CAPS CENTER FOR APPLIED PLANT SCIENCES

SCIENTIFIC ANNUAL REPORT 2014-2015

THE OHIO STATE UNIVERSITY


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CREATIVE PROBLEM SOLVING IN THE PLANT SCIENCES

The focus of the Center for Applied Plant Sciences (CAPS) is to tap into the incredible scientific expertise available at The Ohio State University. Membership to CAPS is based on teams, which are formed by investigators from many disciplines, departments, colleges and campuses of The Ohio State University. Teams have access to research facilities and support, postdoctoral fellowships and PhD students and graduate fellowships through the university's new Interdisciplinary Graduate Program in Translational Plant Sciences (TPS).

CAPS Team Strategic Areas

Photosynthesis and Carbon Fixation

Biomass and Bioproducts

Crop Improvement and Functional Foods

Plant-Microbe Interactions

CAPS Headquarters | 012 Rightmire Hall | 1060 Carmack Road | Columbus, Ohio 43210

Dear Colleagues,

CAPS just completed four years of existence. This is a milestone year as we envisioned that the first four years would be a period of developing and testing a number of novel ideas, and those successful would then be implemented and expanded into what we have come to call CAPS v2.0. However, as this document is going to print, the 2015-2020 budget that would make CAPS v2.0 possible is still under review.

These past four years have witnessed a number of successes, including the development of six Scientific Teams comprised of a total of 38 faculty members from three colleges (ASC, CFAES and COE) and eight departments. CAPS also sponsored two Opportunity Teams with industry, including an ongoing scientifically exciting collaborative partnership with the J.M. Smucker Company. The developing Industry/University Cooperative Research Center on the Sustainable Use of Greenhouse Gases ($CSUG^2$) is bringing together and building synergy between several universities in Ohio and an extensive number of industry partners. Federal funding, which has been weak for the past 3-4 years, is coming back with several new single and multiple investigator grants being funded in the last few months.

The Interdisciplinary PhD Program in Translational Plant Sciences (TPS) recruited three new, excellent students in 2014, bringing the total to eight current TPS Fellows. One of our TPS Fellows, Stephanie Verhoff, was awarded a 4-year United Soybean Board Fellowship. The first student for the International Dual PhD Degree Program between TPS and the University of São Paulo (USP) finally began her research at Ohio State.

CAPS continues to work towards transformative solutions in grand global challenges where the expertise of the plant community at Ohio State is distinctively situated to tackle. Synergies beyond funding have been forged across campuses, colleges and departments. Seminar series have been expanded; workshops, retreats, social hours, and networking have been established. We are inching closer to a unified plant community. We have discovered pitfalls and hit road bumps, but we have also celebrated successes and are starting to learn what works and what doesn't in team science at Ohio State. We will use this knowledge to continue to enhance Ohio State's global research impact in the use of plants for a sustainable future in health, energy and the environment. As the university's leadership continues to investigate these areas, especially within the Discovery Themes, we hope you advocate that their prototype is right here, your center, CAPS.

The center's many victories were met by great sadness this year, as we lost two dear colleagues, Dr. Biao Ding and Dr. Mark Bennett. Their extraordinary personal and scientific contributions to the university and CAPS family are irreplaceable and will be deeply missed; their memory has been honored at the conclusion of this report.

All CAPS achievements are only possible thanks to the enthusiasm and professionalism of CAPS staff; my most sincere appreciation to all of you for continuing to make this center your own.

Sincerely,

Erich Grotewold

Erich Grotewold, Director

OUR TEAMS

CAPS SCIENTIFIC TEAM

CMAP: Converting Greenhouse Gases into High-Value Materials

Carbon dioxide (CO2) and methane (CH4) are the two most abundant greenhouse gases, trapping thermal radiation close to the Earth's atmosphere and contributing to global warming and climate change. These two gases composed an estimated 94% of all the greenhouse gas emissions in 2010. CO2 emissions are expected to increase by more than 40% by 2035, unless major worldwide policies are soon implemented. However, from an industrial perspective, CO2 and CH4 provide very abundant sources of carbon for the synthesis of a large range of chemicals. While plants and microbes are efficient at converting CO2 into sugars and other compounds, the sophisticated chains of enzymatic reactions that usually accomplish these processes are difficult to replicate in an industrial context. Existing industrial methods to convert CH4 into methanol also are very energy consuming. Although biological systems are among the most efficient and ubiquitous catalysts for CO2 fixation, the use of free- or cell-based enzymes as biocatalysts for large-scale industrial processes pose significant drawbacks due to their incompatibility with reaction conditions that often depart from their physiological states.

The CMAP team, a group of biochemists, microbiologists and engineers, aims to address the greenhouse gas fixation problem by constructing catalytic systems that mimic the cellular environment, but also are scalable for economical use, robust enough to withstand harsher industrial-like conditions and are separable from the final product. The team, now in its second year, consists of Dr. Jon Parquette (team lead), Dr. F. Robert Tabita, Dr. Vishnu Sundaresan, Dr. Venkat Gopalan, Dr. Jovica Badjic, Dr. T.V. RajanBabu, Dr. Christopher Jaroniec, Dr. Vish Subramanium, postdoctoral researcher Dr. Lei Zhiquan, three graduate students and two research scientists.

One of the "youngest" CAPS teams, CMAP already has made great progress toward its four ambitious goals: (1) to encapsulate CO2 reducing enzymes within synthetic nanostructures to mimic natural carboxysomes found in nature, (2) to create a catalytic RNA molecule for methane oxidation, (3) to develop supramolecular catalysts for the conversion of CH4 into commodity chemicals and (4) to develop strategies to deploy these catalysts in real-world environments. The team was pleasantly surprised to achieve its first goal in a mere nine months when they successfully developed methods to encapsulate the enzyme RubisCO with self-assembled nanotubes. Because RubisCO is the primary step for CO2 capture and is often the rate-limiting step, it was decided to use RubisCO as a model protein for encapsulation in macromolecular scaffolds, such as organic nanotubes and electro polymers. The team furthered this process by examining the use of polypyrrole as a way to further cast the nanotubes-RubisCO complex into a more stable platform. The team has optimized the activity of the nanotube-RubisCO coassembly to achieve near native activity levels of the enzyme. Furthermore, the nanotube-

From left: Dr. F. Robert Tabita, Dr. Vishnu Sundaresan, Dr. Vish Subramaniam, Dr. Jon R. Parquette, Dr. Venkat Gopalan, Dr. Jovica Badjic, Dr. T.V. RajanBabu. Absent: Dr. Christopher Jaroniec

RubisCO complex remains active in the presence of proteases that would normally degrade the enzyme. Recent efforts of the team have demonstrated the co-encapsulation of three enzymes (phosphoribose isomerase, phosphoribulokinase and RubisCO) by a single nanotube. This catalyst is capable of converting ribose-5-phosphate all the way to 3-PGA via carbon dioxide fixation. These tiny nanoscale structures will enable carbon fixation without reliance on living systems like bacteria, which require sterile environments and continual replenishment of nutrients. The optimized RubisCO/nanotube system will be a valuable alternative, as preliminary results clearly indicate that these scaffolds impart better stability and/or resilience to the enzyme in comparison to the free form.

The team also has made good progress toward the second goal of developing a catalytic system for methane oxidation. In nature, methanotrophs, or organisms that utilize methane as their sole energy source, convert methane to methanol via methane monooxygenases. CMAP aims to utilize this class of enzymes to convert greenhouse gases to usable products. This goal is ambitious, however; as the very nature of the membrane-bound, trimeric, copper-requiring enzyme makes it difficult to use in vitro. Synthetic catalysts that mimic the active sites of the particulate form of the enzyme are able to carry out the reaction, but with reduced efficiency and only in organic solvents. As such, the CMAP team actively is pursuing several avenues for employing this enzyme in methane conversion. One intriguing aspect of this project is the team's development of methane-trapping molecular baskets, which they recently published in *Chemical Communications.* The team anticipates that with the inclusion of a catalytic center, these baskets will be able to convert methane to methanol upon entrapment, providing yet another innovative option for greenhouse gas management.

CAPS SCIENTIFIC TEAM

TIRE: Buckeye Gold — Progress towards a Viable Rubber Crop for Ohio Farmers

From left to right: Dr. Scott Shearer, Dr. Pablo Jourdan Dr. Katrina Cornish, Dr. John Cardina, Dr. Ajay Shah and Dr. Josh Blakeslee.

The TIRE team employs unique and innovative research to address the real-world problem of natural rubber shortages. Natural rubber is largely made from the milky latex sap harvested from *Hevea brasiliensis* rubber trees cultivated in tropical regions of South America, Southeast Asia and Western Africa. Natural rubber from this processed latex is of superior quality to petroleum-based synthetic rubber, and is often selected for use in products such as aircraft tires, balloons and latex gloves. Over the years, however; shortages of natural rubber have steadily risen, mainly due to the two-pronged problem of farmers switching from *Hevea* to the more rapidly-growing oil palm crop at the same time that countries such as India, China and Brazil experience economic growth and thus have a higher demand for rubber. The United States is the world's second highest consumer of natural rubber, yet ranks at the bottom of the list when it comes to natural rubber production. It has been estimated that 8.5 million new hectares of rubber trees will be needed to meet demand in the next decade. Such plantings will devastate one of the most ecologically diverse areas of rain forest left in the world. In an effort to offset this imbalance and to generate sustainable natural rubber production in non-tropical regions, the TIRE team has targeted the dandelion plant for its development into an economical latex crop. Overall, the team aims to integrate its research into the local Ohio – and eventually northern U.S. – farming infrastructure to allow the BuckeyeGold variety of dandelion (*Taraxacum kok-sahgyz,* also known as the Russian/Kazak dandelion) to be used as a rotation crop.

Led by Dr. Katrina Cornish, the team is currently composed of Drs. Josh Blakeslee, John Cardina, Ajay Shah, Pablo Jourdan, Scott Shearer, postdoctoral researcher Xiaofeng Zhuang and four graduate students, with significant past contributions from Dr. Matthew Kleinhenz and the late Dr. Mark Bennett. Expertise from each member's research group is used to accomplish the team's main goals: develop high-rubber producing cultivars of BuckeyeGold dandelion, establish planting, tilling and harvesting methods that are economical for the average farmer, obtain weed control and determine the ecological risks of BuckeyeGold as a rotation crop.

