The Presidential Initiative for Interdisciplinary Research

Changing the World

IOWA STATE UNIVERSITY
OF SCIENCE AND TECHNOLOGY

When researchers from around the world get together to take on the grand challenges of our age, major advances, discoveries, and technologies are sure to follow.

That's the idea behind the Presidential Initiative for Interdisciplinary Research (PIIR), a program launched by Iowa State University President Steven Leath in the fall of 2012. Since then, PIIR has offered a pivotal funding program to help Iowa State researchers build diverse cross-disciplinary and interinstitutional teams to aggressively seek large-scale external funding for major research thrusts at Iowa State.

PIIR has a big goal. And, after just four years, PIIR is already yielding big results.

$42.6 million in external research funding: PIIR teams have attracted $42.6 million in external funding for research that will improve our lives. Researchers are working to advance agricultural production and sustainability to feed our world's growing population; develop next-generation vaccine delivery systems that help developing countries fight diseases; harness large, complex data sets to create new solutions for promoting animal and human health; reduce energy costs for low-income community residents; and broaden accessibility to information resources.

Transformed culture of multidisciplinary research: PIIR has launched more than a dozen new interdisciplinary research teams, made up of more than 100 Iowa State faculty from a wide range of disciplines. PIIR teams bring together researchers in Iowa State's longtime areas of strength with faculty in social sciences, humanities, and arts to form holistic collaborations to advance science with an eye towards societal impacts. And PIIR scholars have extended Iowa State's reach by teaming with researchers from other universities, national labs, nonprofits, companies, and hospital systems.

> **PIIR has both secured Iowa State's leadership in longtime research strengths and set the stage for us to pioneer emerging fields.**

The PIIR program began with the goal of developing major research initiatives, called "Pursuit" projects, aimed at aggressively seeking external funds to support new research thrusts. In addition, the program funded smaller "Proof of Concept" projects to explore risky new ideas. More recently, the PIIR program has supported President Leath's investments in data-driven science with seed funding to develop new, multidisciplinary data-driven science teams to leverage the power of data to advance research.

PIIR's success has both secured Iowa State's leadership in fields of longtime strength and set the stage for Iowa State to pioneer emerging areas of research. Read on for more about the impact, progress, and new possibilities created by PIIR:
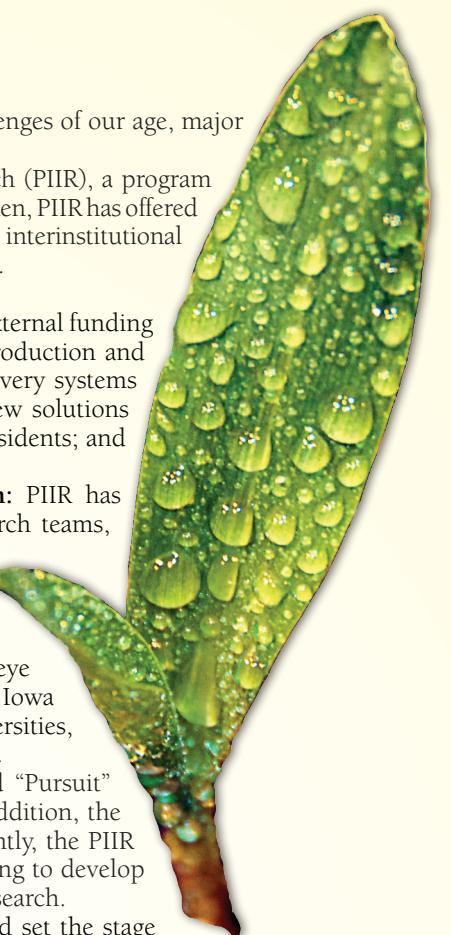
Impact: 2013-2016 PIIR Pursuit Projects

Nanovaccines to revolutionize disease prevention and treatment
Principal Investigator: Balaji Narasimhan, chemical and biological engineering

In three short years, Iowa State's nanovaccine team has built an interdisciplinary research consortium to develop life-saving nanovaccines and nanotherapies for diseases including influenza, cancer, neural disorders, and malaria. More than 65 researchers from 19 universities, industry, national laboratories, and hospitals, including 25 Iowa State researchers from 19 departments and five colleges, have now joined the effort to create refrigeration-free biodegradable polymer nanoparticles that help deliver vaccines and other therapies right where they're needed in the body. Nanovaccine initiative members have received more than $9.5 million in external funding for their work, published more than 120 journal articles, filed four patents, and presented more than 60 conference talks.

