The Predictive Plant Phenomics (P3) Program, a National Science Foundation Research Traineeship (NRT), serves as a model for the future of transdisciplinary education, notably in the field of Plant Sciences.

We have formed a community of practice here at Iowa State University, in synergy with the Plant Sciences Institute. The P3 model has been used in new plant science-based NRTs at Cornell, Michigan State University, University of California-Riverside and North Carolina State University.

Our vision of the P3 NRT project is realized through three goals:

1. Utilize transdisciplinary research bridging engineering, plant sciences and data sciences to improve the understanding of crop and agricultural production.

2. Develop scientists and engineers with broad skillsets to address the research needs of Goal 1, and who have an appreciation of the abilities and limitations of other disciplines and the confidence and communication skills to interact with them.

3. Implement and assess the ASPB T-training model at ISU to create a community of practice at ISU and across other plant sciences programs for effective transdisciplinary training.

Since 2016, this specialization has matriculated 29 doctoral students, including twenty-six (26) NSF NRT funded doctoral students (scholarship recipients), and two (2) non-funded doctoral students. Twenty-five students have completed the program or will complete it this year, and are now endowed with the understanding and tools to develop methods to predict plant growth and productivity based on information about their genome and environment.
P3 Leadership Team

Julie Dickerson
Principal Investigator
Professor, Electrical and Computer Engineering

Ted Heindel
Co-Principal Investigator
Bergles Professor of Thermal Science, Mechanical Engineering

Carolyn Lawrence-Dill
Co-Principal Investigator
Professor, Genetics, Development and Cell Biology

Patrick Schnable
Co-Principal Investigator
C. F. Curtiss Distinguished Professor, Agronomy and Genetics, Development and Cell Biology
Iowa Corn Endowed Chair in Genetics
Baker Scholar of Agricultural Entrepreneurship
Director, Plant Sciences Institute
Director, Center for Plant Genomics
P3 2016 Trainees

**Ian Braun**
Bioinformatics & Computational Biology

*Research:* Computing on phenotypic descriptions for novel candidate gene prediction

**Katerina Holan**
Plant Biology

*Research:* Identification and characterization of candidate secreted effector proteins in the rust pathogen *Puccinia sorghi*

**James McNellie**
Genetics & Genomics

*Research:* Exploring Phenotypic Plasticity, Heat Tolerance and Neural Networks for Genomic Prediction in Maize

**Johnathon Shook**
Agronomy-Plant Breeding

*Research:* Development and improvement of phenotype prediction models with big data in soybean

**Therin Young**
Mechanical Engineering

*Research:* Using Terrestrial Laser Scanning and Data Science for High-Throughput Crop Phenotyping
Clayton Carley
Agronomy-Plant Breeding

Research:
Breeding below ground: phenomics and genomics for advancing soybean root traits

Ashley Paulsen
Genetics & Genomics

Research:
Microbiomes in transparent soil as a means of phenotyping root-environment interactions

Lyle Sisson
Genetics & Genomics

Research:
Modeling and optimization of single and multi-allele introgression in cannabis

Zachary Lozier
Bioinformatics & Computational Biology

Research:
Functional analysis of subgenomic RNAs produced by autonomously replicating small RNA species

Schuyler Smith
Bioinformatics & Computational Biology

Research:
Analyses of microbiomes and their impact within their environmental systems

Paul Villanueva
Bioinformatics & Computational Biology

Research:
Persistent homology of microbial community assemblages
Matthew Carroll
Agronomy-Plant Breeding

Research:
Optimization and machine learning for plant breeding

Samantha Snodgrass
Plant Biology

Research:
Genomic sequence evolutionary consequences in *Zea*: form follows functions?

Cassandra Winn
Agronomy-Plant Breeding

Research:
Evaluating use of crop-growth models in genotype x environment interactions; and implementation in plant breeding

Tanner Cook
Plant Biology

Research:
Tool to detect meiosis induction in high-throughput genotyping

Colleen Yanarella
Bioinformatics & Computational Biology

Research:
Speech-to-text for building phenotyping data for ontologies analysis

Jacob Zobrist
Genetics & Genomics

Research:
de novo domestication of teosinte
Kevin Chiteri  
Genetics & Genomics  
non-funded trainee

Tyler Foster  
Agronomy-Plant Breeding

Brianna Griffin  
Plant Biology  
Research: Rel2-acetylation in plant pathogen interactions