Now in its second year, the TIRE team has seen many exciting advances in the BuckeyeGold domestication project. On the CAPS-funded side, genome-sequencing efforts have begun and genetic mapping will commence on important rubber-production loci to aid in breeding studies. So far, more than 10,000 single nucleotide polymorphisms (SNPs) have been identified for rubber concentration alone. More than 250 gb data from 2 billion of short reads have been produced and now are undergoing quality control, de novo assembly and gene annotation. Metabolomic and transcriptomic data are being collected from high- and low- rubber-producing dandelions to establish changes in the rubber biosynthesis pathways during plant growth. Further genomic analysis will be done using CRISPR technology now under development for BuckeyeGold. In addition to this work, extensive progress has been made on the agricultural aspects of the project. Ever ecologically-minded, the team carefully designed controllable transgenic dandelions so that their pollen would not contaminate near-by native dandelions. Even more innovative, these transgenic plants are resistant to glufosinate, but not to glyphosate or 2,4-D, which allows not only for weed control during the growing season, but for clearing the field before planting a different crop the next year. Greenhouse studies are underway for establishing the herbicide tolerance of the nearly 100 transgenic glufosinate-resistant plants now available. Extensive field trials have developed planting and tilling methods that utilize common farm implements in use for many conventional Ohio crops, as well as determined what soil types are best for growing BuckeyeGold. Other studies are underway for efficient harvesting and processing of seed. As all this progress suggests, the TIRE team is well on its way to developing an exciting new crop for Ohio and the United States!

CAPS SCIENTIFIC TEAM

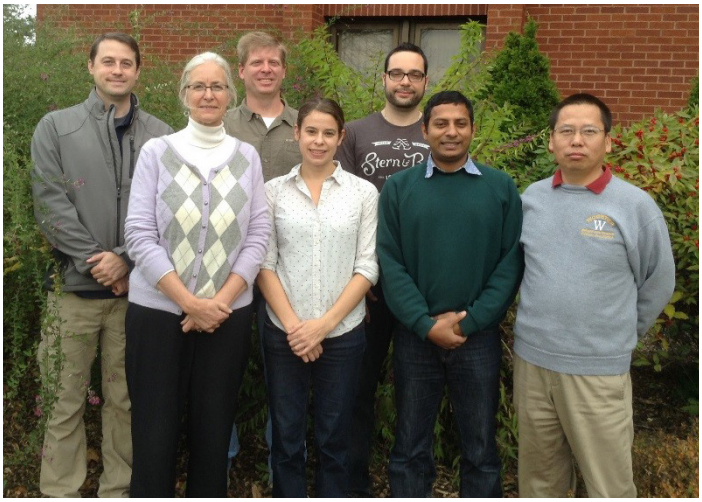
SOYRES: Understanding Soybean Resistance to Multiple Pests and Pathogens

In 2014, the USDA estimated that soybean production in Ohio contributed about $2.6 billion (254 million bushels) of the national production value of more than $40 billion (3.91 billion bushels). Beyond its economic importance as a food and feed crop, soybean is used industrially in a growing list of products ranging from soy ink to plastics and biodiesel. While the revenue from soybean production is high, many don't realize just how much bigger the profit margin could be if pests and diseases were eliminated. According to the national soybean disease-loss database curated by the University of Illinois, nearly 273 million bushels of soybean were lost to disease in 2014 alone. Of that, approximately 125 million bushels were lost to soybean cyst nematode, 32 million to *Phytophthora* rot and 1 million to downy mildews.

The CAPS Soybean Rescue Team, or SoyRes, aims to identify soybean genes that can naturally confer resistance to many of these diseases, as well as insect pests like the soybean aphid. Dr. Anne Dorrance and Dr. Leah McHale focus on the soybean resistance to *Phytophthora sojae* and other oomycete pathogens, while Dr. Chris Taylor, Dr. Andy Michel and Dr. Feng Qu provide expertise on soybean interactions with nematodes, aphids and viruses, respectively. The team also received significant contributions from Dr. Rouf Mian, now with the USDA-ARS in North Carolina. Postdoctoral researchers also play an important role as team members and currently include Drs. Md. Emran Ali, Wenshuang Xie and Sungwoo Lee. Former CAPS postdoctoral researcher Dr. Bryan Cassone, who recently accepted an assistant professor position at Brandon University in Manitoba, Canada, facilitated experiments that analyzed how aphid feeding habits change on virus-infected soybeans. The SoyRes team also fosters an educational environment by integrating many graduate students' (including two TPS Fellows) projects that align with the team's overall goals. This past year, three SoyRes students earned their graduate degrees: Bhupendra Acharya (MS), Rhiannon Schneider (MS) and Jacob Wenger (PhD).

The main thrust of the SoyRes team is to develop models and hypotheses that assess the effectiveness of quantitative disease resistance (QDR) to the many biotic stresses soybeans are subjected to in any given year. To accomplish these goals, the team has focused on three objectives: 1) systematically identify genes conferring resistance to pathogens, 2) confirm the role of these genes in the soybean defense response and 3) integrate the genes into the soybean breeding pipeline.

The team made great progress during its third year, with nearly ten peer-reviewed manuscripts published, or in-press. On the QDR front, a novel locus for *Fusarium graminearum* was identified, as well as one for *Phytophthora sojae*. In addition, the team successfully narrowed another region previously associated with resistance to three different pathogens: *P. sojae, Pythium irregulare* and *F. graminearum.* Furthermore, efforts to fine-map Rps8 for resistance to *P. sojae* and *Rag5* for aphid resistance were rewarded by narrowing these loci down to six putative CC-NBS-LRR and seven putative NBS-LRR genes, respectively.



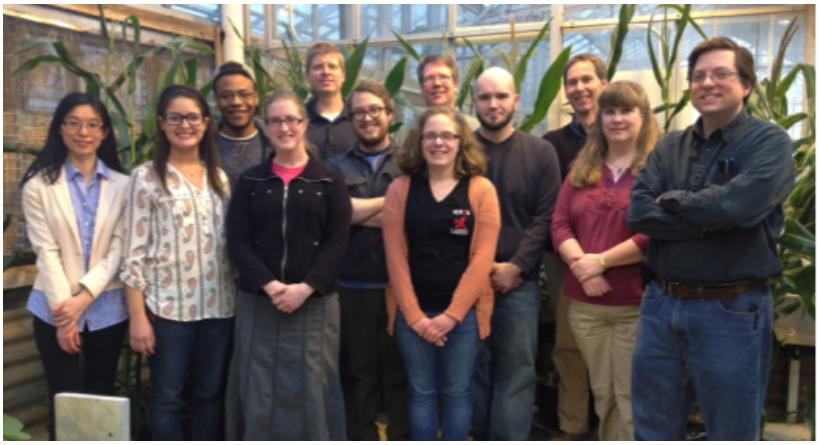
From left: Andy Michel (Entomology), Anne Dorrance (Lead, Plant Pathology), Chris Taylor (Plant Pathology), Leah McHale (Horticulture and Crop Science), Bryan Cassone (Post-doctoral Researcher, Bioinformatics); Md Emran Ali (Post-doctoral Researcher, VIGs) and Feng Qu (Plant Pathology) Absent: Wenshuang Xie (Post-doctoral Researcher, RNAi constructs), Rouf Mian (joined USDA-ARS, North Carolina), Terry Niblack (Plant Pathology), Josh Blakeslee (Horticulture and Crop Science)

In addition to the gene-mapping projects, the team also improved and expanded its array of methods and resources for studying soybean pathogens and insects. Two exciting breakthroughs were the development of a gene-silencing system for the soybean aphid and disarming new *Agrobacterium* strains for soybean transformations. The team also developed the bioinformatics resources needed for genome analysis of the soybean aphid and its endosymbiont Buchnera aphidicola. Using these resources, the team began assembly of the soybean aphid genome by combining transcriptomic and genomic reads from Illumina MiSeq and Pacific Biosciences. Further projects included the characterization and release of several soybean genotypes, as well as studies of the transcriptomic responses of soybean during interactions with bean pod mottle virus, *P. sojae*, soybean cyst nematode and the soybean aphid. Additionally, the team is actively pursuing and perfecting several Virus-Induced Gene Silencing methods for individualized soybean gene-silencing to enable identification of pathogen resistance genes.

CAPS SCIENTIFIC TEAM

MBSA: Microbial Bioproducts Scale-Up and Applications

Modern agricultural practices rely heavily on chemical herbicides, pesticides and fertilizers to produce optimal crop yields. The consequences of these chemical applications are not always restricted to better yields, however; as research has linked these compounds to a number of environmental problems, such as algal blooms and the decline in honeybee-pollinator numbers.



From left to right: Dr. Chris Taylor, Dr. Matt Kleinhenz, Dr. Michelle Jones, Dr. Josh Blakeslee, and Dr. Ana Alonso.

The CAPS Microbial Bioproducts Scale-Up and Applications (MBSA) team actively seeks environmentally-friendly alternatives for traditional chemical agricultural products. At the forefront of its biopesticide and biofertilizer research is the identification and characterization of naturally-occurring microorganisms. The team's greenhouse and field studies with soil-borne bacteria, such as *Pseudomonas, Mitsuoria* and *Bacillus* have revealed their ability to enhance plant disease-resistance to a number of fungal, nematode and bacterial pathogens.

The MBSA team saw a transition in leadership this past year. In February 2015, Dr. Brian McSpadden Gardener accepted a position with The Scotts Miracle-Gro Company, passing the team-lead position to Dr. Chris Taylor. The team now combines the expertise of five laboratories (Drs. Taylor, Matt Kleinhenz, Michelle Jones, Josh Blakeslee and Ana Alonso) and a total of two CAPS-funded post-doctoral students and four graduate students from many university departments, including plant pathology, horticulture and crop science; and the Translational Plant Sciences Graduate Program. Two MBSA students graduated this past year: Spencer Debenport (PhD) and Scott Menicos (MS).

The main goal of the MBSA team is to learn how to utilize *Pseudomonas* and other bacteria to influence both the growth and development of the plant host, as well as promote disease resistance and improve crop yield. Of particular interest to the team is the collection of bacteria (primarily *Pseudomonas*) from the McSpadden Gardener and Taylor labs that have not only been shown to control plant-parasitic nematodes, but have broad-spectrum activity against fungal and bacterial plant pathogens. Experiments have shown that some of the metabolites secreted by these strains are known to have multiple effects on plants as well. As such, the characterization of the secretome and metabolome of these strains and their individual and combined effects on plants are a major focus of the team's research.