Pioneering crop technologies to help feed the world
Principal Investigators: Martin Spalding and Bing Yang, genetics, development, and cell biology; Kan Wang, agronomy

In the rapidly changing field of plant genome engineering, Iowa State's Crop Bioengineering Consortium (CBC) leads the way with breakthroughs in developing and using emerging technologies for crop improvement – all with an aim to address the grand challenge of providing sufficient food, feed, biofuels and biorenewable chemicals to a growing world population. So far, the team has made key developments in using CRISPR and related genome editing technologies to improve corn and rice plants, supported with more than $21 million in external funding. CBC scientists have together made over 100 presentations and contributed over 50 peer-reviewed research publications. CBC researchers are the first to receive USDA clearance granted to a public institution for a disease-resistant rice line created with engineered nucleases, establishing a roadmap for taking genome-edited crops from the lab to the field.
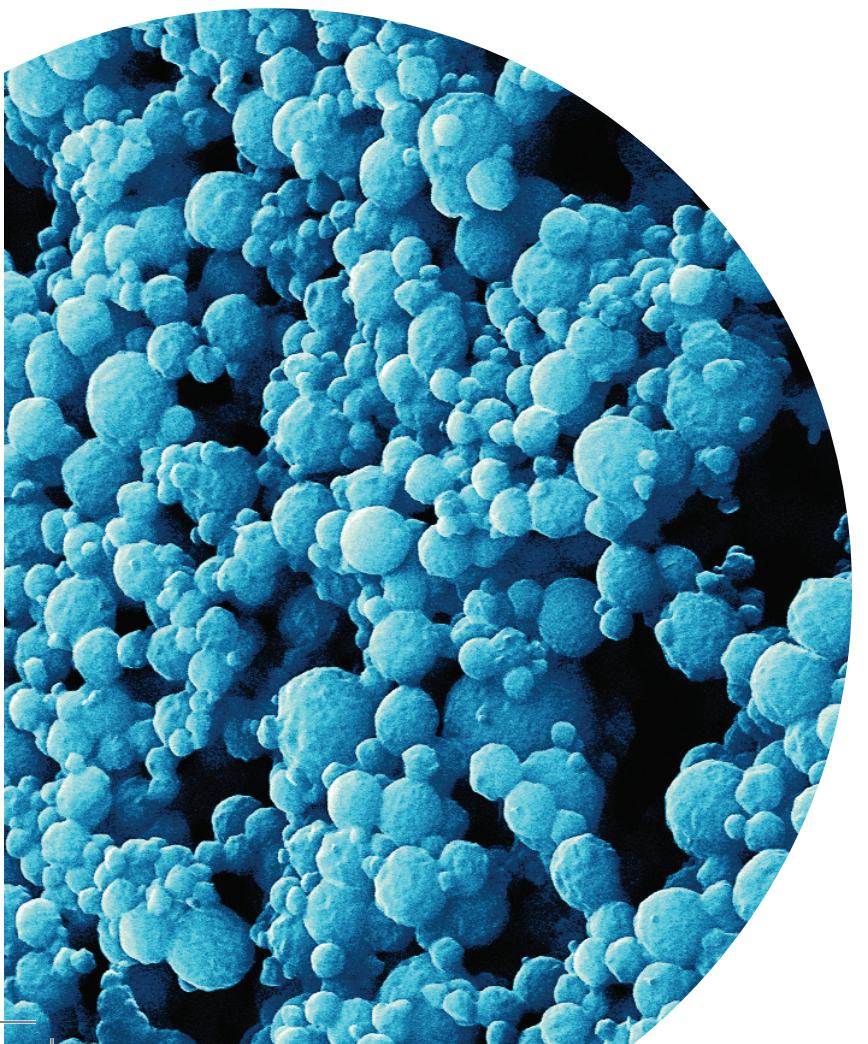
Strong connections for global food security
Principal Investigators: Manjit Misra and Dirk Maier, agricultural and biosystems engineering; Max Rothschild, animal science