Henri Chung  
Bioinformatics & Computational Biology

Colin Finnegan  
Bioinformatics & Computational Biology

Kaitlin Higgins  
Genetics & Genomics

Juan Panelo  
Agronomy-Plant Breeding  
non-funded trainee

Ashlyn Rairdin  
Agronomy-Plant Breeding
Trainee Demographics

Cohort 1

Cohort 2

Cohort 3

Cohort 4

Major Programs

28%
Genetics & Genomics

28%
Bioinformatics & Computational Biology

24%
Agronomy-Plant Breeding

13%
Plant Biology

7%
Mechanical Engineering

○ Dot denotes trainee who exited program
Professional Aspirations

- Government
- Industry
- Academe

Internships
- BAYER
- CORTEVA
- Ford

Mentorships
- BAYER

Professional Programs
- NAB
- American Society of Plant Biologists
  (Conviron Scholars Program)
- American Society of Plant Biologists
  (Ambassadors Program)
P3 students have had an award-winning year. Ten students received awards, fellowships or other accolades during the 2019-2020 academic year.

- **Samantha Snodgrass** is a 2020 Conviron fellow through ASPB.
- **Clayton Carley** and **Cassandra Winn** each received 2020 National Association of Plant Breeders’ (NAPB) Borlaug Scholarships for outstanding contributions to agronomy.
- **Colleen Yanarella** and **Kevin Chiteri** each began Science Communication Fellowships from Reiman Gardens, a partner in the Portal to the Public program, to hone their communication skills.
- **Ashley Paulsen** was awarded a second Iowa Space Grant Consortium Fellowship and won third place in the American Society for Gravitational and Space Research for her poster presentation.
- **Tanner Cook** was awarded the agronomy department’s Josef F. Schuler Graduate Fellowship and a university Brown Graduate Fellowship.
- **Brianna Griffin** is currently acting as Ambassador, American Society of Plant Biologists through spring 2021.
- Finally, **Katerina Holan** and **Ian Braun** both received National Institute of Food and Agriculture (NIFA) pre-doctoral fellowships which they each will use to complete their research and wrap up their graduate experience.
This year, the Predictive Plant Phenomics (P3) program developed student awards to recognize some of the achievements of P3 graduate students.

Four categories of awards were developed to acknowledge the hard work, dedication and successes of P3 students. Each category, along with the winners, is described below. Winners received $100 and a glass etched with the name of their award.

Nominations were submitted by P3 students and faculty.

**Predictive Plant Phenomics student leadership award.**
There are two awards available in this category. This award is to recognize two students who have engaged in outstanding service to the P3 program, fellow students, and the university. The services donated by these students have potentially impacted P3 and the university.

WINNERS: Colleen Yanarella & Tanner Cook

**Predictive Plant Phenomics student engagement award.**
This award is to acknowledge a P3 student’s contribution to learning through an activity – including, but not limited to, a presentation or tour – that was both engaging and displayed a mastery of content that inspired further learning by those in attendance.

WINNER: Paul Villanueva

**Predictive Plant Phenomics peer mentor award.**
This award is to recognize exceptional peer mentoring by a P3 student to another P3 student. The nominee should have a demonstrated commitment to sharing their knowledge, abilities, and experiences to help develop the capacities of others, in terms of professional or personal growth.

WINNER: Samantha Snodgrass

**Predictive Plant Phenomics research excellence award.**
This award is to recognize the high quality research, pursued by a P3 student, which advances the field of predictive plant phenomics. A student may be awarded based on the uniqueness or strength of their research project, including a project which embodies the collaborative spirit which is required for the interdisciplinary work inherent in predicting plant phenotypes.

WINNERS: Johnathon Shook & James McNellie
P3 in the News: Plant Cy-nce Toy Boxes

The achievements and awards of Predictive Plant Phenomics faculty and trainees are chronicled on the P3 website (https://www.predictivephenomicsinplants.iastate.edu/), under the News tab. The program and its faculty affiliates has been highlighted by various Iowa State University news services over the years. For example, in October 2019, the Vice President for Research Office published a story on the P3 core course, “Fundamentals of Predictive Plant Phenomics,” describing the implementation of Plant Cy-nce Toy Boxes. These boxes are designed to encourage experimentation and exploration with a variety of plant and environmental sensors. Also included in the boxes are cameras, processors and kits to build economical rovers.