Mutagenesis of nematicidal *Pseudomonas* strains has identified several possible factors that reduce nematode parasitism including hydrogen cyanide, harpins, hemolysins and other proteins of unknown function. In 2014-15, mutatgenesis of one of the stronger soybean cyst nematode (SCN)-lethal strains was completed. More than 4000 mutant isolates for this strain have been produced and currently are being screened for their activity against SCN. Interestingly, this strain can induce root-growth and promote germination and emergence in sweet corn. Preliminary data suggest this may be due to the production of auxin. Dr. Blakeslee's laboratory is in the process of screening all *Pseudomonas* isolates for the production of plant hormones and organic acids. In the last year, his lab has developed methods for extracting and quantifying these compounds from microbes and/or plant roots.

Nearly all the *Pseudomonas* strains in the McSpadden Gardener and Taylor collections have been analyzed for hydrogen cyanide (HCN) production. Analysis of the *Pseudomonas* genomes indicates that the genes responsible for HCN production are found in more than >70% of the strains. Identification of other volatiles effective against soybean cyst nematodes are underway as well.

The team's collaboration with the bioproduct company, Plant Health Care, Inc., has led to studies on harpin proteins secreted by plant-interacting bacteria. Application of harpins can in some cases improve crop disease resistance as well as plant growth. The team has identified numerous *Pseudomonas* strains that contain harpin-encoding genes, and emphasis is now placed on the cloning and production of these proteins to determine if they can influence gene expression in the host plant, improve disease resistance and/or affect plant growth.

Another MBSA team goal is to provide meaningful and accurate information to growers about bioproducts to help them better evaluate their options. In March 2015, Dr. Kleinhenz and new CAPS postdoctoral researcher Dr. Zheng Wang launched a grower-centered database of plant growth-enhancing microbial bioproducts that are organically approved.

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(http://hcs.osu.edu/vpslab/org_micro_bioproducts). This website provides a searchable database of all currently available, commercial microbial-based products; their target crops, ingredients and mode of application. The website is accessible by both public and private users, and provides a single location from which growers can better compare products. The database also offers direct links to products being sold.

With six publications in progress, the MBSA team is making great strides toward its goals of understanding and developing useful bioproducts for the agricultural sector. Another MBSA team goal is to provide meaningful and accurate information to growers about bioproducts to help them better evaluate their options. In March 2015, Dr. Kleinhenz and new CAPS postdoctoral researcher Dr. Zheng Wang launched a grower-centered database of plant growth-enhancing microbial bioproducts that are organically approved. (hcs.osu.edu/vpslab/org_micro_bioproducts). This website provides a searchable database of all currently available, commercial microbial-based products; their target crops, ingredients and mode of application. The website is accessible by both public and private users, and provides a single location from which growers can better compare products. The database also offers direct links to products being sold.

CAPS OPPORTUNITY TEAM

COFFEE RESEARCH

From left to right: Dr. Erich Grotewold, Dr. Ana Alonso, Dr. Enrico Bonello, Dr. Tom Mitchell, Dr. Josh Blakeslee, Dr. Michael Joe Vaughan, and Teddy Ezeji.

The Opportunity Team for Coffee Research (CAPS-OTCR) continues to foster its ongoing relationship with the J.M. Smucker Company through its public-private partnership. The team, originally led by Dr. Brian McSpadden Gardener, and now guided by Dr. Erich Grotewold and supported by Drs. Alonso, Bonello, Mitchell, Blakeslee, Ezeji and post-doctoral researcher Dr. Michael Joe Vaughan, is committed to investigating questions of broad significance to the coffee industry, as well as sponsoring specific research and development questions. On the confidential side of the project, the team is working closely with its partners to identify and investigate new lines of intellectual property development. On the public side of the project, the OTCR continues to develop its brand and expand its connections with academic researchers and leaders in the coffee industry.

In 2015, the OTCR hosted an internationally renowned expert in coffee roasting and quality analysis to continue its mission to deepen our understanding of coffee and coffee science at the university. Building on the foundations laid through previous research efforts, the team continues to utilize a multi-faceted approach for analyzing the microbiology and biochemistry of coffee beans to identify microbes with significant impact on coffee seed health and quality. These efforts have led to the development of a fermentation system using coffee-associated microbes to improve coffee seed quality for downstream applications. In addition, the OTCR has expanded its exploration of fungal and bacterial endophytes associated with defective coffee seeds using massively parallel sequencing of community amplicons to find targets for defect control. The team then will use the sequencing results to screen for highly impactful microbes within the coffee-associated microbe collection housed in the labs of the OTCR for future investigations.

The results of these research efforts were presented at an international meeting in New Orleans, and these data currently are being written for publication. The team also saw the release of its first peer-reviewed article concerning coffee microbiology. In 2015, Dr. M.J. Vaughan was privileged to travel with J.M. Smucker Company colleagues to the coffee producing regions of Nicaragua to further the OTCR network and learn more about coffee production. In this final year of the initial sponsored-research agreement, the OTCR will be working closely with the J.M. Smucker Company to explore options for continued collaboration. In the coming year, the team will be looking at ways to expand its membership and focus to include additional aspects of coffee processing.

TPS PROGRAM

TRANSLATIONAL PLANT SCIENCES **GRADUATE PROGRAM**

A NEW WAY TO TRAIN THE NEXT GENERATION OF PHD STUDENTS IN PLANT SCIENCES

The Translational Plant Sciences Graduate Program (TPS-GP) is a five-year PhD program within the Center for Applied Plant Sciences at The Ohio State University. This innovative program is designed to provide exceptional PhD training for talented and highly-motivated students to become next-generation leaders in the plant sciences. TPS-GP promotes a low-coursework load and high-impact research in globally important plant and agricultural research and sponsors students to participate in internships (three months and longer) focused on industry, teaching, policy, and science writing, among many other options. Tailored to each student's needs and career goals, TPS-GP is the first of its kind at Ohio State, and closely aligns with the university's Discovery Themes in Health and Wellness, Food Production and Security, and Energy and Environment, with emphasis on teamwork and One University for One World.

2015 TPS APPLICANTS

No. of Applicants	8
Avg. GPA	3.6
Avg. GRE V	158
Avg. GRE Q	158
Avg. GRE W	4

TPS-GP had an exciting year in 2014 – 2015. The program accepted the third class of outstanding fellows in 2014, as well as welcomed its first international student into the International Dual Degree Program. First-year student Stephanie Verhoff was a recipient of the prestigious United Soybean Board Fellowship for her contributions to agronomy through research, education and service. Another first-year student, Ashley Yates, was accepted into the Cold Spring Harbor Laboratory's intensive two-week-long Proteomics Course. Second-year student Irene Gentzel was an author on a Plant Physiology paper published by the Dr. David Mackey lab.

RETURNING TPS FELLOWS

IRENE GENTZEL

Irene enrolled in TPS in August 2013 and joined Dr. David Mackey's lab after completing rotations with Drs. Mackey, Dorrance and McSpadden Gardener. Her co-advisor is Dr. Ana Alonso. She also passed her candidacy exam at the end of the 2014-2015 academic year. Her project focuses on the bacterial pathogen *Pantoea stewartii* that infects maize to cause Stewart's Wilt. This bacteria is particularly useful to study because one of its proteins, called WtsE, an effector protein that the bacteria pump into plant cells via the type three secretion system to promote growth and virulence, is sufficient to cause disease-like symptoms. Furthermore, plants that are infected with the wtsE-mutant bacteria do not develop the characteristic symptoms associated with the wild-type strain. After finding that WtsE can induce maize to produce certain phenylpropanoid metabolites, the Mackey lab recently started RNA-seq and untargeted metabolomics experiments to examine both the bacterial and maize responses during their interaction. To complement this work, Irene is in the process of confirming these results with quantitative RT-PCR, and she also is developing an approach to use reporter *P. stewartii* strains to monitor their gene expression patterns over time in planta. Specifically, the reporter strains will be used to analyze the impact of induced maize compounds on *P. stewartii* gene expression.

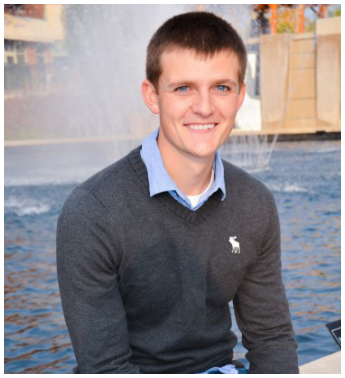
Special thanks to Irene for all her hard work on the writing and organization of this year's Annual Report.

REBECCA KIMMELFIELD

Rebecca joined TPS in August 2013 and after rotations in the Dr. Mitchell and Dr. Taylor labs, she joined Dr. Taylor's lab the following year. Her co-advisor is Dr. Michelle Jones. Rebecca passed her candidacy exam at the end of the 2014 -2015 school year. Her project focuses on the use of *Pseudomonas* as a biological control agent of plant parasitic nematodes. Interactions in the rhizosphere between the plant, bacteria and nematode are being identified. She currently is investigating the ability of approximately 45 *Pseudomonas* strains to produce volatile compounds that can hinder pathogen activity and promote plant activity. One volatile of particular interest is hydrogen cyanide (HCN), which is produced by a majority of the strains. HCN producing bacteria have demonstrated

nematode lethality. She also is determining the effects of HCN on plant growth. Additionally, non-HCN producing isolates have demonstrated nematode lethality. Genomic and biochemical approaches are being used to analyze the volatile profiles of these strains. Finally, the root exudates of soybean (*Glycine max*) are being quantified so that a medium more representative of the rhizosphere may be used in future experiments.

WILLIAM ROLLING



William joined TPS in May of 2014. He completed rotations in the Dorrance, Mitchell and McHale labs. In spring 2015, he joined the McHale lab (co-advised by Dr. Anne Dorrance) to study the interaction of soybean with *Phytophthora sojae*, the third most yield-limiting pathogen in soybean production. It causes losses estimated at 30 million dollars in the United States and 1-3 Billion dollars worldwide, annually. Currently, the best method of defense is genetic resistance. The most commonly used genetic resistances are single dominant genes providing complete resistance to specific races of the pathogen. The widespread deployment of individual genes for resistance against *P. sojae* (Rps genes) causes intense selection pressure on *P. sojae*, resulting in rapid diversification of populations. This diversification has caused many Rps genes to become obsolete. This is why studying the alternative types of genetic resistance is becoming increasingly important.