Iowa State's Global Food Security Consortium (GFSC) is addressing international agricultural development and food security with strong collaborations and a unified approach to each link in the food system – from the smallest seeds and livestock to the largest questions about water, development, policy, and trade. The GFSC has established collaborations with 11 other academic institutions, six international research centers, and five other organizations. And, with the help of the GFSC, Iowa State became a charter member of university Presidents United to Stop Hunger, which is dedicated to taking collective action at universities to end hunger and malnutrition. The GFSC has received $7.3 million in external support, including two projects supported by the Bill and Melinda Gates Foundation and three projects supported by USAID.

"In the Corn Field" by Lars Plougmann is licensed under CC BY 2.0

Vaccines that aim at ever-moving-target of evasive viruses
Principal Investigator: Michael Cho, biomedical sciences

The goal: new vaccines to take on cunning viruses, including HIV-1 and influenza, that continually alter their makeup to evade the body's immune response. So far, the Interdisciplinary Vaccine Research Against Antigenically Diverse Viruses team's efforts have resulted in four patents for new vaccines and vaccine technologies, with two more soon to be submitted. PIIR team members organized two international symposia to build collaborations with other world-leading vaccine researchers, and the team made significant seed grants to support the work of early-career researchers, with an eye on strengthening Iowa State's long-term growth and leadership in vaccine research.

Progress: Data-Driven Science PIIR Projects Started in 2015

Data-driven discovery for agricultural innovation
Principal Investigators: Carolyn Lawrence-Dill, genetics, development, and cell biology; Asheesh Singh, agronomy; and Baskar Ganapathysubramanian, mechanical engineering

The Data-Driven Discovery for Agricultural Innovation, or D³AI, team is leveraging new technologies and data streams to improve agricultural production and sustainability. D³AI researchers are integrating and analyzing environmental sensing, genomic, and crop management data – with a vision of establishing Iowa State as the international research leader in data-driven agriculture. And the team is well on its way. D³AI has become a focal point for the Digital Agriculture spoke of the National Science Foundation-funded Midwest Big Data Hub.

Automated language extraction to synthesize research findings
Principal Investigators: Annette O'Connor, veterinary diagnostic and production animal medicine; Elena Cotos, Carol Chapelle, and Sowmy Vajjala-Balakrishna, English; Kris De Brabanter, statistics; Ruth MacDonald, food science and human nutrition; Stephen Gilbert, industrial and manufacturing systems engineering; Zhu Zhang, supply chain and information systems; Vijay Kalivarapu, Virtual Reality Applications Center

As the volume and pace of research publications increase, policy makers, interested citizens, and even fellow researchers need faster, comprehensive, and accurate literature reviews to make sense of the ever-growing amount of research information. Automating literature reviews could help solve this problem. However, scientific information is often conveyed in linguistically complex ways, which has until now posed a critical barrier to developing text-mining methods. The Automated Functional Language Extraction (AFLEX) project brings together experts in applied and computational linguistics, research synthesis, biomedical research, statistics, human computer interaction, and machine learning to take on the challenge of automating information extraction from scientific publications. The team will start its work in biological and medical publications, but automated literature reviews have potential applications in a wide variety of fields.