Students have been quite committed to learning and utilizing the boxes both in terms of outreach and research. For example, members of the Predictive Plant Phenomics Graduate Student Organization (P3GSO) built three styles of rovers - of increasing sophistication - and put together three demonstrations for attendees of the Phenome 2020 conference in Tucson, AZ. This activity was part of the second annual P3 symposium, which is generously sponsored by Corteva Agrisciences. Prior to the conference, members of the P3GSO arranged a demonstration of their planned activity for P3 faculty so the trainees could practice their duties for the demonstrations and to work through any challenges that popped up. Non-P3 students have also enjoyed exploring the Plant Cy-nce Toy Boxes: one student from the Fundamentals course kept her group’s kit so that she could incorporate some of the sensors into her graduate research project and two engineering students checked out spare kits for their projects.
## 2019-20 P3 Activities & Responding to COVID-19

<table>
<thead>
<tr>
<th>Completed Activities</th>
<th>Postponed Activities</th>
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<tbody>
<tr>
<td><strong>P3 Learning Community</strong>: includes student-led planning for P3 Symposium; virtual policy talk with Senator Quirmbach; virtual “how to balance commitments” with Dr. Lawrence-Dill (bottom left photo)</td>
<td>P3 student-led outreach activity with community organization or school to practice their science communication skills</td>
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<td>Workshop on training for the small unmanned aerial systems (sUAS) pilot license (bottom center photo, courtesy Carolyn Lawrence-Dill)</td>
<td>Workshop for NRTs on how to organize boot camps for incoming trainees (may be held during virtual NRT annual meeting in January 2021)</td>
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<tr>
<td>P3-organized <strong>Field Trip</strong> to Zylstras’ farm in Central Iowa, in coordination with Iowa Corn (bottom right photo, courtesy of Rod Williamson/Iowa Corn)</td>
<td>P3 student-led field trip to local farm and businesses</td>
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<tr>
<td>P3 Graduate Student Organization (P3GSO) visit to Corteva Agrisciences campus</td>
<td>P3 Symposium - which is planned by the P3GSO beginning in the summer - will be postponed to spring 2021 or later</td>
</tr>
</tbody>
</table>
Institutional Impact

The 2020-21 Academic Year will mark P3’s first no-cost extension year. Although there is an option for a second no-cost extension, P3 Leadership is making plans for closing out the program and arranging for certain program elements to continue without any centralized P3 administrative support. Below is a list of program elements and an explanation of if and how it will continue to be offered at the university.

- **P3 Boot Camp** - A 10-day introduction to the emerging field of predictive plant phenomics that includes some workshops open to non-trainees. The open events have been popular with non-trainees, particularly the data skills training sessions. No boot camp is planned for 2020, but some elements - like the data skills sessions - could be institutionalized.

- **Fundamentals of Predictive Plant Phenomics** (course) - This course provides students with the necessary tools and vocabulary to tackle multidisciplinary predictive plant phenomics problems. It exposes students to engineering principles such as transport phenomena and sensor design, data science activities, and plant science fundamentals. Will continue to be offered in fall semesters.

- **Plant Cy-nce Toy Boxes** - Built for the Fundamentals course and exhibited at Phenome 2020 conference, these plant sensor kits include environmental sensors, mini processors, color card, cameras, and rover parts. Will continue to be available in the course and for individual check-out from Dr. Lawrence-Dill.

- **Entrepreneurship for Graduate Students in Science & Engineering** (course) - This course introduces students to key topics of starting a technology-based company, intrapreneurship and the entrepreneurial ecosystem at ISU and in Central Iowa. Local entrepreneurs share their stories in guest lectures and class culminates in five-minute business pitch competition. Included as core course in DataFEWsion NRT. Will continue to be offered fall and spring semesters.
• **Experiential Learning** (course) - This one-credit summer semester course brings graduate students and advanced undergraduate students to farms, businesses, and other agricultural institutions across the United States to expose them to different agricultural, economic, and cultural environments in order to gain an understanding as to how these factors contribute to the food system. It is planned for Summer 2021 and includes overnight travel.

• **P3 Research Grants** - Available to all students conducting research related to predictive plant phenomics, until August 2021.

• **P3 Travel Grants** - Available to all students conducting research related to predictive plant phenomics, until August 2021. Limited to domestic flights and air carriers.

• **P3 Small Project Grants** - Available to all students conducting research related to predictive plant phenomics until, August 2021. Includes team-based projects.

• **P3 Graduate Student Organization** - Student-led group that plans events for professional development, including the P3 Symposium. Coordinates an annual visit with Corteva Agrisciences in Johnston. Continuance is dependent on student leadership.

• **P3 Symposium** - Student-led, two-day event that showcases work of P3 students and four invited speakers. Preceeded by a workshop the previous day. Sponsored by Corteva Agrisciences. Continuance is dependent on student leadership and sponsorship.

• **P3 Learning Community** - Students in specialization meet at least once monthly to explore professional development opportunities, practice science communication skills, plan P3GSO events, or discuss any other topics of interest. This activity will not be continued.