Quantitative defense is an alternative to Rps gene-mediated defense. It is conferred by many genes; it is not isolate-specific and is more durable than the Rps gene-mediated defense. Recently, efforts have been made to map the locations of the quantitative defense loci, and many QTLs have been genetically mapped. This project aims to determine specifically which genes in the QTLs are conferring the defense through gene expression experiments and functional analysis. In particular, this project is studying the possible involvement of NB-LRR genes in this type of resistance. The understanding of which genes are responsible for this quantitative resistance will enable the development of perfect markers. Armed with this knowledge, soybean breeders can more effectively incorporate quantitative resistance traits into the elite cultivars using marker-assisted selection.

STEPHANIE VERHOFF

Stephanie joined TPS in 2014, after completing an internship with Monsanto. Her rotations were with Dr. Leah McHale and Dr. Anne Dorrance, who are now her advisor and co-advisor,

respectively. Her project studies *Phytophthora* stem and root rot, which is caused by the soil-borne oomycete *Phytophthora sojae Kaufmann and Gerdemann*, and is a serious disease of soybeans [*Glycine max* (L.) Merr.]. Host-resistance is a common management practice for this disease and race-specific dominant genes for resistance (Rps genes) have been incorporated into numerous commercial varieties. However, the widespread deployment of Rps genes has led to a shift in physiological races of *P. sojae*. Partial resistance is quantitatively inherited and effective against a wider range of races of *P. sojae*, resulting in a reduced level of root rot. Due to its broad-spectrum nature and the development of low levels of disease, partial resistance places less selection pressure on *P. sojae* populations and is theoretically more robust than Rps gene-mediated resistance. It also has been shown that genetic traits associated with high levels of partial resistance do not have a negative effect on yield, even in environments with low disease pressure. Recently, a major quantitative trait loci (QTL) was identified on chromosome 18 (8-16 cM), explaining 10-45% of phenotypic variance. A QTL of large effect is an uncommon occurrence in *P. sojae* — soybean interactions — and it remains unknown if it represents a unique resistance mechanism. Near isogenic lines (NILs) were developed from three recombinant inbred lines (RILs), derived from crosses between either OX20-8 and PI 427105B or OX20-8 and PI 427106, identified as segregating for the QTL of interest. A total of 51 homozygous lines were selected from the three RILs based on flanking SSR marker genotypes. These 51 lines were phenotyped for partial resistance using both a tray and layer test. Gene expression differences between NILs currently is being assessed using RNAseq. The development of NILs for this major QTL will enable field evaluation of the effect of this QTL, as well as functional analysis of candidate genes conferring partial resistance.

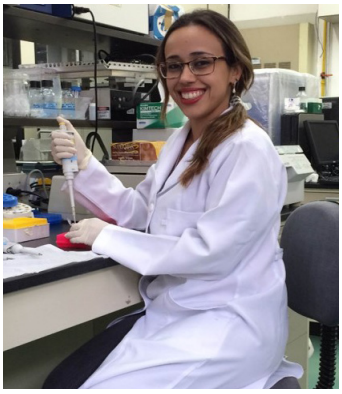
ASHLEY YATES

Ashley joined TPS in August of 2014, and completed a laboratory rotation with Dr. Feng Qu utilizing virus-induced gene silencing (VIGS) to silence soybean aphid genes. Ashley also completed a laboratory rotation with Dr. Andy Michel investigating the expression of two putative aphid-effector genes in different aphid biotypes. Since joining Dr. Andy Michel's lab in the spring of 2015 (and co-advised by Dr. Josh Blakeslee), Ashley's research is focused on the molecular interaction between the soybean aphid and aphid-resistant soybean. The soybean aphid is a significant agricultural pest of soybean. One means of management is through host-plant resistance, which utilizes plant cultivars naturally expressing gene(s) that provide the plant protection from

aphids. However, several aphid biotypes are capable of survival and reproduction on aphid-resistant soybean, threatening the use of host-plant resistance. The molecular mechanisms underlying this interaction are not well-understood. Ashley is studying the molecular differences (gene expression, protein) between aphid biotypes. Previous data from the Michel lab suggests differences in candidate-effector proteins and detoxification enzymes between aphid biotypes. She also will study soybean defense response (metabolite) to aphid infestation with Dr. Josh Blakeslee. Previous data suggest the production of secondary metabolites in response to aphid feeding. Additionally, she is working with Drs. John Finer, Feng Qu and Andy Michel (the SoyRes Scientific Team) to develop a functional genetics tool (RNAi) in soybean aphid.

INTERNATIONAL PHD DUAL DEGREE PROGRAM

DANIELLE IZILDA RODRIGUES DA SILVA



Dani joined the lab of Dr. Erich Grotewold as part of a collaboration with Dr. Glaucia Souza, where she will continue her work on the "Comprehensive Analysis of Global Sugarcane Transcriptome Changes in Response to Drought" project. This project aims to define genomic sequences enriched in RNA Polymerase II, identify active promoters and genes that are activated under drought conditions, and generate tools to allow the scientific community to associate regulatory motifs with traits such as drought.

Dani joins the TPS-GP as the first student representing the USP International PhD Dual Degree Program between Ohio State and the University of São Paulo, Brazil. The objectives of this unique program are to encourage outstanding scientists to spend one year or more in an international setting where they can progress in their research, develop overseas contacts, receive professional development and foster international collaborations between the two institutions. More information regarding the program can be found at internationaldualphd.com

THOUGHTS FROM OUR NEW STUDENTS

ALEX TURO

Research for my master's thesis at Binghamton University (SUNY) has focused on applying techniques of statistics and computational biology to support investigations into the molecular basis of ecologically-relevant traits that cause reproductive isolation between wild populations of monkey-flowers (*Mimulus spp.*). For example, I've assembled a draft genome of *Mimulus norrisii,* an edaphic endemic of the Sierra Nevada Mountains in California, in order to support forthcoming population-level genomic analyses between *M. norrisii* and a sister species that may provide insight into the genetic basis of edaphic endemism. My recent coursework, meanwhile, has focused on applied math that hopefully will be useful at CAPS for the purposes of modeling multivariate biological phenomena at both micro- and macroscopic-levels, such as gene co-expression networks. I am delighted to begin working as a new TPS fellow for CAPS because of the emphasis on learning domain knowledge through practical research experience, as well as the modern perspective on a scientific career espoused by the graduate committee. On a more personal note, I have only ever worked in a small university setting, and am optimistically anxious about traveling from a department with a veritable dearth of plant biologists to a multi-departmental center at Ohio State devoted to a wide spectrum of plant science!

TAMARA MCCLURE

I received my BSc in biochemistry from The Ohio State University in the spring of 2015. As an undergraduate, I worked in Dr. Ana Alonso's lab and studied the effect of ecotype and environment on soybean biomass composition. My long-term career interests include plant biochemistry, crop improvement and the development of plant products. I chose to enter the TPS program because of the individualized format, the opportunity to pursue an industry

internship and the diverse faculty that would allow me to explore different plant research topics. I hope to rotate through the labs of Drs. Enrico Bonello, Thomas Mitchell and Joshua Blakeslee.

KATHERINE D'AMICO

I earned my BSc in biology from John Carroll University and my MSc in conservation biology from SUNY College of Environmental Science and Forestry. Prior to joining the TPS program I worked for the USDA ARS in Ithaca, NY, as part of the *Pseudomonas* Systems Biology group under Dr. Melanie Filiatrault. The research focus in the lab is on small RNAs and how they contribute to virulence in the model bacterial pathogen, *Pseudomonas syringae pv. tomato DC3000*. I also previously worked on American chestnut under Dr. William Powell, whose lab is using genetic modification to enhance resistance to chestnut blight. As a TPS student, one of my lab rotations will be with Dr. Enrico Bonello. My long-term career interests are forest pathology, response to pest/pathogens in trees and U.S. government science policy and budgets.

FACILITIES

CAPS COMPUTATIONAL BIOLOGY LABORATORY (CCBL)

The CAPS Computational Biology Lab (CCBL) is a self- sustaining collaborative research space focused on Bioinformatics and Computational Biology research. The concept for CCBL is inspired by the casual and dynamic environment of technology start-ups. The CCBL is aimed at catapulting Ohio State's computational biology expertise to a national level through fostering peer connectedness, deliberate creative problem solving, research acceleration and idea incubation and exploration. Relying on a transdisciplinary approach to education and research, the CCBL hosts faculty, postdocs, students and anyone else with the required skill set and desire to contribute. The CCBL is not a training environment, but instead is a dynamic research space for colleagues to be physically close to their peers.

This year the CCBL formed ties with the bioinformaticians associated with the Solid Tumor Biology Program by participating in their monthly bioinformatics journal club. The lab also formalized its weekly meetings to ensure time for sharing relevant computational programs and algorithms, gaining directed feedback on students' bioinformatics projects, and reaching out to the community through problem-solving Q&A forums. The lab also has time slots for Ohio State's bioinformaticians outside of the CCBL to share their data and gain new insight into their work--Kaushik Panda, a graduate student in Keith Slotkin's lab, recently shared his work profiling methylomes in *Arabidopsis*. Finally, the CCBL was very excited to host Dr. Michael Snyder, Department of Genetics, Stanford University, in August.

To find out more please visit **caps.osu.edu/caps-computational-biology-laboratory.**

TARGETED METABOLOMICS LABORATORY (TML)

The mission of the TML is to serve research through the detection and quantification of small molecules from biological sources. The TML is a cost recovery unit that has many standard protocols and encourages the development of new techniques to quantify additional compounds. The facility provides access to state-of-the-art chromatographic and mass spectrometric instrumentation. The methods are designed to take advantage of a high throughput liquid chromatography (Agilent UHPLC 1290) coupled to a highly sensitive mass spectrometer (AB Sciex QTRAP 5500) and a gas chromatography coupled mass spectrometry (ThermoFisher GC-MS). Moreover, the laboratory has a High Pressure Liquid Chromatography-Photodiode Array Detector (Waters Alliance HPLC/PDA system) to separate and monitor metabolites that have UV-Vis absorption. The TML also offers expertise in experimental design, extraction methods and data interpretation.