Possibilities: New Data-Driven Science PIIR Projects Starting in 2016

Bioinformatics tools to stop flu in its tracks
Principal Investigator: Phillip Gauger, veterinary diagnostic and production animal medicine

A multidisciplinary team will develop new bioinformatics tools for real time tracking of flu in swine, improving animal health and welfare, protecting human health, and securing our food supply. Researchers will develop techniques to integrate and analyze large caches of diagnostic and genetic data on influenza A virus, which is known to move frequently between
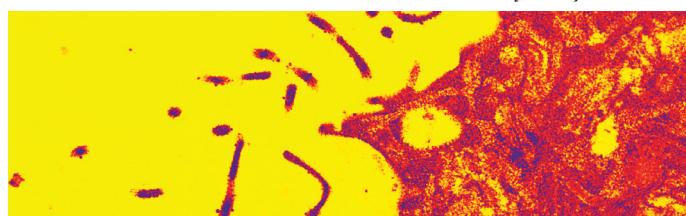
swine and humans. The team will draw from the Iowa State Veterinary Diagnostic Laboratory's large database of influenza A virus diagnostic cases and genetic sequences, combined with publicly available sequences, to create data analysis techniques for monitoring, modeling, and making predictions that will help us recognize and respond to emerging influenza threats to the swine population, ultimately stopping flu in its tracks.

Biomarkers to help develop neurodegenerative disease treatments
Principal Investigator: Anumantha Kanthasamy, biomedical sciences

A team of neuroscientists, toxicologists, chemists, immunologists, engineers, physicians, social scientists, and data scientists will join forces to use large datasets about Alzheimer's and Parkinson's patients to help develop new treatments. The researchers will identify biomarkers that indicate risk for developing neurodegenerative diseases and track the diseases' progression. Identifying these biomarkers will shed light on complex mechanisms of degenerative processes, accelerating development of treatments that slow or stop neurodegenerative declines.

Data-driven decision making for sustainable cities and vulnerable populations
Principal Investigator: Ulrike Passe, architecture

Researchers will use data about how urban dwellers live to develop new methods for cities to make data-driven policy decisions that are sustainable and meet vulnerable urban citizens' needs. The team, made up of faculty in engineering, design, humanities, and the social sciences, will link complex data about how citizens interact with their homes, neighborhoods, and cities with a range of computational thermal-physical models of buildings and near-building environments. The result will be first-of-their-kind decision-making models that integrate traditional planning data with the needs and values of marginalized urban populations – who are often most at risk to the effect of climate change but least included in urban planning decisions.

Cyberinfastructures that open the door to data science
Principal Investigator: Hridesh Rajan, computer science

Data-driven science is shifting the foundations of research. But many researchers aren't yet able to use large, complex data sets in their areas of expertise because working with those data sets requires specialized computation skills and infrastructure. Therefore, a team of Iowa State researchers will create an ecosystem of shared data science tools and software that provides researchers with easy access to using large data sets. Initial cyberinfrastructures developed by the team will help researchers better explore data in the areas of genomics, vehicle traffic, and non-destructive evaluation.

Seeds: PIIR Proof-of-Concept Projects

Language of writing in STEM disciplines
Principal Investigator: Carol Chapelle, English

Researchers laid the groundwork for a center of scholarship on the study of language in STEM disciplines, with a vision of improving methods for analyzing, teaching, and evaluating STEM writing. Activities included cross-disciplinary networking events and collaboration on two grant proposals. Members of the team are now lending key linguistic expertise to the PIIR Automated Functional Language Extraction project.

Combining Big Data and survey data to meet new policy-making challenges
Principal Investigator: Zhengyuan Zhu, statistics

An interdisciplinary team of Iowa State economists and statisticians created new data methods to transform policy evaluation. Researchers developed a framework to combine information from different sources – at both micro and macro levels – to establish causel effects of policy programs. They applied the data-driven methodology to evaluate the impact of the U.S. Social Security Disability Insurance program.

Computationally engineered plants
Principal Investigator: Daniel Attinger, mechanical engineering

Iowa State engineers and plant scientists collaborated on new approaches to designing optimum crops with better yields and better tolerance to climate change. PIIR-supported work helped grow Iowa State's leadership in plant science, and research continues in the areas of digital agriculture and data-driven crop design.

Identifying potential RNA therapeutic targets in infectious disease
Principal Investigator: Drena Dobbs, genetics, development, and cell biology

The team pursued an innovative strategy for integrating new high-throughput experimental technologies with computational methods to identify and characterize novel targets for RNA-based therapies. This PIIR-supported work has contributed to Iowa State's efforts to develop new treatments for diseases like influenza and AIDS.