important assessments of challenges such as affordability, accessibility, and viability. For example, the robotics and artificial intelligence sector in the Pittsburgh area has experienced explosive growth in the past five years, signaling opportunity for the Commonwealth to seize this accumulation of expertise in realizing a new vision for agricultural and environmental applications of emerging and advanced technologies. Partnerships with these companies can be vital in helping collaborative research networks to align with industry needs, work towards prototypes that can be scaled, drive the design of training programs and internships for students, and form networks for in-field testing and development. Likewise, these partnerships can uncover opportunities to tackle challenges, such as affordability, accessibility, and viability of technologies. Support structures at Penn State, including the Corporate Engagement Center and the College of Agricultural Sciences Entrepreneurship & Innovation program, combined with the strong stakeholder support of the Penn State Agricultural Council (comprised of 80 Pennsylvania agricultural sector associations and organizations) can help to facilitate these partnerships.

The Penn State College of Agricultural Sciences is committed to our role as the land-grant institution for the state to bridge the gap between discovery and delivery by organizing and leading this statewide initiative in the development and application of emerging and advanced technologies **to support healthy living systems**. By integrating efforts across the full spectrum of agricultural production to the conservation of our natural resources, this initiative builds on our history over the last 150 years of bringing our stakeholders into conversations to **balance the advancement** of our state's industries with a dedicated effort to also **protect our landscapes** and **ensure the endurance of our living systems** for generations to come.

For more information about this initiative
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This publication is available in alternative media on request.

Produced by the Office for Research and Graduate Education, College of Agricultural Sciences

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