Customer Affiliation: The Ohio State University, Arclin, Bowling Green, Bridgestone, University of Akron, University of Sao Paulo, Virginia Tech

The Ohio State University Department Affiliation: Molecular Genetics, Horticulture and Crop Sciences, Plant Pathology, Center for Applied Plant Sciences, Chemistry and Biochemistry, Food Science Technology, Biosciences, Comprehensive Cancer Center, Optometry, Veterinary Biosciences, Pharmacy

Scientific Director: Dr. Ana Alonso
Research Associate: Christophe Cocuron
Program Manager: Donnalyn Roxey

For more information please visit **metabolomics.osu.edu.**

EDUCATION AND OUTREACH

ABRC once again had a busy outreach year. They participated in booths at events, including the Center of Science and Industry's (COSI) Teacher Resource Fair and Science Education Council of Ohio (SECO) Conference. These annual events provide the opportunity to engage Ohio science teachers interested in incorporating more hands-on activities into their classrooms. ABRC also interacted directly with students through participation in the OARDC Science of Agriculture workshop, Ohio State's Math and Science Program, JW Reason Family Science Extravaganza, and State Science Day. In addition, ABRC collaborated with a faculty member from the molecular genetics department, Amanda Simcox, to organize a two-day "internship" with 3-5 seniors from Pam Snyder's Fort Hayes Bioscience Technology class. In addition to these in-person events, ABRC also continues to maintain an electronic series of experimental modules for K-12. These TRAINED and Greening the Classroom modules are composed of a series of hands-on activities, illustrating biological concepts and processes like inheritance, development and response to environmental conditions. Teachers can download these resources to carry out experiments with their classes. Materials are available to teachers around the world via abrcoutreach.osu.edu.

BREAKFAST OF SCIENCE CHAMPIONS

Forty-five sixth-grade students from the Hubbard Mastery School visited CAPS on November 13, 2014 for another engaging Breakfast of Sciences Champions' event, organized by Ohio State's STEM Outreach Program. In our third year as a host site, CAPS called on plant sciences' staff, graduate students, postdocs and faculty to create a robust experience, aimed at encouraging these students to consider studies and careers paths in the areas of science, technology, engineering and math. The schedule was divided into three sections: breakfast and scientist/scientific theory introductions, nitrogen fixation greenhouse experiment and facilities tours. Pre- and post-trip activities were administered by the class's teachers, giving us a gauge of original STEM interest and knowledge as well as the visit's impact.

CCBL CARPENTRY WORKSHOP

The CAPS Computational Biology Laboratory hosted a two day informatics bootcamp on October 6-7, 2014. The Software Carpentry Bootcamp targeted researchers who are familiar with basic programming concepts, and looking to improve their programming abilities and learn common best practices. Developed and taught by Software Carpentry Instructors, this programming bootcamp empowered participants' coding by teaching them how to get the most from the command line, version tracking software, standard libraries and SQL databases.

CONVIRON TRAINING

A two-day (November 18-19, 2014) growth chamber service-training seminar was conducted by Greg Anderson of Controlled Environments LTD (Conviron) and facilitated by CAPS Greenhouse Manager, Joan Leonard. The training, conducted in Rightmire Hall, offered practical hands-on experience for those who trouble-shoot, repair, service or maintain Conviron equipment.

PECHAKUCHA NIGHT

CAPS, Byrd Polar Research Center and the Center for Automotive Research sponsored their first PechaKucha Night on Wednesday, November 5, 2014. This event featured Ohio State Graduate students (in each of the center's respective fields) presenting their research, theory or novel idea in a 20 imagesX20 seconds, rapid-fire format in front of a live audience and judging panel. The show-and-tell meets open-mike meets happy-hour was a welcome departure from the more formal seminar and conference platforms normally provided to the young scientist community.

CONTINUED ON PG. 18

COSI

CAPS Program Manager, Donnalyn Roxey, was joined by Dr. Jon Parquette from the Department of Chemistry/Biochemistry and Bettina Wittler from ABRC to bring the plant sciences alive at COSI's "Meet A Scientist" event, held February 7, 2015. CAPS provided hands-on activities including DNA extraction from applesauce, pH testing and membrane-interaction visualization. In addition to these experiments, CAPS provided plants to learn about model systems and how some plants are being used for biofuel purposes. Tools like microscopes were available for the public to interact with and a matching game of seed to product was available to play.

CAPS PORTUGUESE TRAVEL-SURVIVAL COURSE

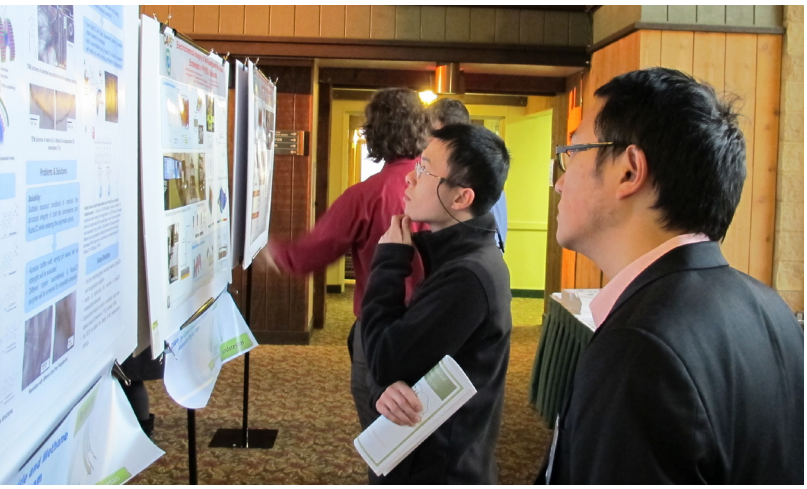
Inspired by a fall 2014 faculty trip to the University of São Paulo, Brazil, CAPS partnered with the Department of Spanish and Portuguese to develop an unmatched language course at Ohio State. The "CAPS Portuguese Travel/Survival Course" is an accelerated offering to faculty, staff and students of the greater research community with strong Brazilian/Ohio State Gateway interaction interests or current collaborations. Kicking off in June, 2015, the class will run through December 2015 and is instructed by current PhD candidate, Clara Carolyne and Lecturer Shirlei Silveira. Joanna Gardner, CAPS program associate and current student, describes the curriculum as "just the right combination of classic language instruction and real-life conversation skills for the novice Brazilian traveler. We learn so much more than verb conjugation and sentence structure: culture, lodging, transportation, academic atmosphere, social scene, etc. I am gaining a true appreciation for the people and places I hope to visit soon." This course is currently offered on West Campus in Rightmire Hall. The hope is to expand to the Wooster campus via video-link in 2016.

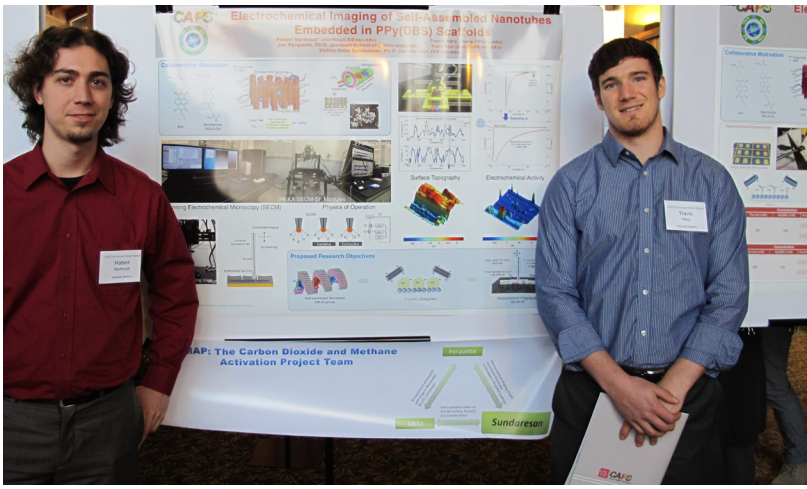
More information can be found at: caps.osu.edu/news/open-enrollment-caps-portuguese-travelsurvival-course

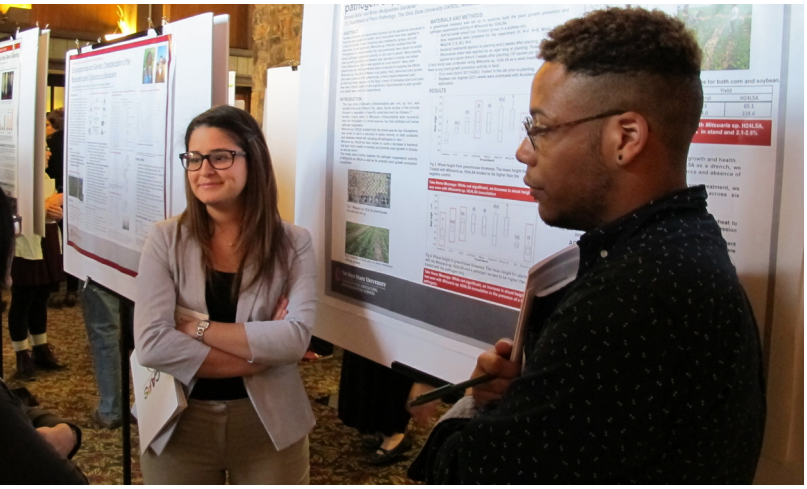
PLANNING THE INDUSTRY/ UNIVERSITY COOPERATIVE RESEARCH CENTER ON THE SUSTAINABLE USE OF GREENHOUSE GASES (CSUG^2)

On June 24-25, 2015, faculty members from The Ohio State University, The University of Akron and The University of Toledo hosted an Industry Planning Conference in support of a new NSF-funded Industry/University Cooperative Research Center (I/UCRC). OSU's LEED certified Nationwide/Ohio Farm Bureau 4-H Center proved to be the perfect venue to highlight the planned center's mission to create environmentally friendly, low cost sources of fuels, chemicals and materials through pre-competitive technologies that involve the sustainable utilization of wasted carbon (such as provided by carbon dioxide and methane). Over a twelve month collaborative effort (and two previous conferences on the topic), these self-selected institutions recruited thirty-one industry and government agency representatives to attend the Center for the Sustainable Use of Greenhouse Gases (CSUG^2) planning event. Under the umbrellas of "Capture, Concentration and Purification", "Carbon Conversion" and "Chemicals, Polymers and Materials", sixty-seven participating faculty submitted forty-seven team abstracts to be considered as possible projects within the scope of the center's focus to utilize wasted carbon. Ten projects were then selected by our industry liaison team to be orally featured, in addition to another seven poster presentations. These project pitches, facilities/instruments, and center structure were then rigorously evaluated by the participants by way of closed and open door feedback sessions. These appraisals enabled our faculty and center coordinators to identify the most viable connections that could result in full industry/government memberships (investments). The call to engagement and membership is now at an all-time high as the center coordinators will spend the next few months confirming letters of commitment and completing the writing of the final full NSF proposal due in January 2016.

ANNUAL RETREAT 2014





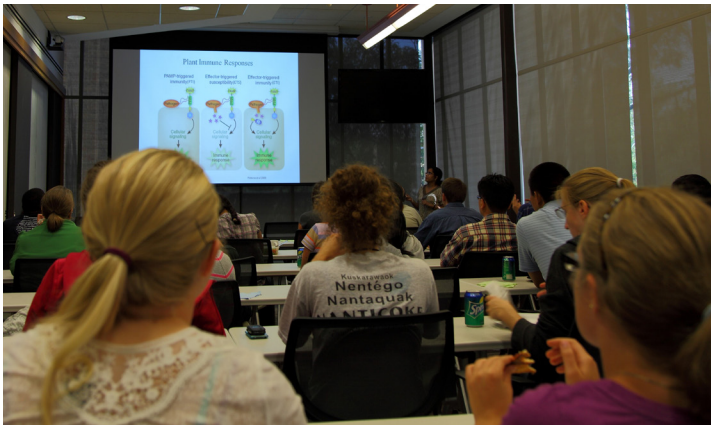


The Third Annual CAPS Winter Retreat was held at Salt Fork Lodge in Cambridge, Ohio, on December 12–14, 2014. A total of 80 faculty, students, and staff were in attendance, as well as 45 family members who joined them for the occasion. This was the first time CAPS had hosted the event at Salt Fork Lodge, and attendee reviews of the location were very favorable.

Created as a means to join scientific discussion and brainstorming with rest and relaxation, the past CAPS annual retreats have proven very fruitful in giving new direction to the center's goal of bridging the gap between basic and applied plant science. Faculty, students, and staff present their work in both poster and oral presentations, and audience participation is encouraged. From overviews on the scientific teams' progress to the details on individual student projects, the retreat is a fun way to catch up on the latest developments and breakthroughs at CAPS.

The 2014 retreat began with a collection of 38 poster presentations by all the CAPS-supported graduate students, post-docs and facility leaders. After a warm welcome from CAPS Director Erich Grotewold, participants were next walked through the many synergy and team-building aspects of CAPS by invited speaker John F. Cabra, associate professor, of SUNY Buffalo's International Center for Studies in Creativity. The following morning, Andy Burnett of KnowInnovation (knowinnovation.com) continued on the theme of Synergy and Team Building before the start of the Scientific Team presentations. In addition to updates from the established MBSA, RapRes, SoyRes, and PlantDom teams, attendees learned about the two new teams, TIRE and CMAP. Furthermore, the participants were honored to hear from Dr. David Manderscheid, Executive Dean and Vice Provost of the College of Arts and Sciences, as he discussed CAPS from the university's perspective. A champagne toast ended the formalities of the event, and the remainder of the evening was spent networking and roasting marshmallows around the campfire.

SEMINAR SERIES

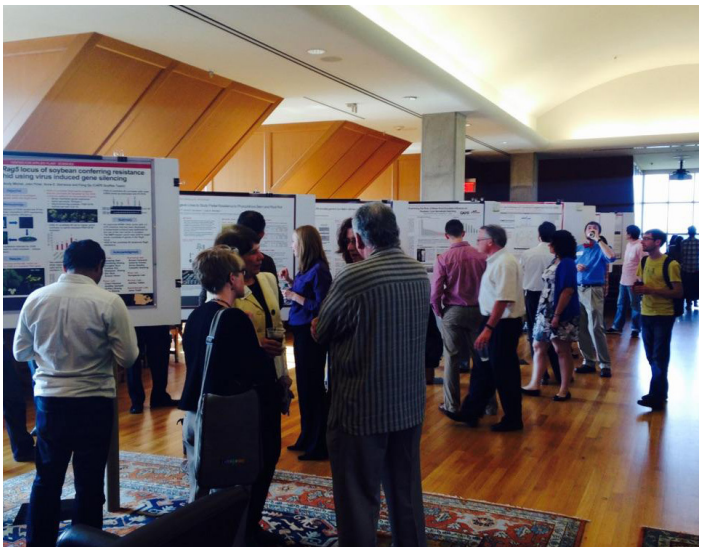


Now in its second year since the transition from the Rightmire Hall weekly seminars, the CAPS Seminar Series features one-hour long scientific presentations by CAPS faculty, staff and students as well as invited guests from other departments, universities and organizations. An average of 50 people attend weekly at the Rightmire Hall location, and nearly 15 more join us from the OARDC Wooster campus via video-link. Attendees are treated to a free pizza lunch as they learn about exciting research projects covering diverse topics including the intricate shape of plant viroids, breakthroughs in soybean resistance to common diseases, complexities of gene regulatory networks, and the details of pollen shape and development. This past year, CAPS invited several distinguished speakers from around the world:

Dr. Brett Tyler, Oregon State University
Dr. Paul Verslues, Inst. of Plant and Microbial Biology (Taiwan)
Dr. Luis Camargo, University of Sao Paulo (Brazil)
Dr. Paul O'Maille, Institute of Food Research
Dr. Zhangjun Fei, Boyce Thompson Institute
Dr. Chris Miller, University of Colorado Denver
Dr. Robert Schmitz, University of Georgia

The CAPS seminar series is open to anyone at The Ohio State University. Come join us on Fridays from 12:30 – 1:30 p.m. in 102 Rightmire Hall, or use our video-linked connection to 203 Selby Hall at OARDC in Wooster, Ohio! More information can be found at caps.osu.edu/seminar-series.

EXTERNAL SCIENTIFIC ADVISORY BOARD REVIEW
MAY 6-9, 2015



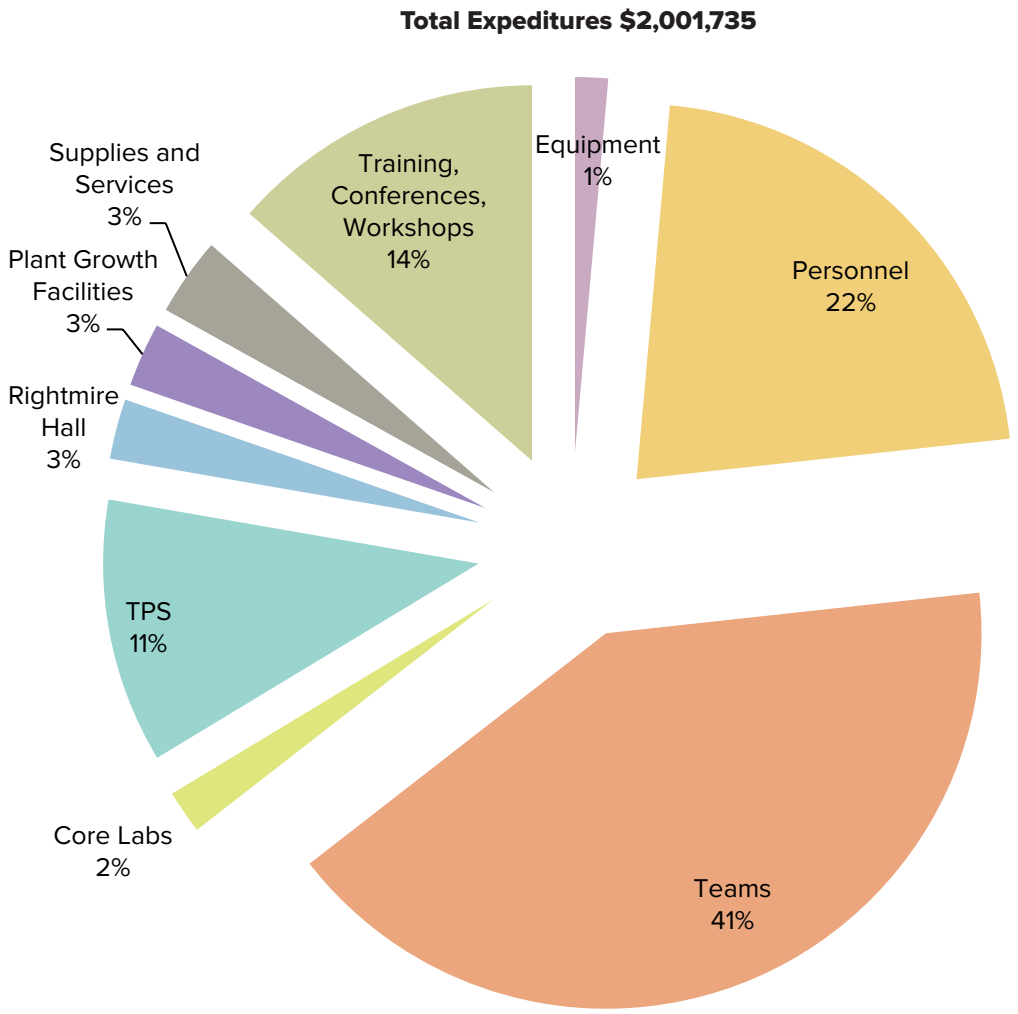
The CAPS External Scientific Advisory Board (ESAB) has many purposes, including ranking proposals for Scientific Team membership, evaluating existing teams' progress and advising the director. The ESAB visited Columbus in May 2015 to evaluate the progress of the four CAPS Scientific Teams. Four of the six-member board attended. The ESAB members were provided written reports, oral team presentations and individual team meetings. They also had time to meet with CAPS staff, graduate students and postdoctoral researchers at a special poster presentation session held on the spectacular 11th floor of Thompson Library. From this information, the ESAB provided CAPS with written reports for each team and recommendations for future resource allocation. In addition, the CAPS ESAB had an opportunity to meet with Ohio State department chairs, deans, provosts and other CAPS key stakeholders.

In attendance at the May 6-9 ESAB Review
David Stern, PhD, President of the Boyce Thompson Institute for Plant Research; Robert Last, PhD, Barnett Rosenberg Professor of Biochemistry at Michigan State University; Richard Flavell, PhD, Chief Scientific Officer for Ceres Inc., Thousand Oaks, CA; and Sophien Kamoun, PhD, Group Leader of The Sainsbury Laboratory, Norwich Research Park, Norwich, United Kingdom.

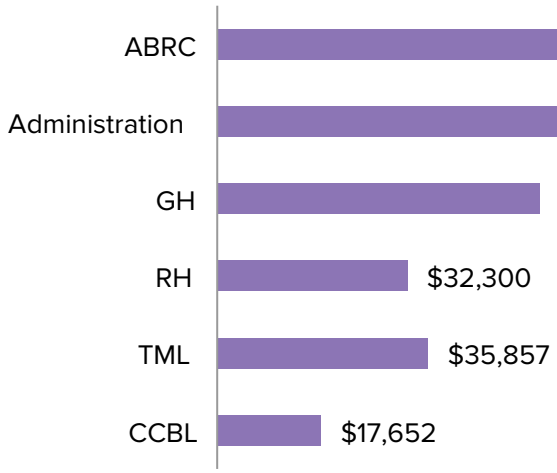
Not in attendance were James Carrington, PhD, president of the Danforth Plant Science Center in St. Louis, Missouri; and Sarah Hake, PhD, director of the USDA Plant Gene Expression Center in Albany, California.

FINANCIALS

Total Expenditures



Staff

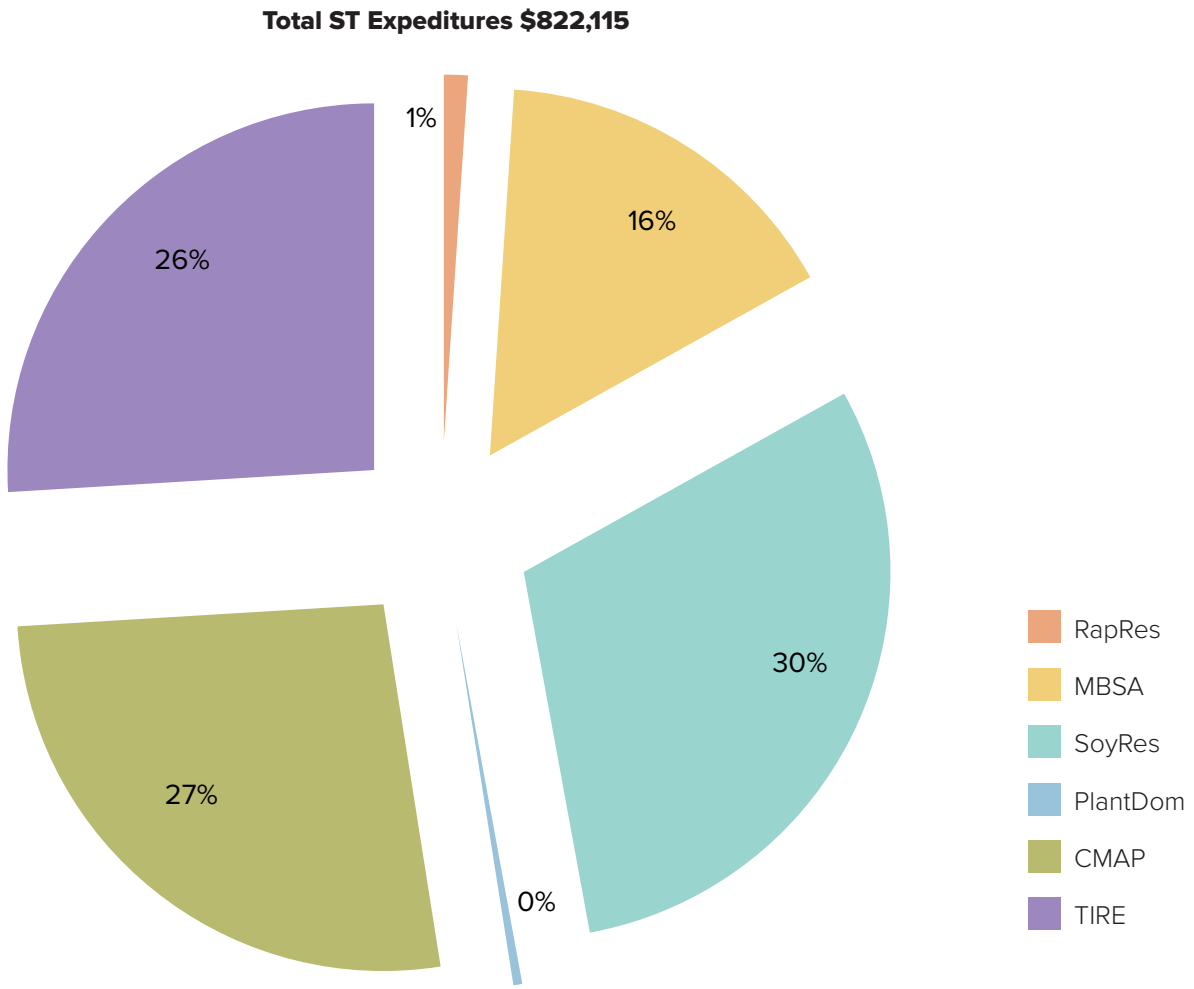


Administration:
- 2 x 1.0 FTE
- 1x 0.5 FTE (TML)
- 1x 0.3 FTE (CCBL)
- 1x 1.0 FTE (ABRC)
- 1 student

Greenhouse Facilities:
- 1x 0.75 FTE
- 1x 0.15 FTE

Rightmire Hall:
- 1x 0.5 FTE
- 1 student

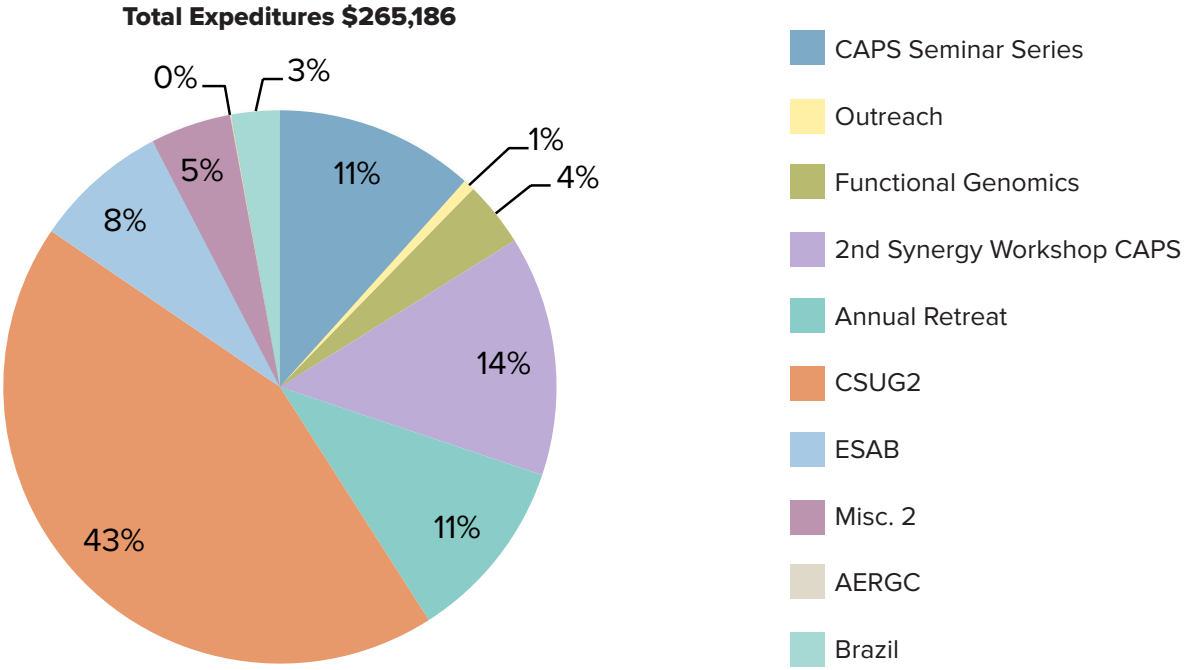
Scientific Teams Expenditures



CAPS supports the Scientific Teams (ST) with a variety of resources including hiring personnel (postdoctoral researchers, undergraduate students, GRA tuition and fees, visiting scholars), training expenses, research supplies, travel accommodations, market analysis, and various other expenditures. These fees cover costs associated with the partial or full appointment for the following non-faculty positions:

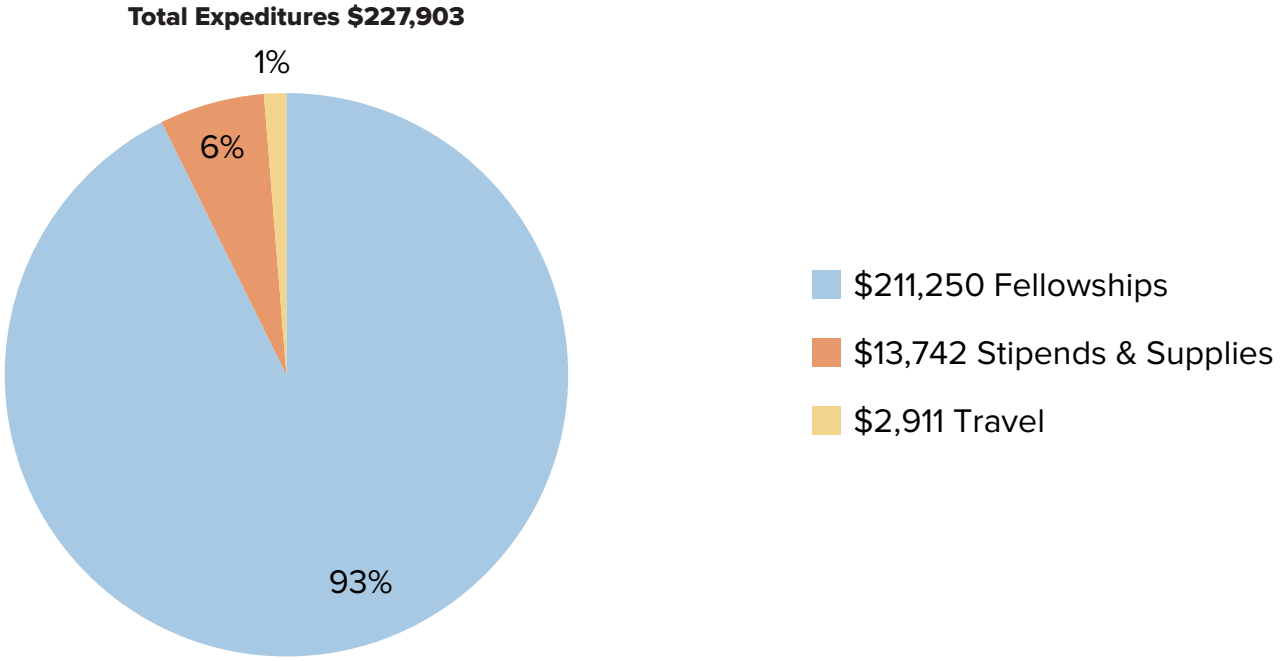
- 10 Postdocs
- 6 Research Staff (Scientists or Associates)
- 21 Graduate Students (tuition and fees)

Training and Workshops

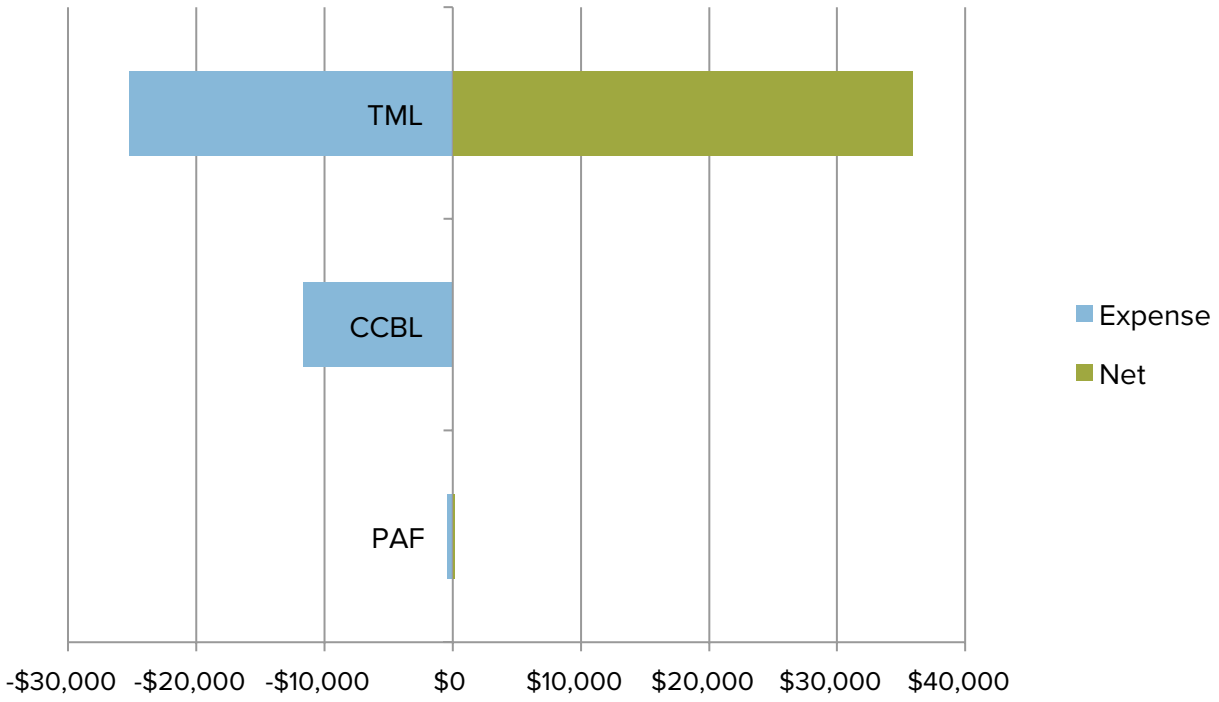


1. CSUG2 represents the following three events: I/UCRC meetings 1 & 2 (partial support from NSF IIP-1362092) and the First Ohio Conference of the Sustainable Use of Greenhouse Gases.
2. Miscellaneous costs include entertainment, alcohol and gifts (sympathy baskets, etc.)

Translational Plant Sciences Graduate Program



CAPS Facilities



The Targeted Metabolomics Laboratory (TML)
- $61,155 Revenue
- $25,259 Expenditures (salaries not included)

Plant Antibody Facility (PAF)
- $550 Revenue
- $402 Expenditures (salaries not included)

CAPS Computational Biology Laboratory (CCBL)
- $0 Revenue
- $11,651 Expenditures (salaries not included)

CAPS ADMINISTRATION AND COMMITTEES

In addition to the daily duties of CAPS business administration, the administrative team also serves the CAPS Biotechnology Support Facility and the Arabidopsis Biological Resource Center (ABRC), as well as Rightmire Hall and the CAPS core labs. The team embodies the CAPS standards of excellence through engagement and personal relationship-building, integrity in work quality and facility upkeep. The CAPS staff strives to maintain state-of-the-art facilities and be engaged citizens of the center's community by working with the utmost integrity.

THE CAPS ADMINISTRATIVE STAFF

Dr. Erich Grotewold, Director
Donnalyn Roxey, CAPS Program Manager
Joanna Gardner, CAPS Fiscal Associate/Program Associate
Christophe Cocuron, TML Manager
Gary Posey, CAPS Greenhouse Superintendent
Scott Hines, Facility Service Manager
Joan Leonard, CAPS Greenhouse Program Manager

EXTERNAL SCIENTIFIC ADVISORY BOARD (ESAB)

(January 2012 – December 2015 Terms)
Dr. Sophien Kamoun, Sainsbury Laboratory, UK
Dr. Sarah Hake, PGEC and UC Berkeley
Dr. Richard Flavell, CERES, Inc.
Dr. David Stern, Boyce Thompsom Institute
Dr. James Carrington, Danforth Plant Science Center, St. Louis, MO
Dr. Robert Last, Michigan State University

TRANSLATIONAL PLANT SCIENCES GRADUATE PROGRAM

Dr. Thomas Mitchell, Chair
Dr. Anne Dorrance
Dr. Jay Hollick
Dr. David Mackey
Dr. Joshua Blakeslee
Dr. Andrea Doseff, Ohio State-USP Coordinator

GREENHOUSE COMMITTEE

Joan Leonard, College of Arts and Sciences Greenhouse Program Manager
Gary Posey, CAPS Greenhouse Superintendent
Dr. David Somers, Professor, Molecular Genetics
Dr. Jelena Brkljacic, Associate Director, ABRC
Dr. Nik Kovinich, Postdoctoral Researcher, CAPS

CAPS would like to thank the faculty, staff and students for their continued efforts to make the center successful. CAPS also thanks its committees for their time, expertise and dedication.

OHIO STATE COLLEGES AND DEPARTMENTS WHOSE FACULTY PARTICIPATE IN CAPS

COLLEGES

College of Arts and Sciences (ASC)
artsandsciences.osu.edu

College of Food, Agriculture, and Environmental Sciences (CFAES)
cfaes.osu.edu

College of Medicine (CoM)
medicine.osu.edu

College of Engineering (CoE)
engineering.osu.edu

DEPARTMENTS

Molecular Genetics (Mol Gen)
molgen.osu.edu

Horticulture and Crop Sciences (HCS)
hcs.osu.edu

Plant Pathology (Plant Path)
plantpath.osu.edu

Chemistry and Biochemistry (Chem/Biochem)
chemistry.osu.edu

Internal Medicine (IM)
internalmedicine.osu.edu

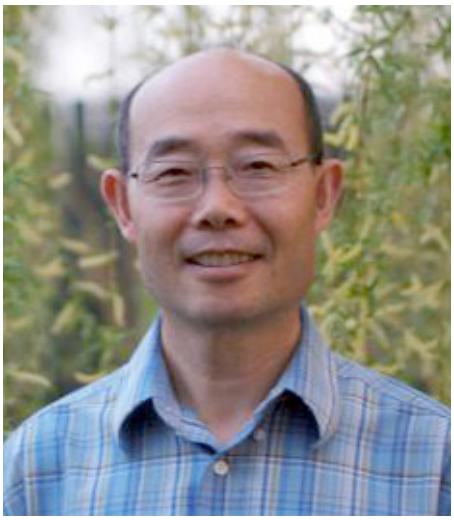
Microbiology (Micro)
microbiology.osu.edu

Chemical and Biomolecular Engineering (CBE)
cbe.osu.edu

Food, Agricultural, and Biological Engineering (FABE)
fabe.osu.edu

Mechanical and Aerospace Engineering (MAE)
mae.osu.edu

IN MEMORIAM



BIAO DING

Biao's primary research interest was intercellular communication in plants through plasmodesmata, specialized structures that physically connect adjacent cells. He turned to the use of viroids, enigmatic plant pathogens comprised of naked, non-coding RNA, as the model molecule to use in his unique approach to studying intercellular transport. Among other accomplishments, he was the first to identify the primary and tertiary determinates of RNA structure needed for systemic viroid movement. His more recent interests included the roles of non-coding RNAs in gene regulation, and the relationship between three dimensional RNA structure and function. His work resulted in more than 40 publications in prominent journals, such as the *Proceedings of the National Academy of Sciences, The EMBO Journal* and *The Plant Cell*. By nature, Biao was a strong team player and his research involved numerous collaborations both in the U.S. and beyond.

His election as Fellow of the American Association for the Advancement of Science (AAAS) in 2012, and prominent positions as senior editor of *Molecular Plant-Microbe Interactions (MPMI)* and scientific editor of *PLoS Pathogens*, testify to his high regard in the scientific community. Biao enthusiastically shared his expertise by giving lectures in numerous workshops and short courses, and recently organized and hosted an International Conference on Plant Vascular Biology here at Ohio State. He was an outstanding teacher both in the classroom and as a research mentor, and started numerous graduate students and post-doctoral associates on successful career paths. His trainees have obtained prestigious faculty positions both in the U.S. and abroad.

Biao was a courageous, independent thinker of the highest quality and integrity, and a gentle, kind and sincere person who generously shared his time and resources with colleagues. His quiet and ever-smiling presence in the research and teaching halls of The Ohio State University will be sadly missed by all.

MARK A. BENNETT

The TIRE team sadly lost one of its co-PI's this year. Dr. Mark A. Bennett was intelligent, curious, kind, generous, and accomplished. To know Mark was to see him as a tireless researcher, educator, mentor, and colleague whose contributions will ripple in homes and businesses near and far for years. His twenty-nine year career at OSU was built on internationally recognized expertise in vegetable production and seed biology. This expertise was displayed in dozens of research articles, a significant array of educational resources and events, numerous Associate Editorships, and as a contributing member to interdisciplinary programs and international working groups. Mark explained relationships among seed quality, stand establishment, and system productivity and helped steer improvements in all through independent and collaborative efforts. Mark expertly bridged research, real-world application, and the transfer of understanding to rising professionals, and most recently contributed his expertise to the TIRE team an enhanced seed germination and seedling establishment. He also served as Interim Chair of the Department of Horticulture and Crop Science, at the request of colleagues. Still, Mark's ambitious research and education activities did not overshadow his genuine interest in the welfare of others or passion for the earth. Many are better off for having known, worked with, and learned from Mark.

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