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For more information, visit the SEEDS website (oardc.osu.edu/seeds) or email us at seeds@osu.edu.
SEEDS: The OARDC Research Enhancement Competitive Grants Program

As the research arm of The Ohio State University’s College of Food, Agricultural, and Environmental Sciences (CFAES), the Ohio Agricultural Research and Development Center (OARDC) employs nearly 650 scientists and staff members throughout the state. OARDC’s Wooster campus is the largest agbioscience research facility in the United States, and OARDC scientists work closely with researchers in Ohio State’s Colleges of Education and Human Ecology, Medicine, Public Health, Veterinary Medicine, Biological Sciences and Engineering.

At any given time, OARDC researchers are engaged in more than 400 research projects. These projects are centered around three signature areas:
• Advanced bioenergy and biobased products
• Environmental quality and sustainability
• Food security, production and human health

Addressing the differing challenges and vast opportunities of Ohio’s agbioscience industry is the ultimate goal of SEEDS: The OARDC Research Enhancement Competitive Grants Program. SEEDS encourages excellence in research by promoting exploration that is consistent with the mission and vision of the OARDC and by encouraging connections across disciplines, with industry and other external partners.

Established in 1996 and supported by an appropriation from the Ohio General Assembly to OARDC, SEEDS is unique among U.S. state-assisted universities. In fostering high-quality research among scientists supported by OARDC and CFAES, SEEDS enables those scientists to collect the preliminary data needed to give them a competitive edge in national programs. It also provides them with leverage to attract industry support. Due to the changing nature of economic and societal trends, the agriculture, food and green industries depend on innovators and researchers to generate new processes and products. Ohio’s largest industry increasingly links with other industries to take on common challenges and opportunities in key areas such as food production and security, energy and the environment, and health and wellness. OARDC’s SEEDS program is just one of the many ways in which Ohio State’s innovative research and development connect to industry and the community on a global scale.

The following pages will provide a quick glance at the SEEDS objectives and successes. Each faculty project completed in 2016 is included with a brief explanation of the problem being addressed, its importance and the impact of the results. You will also see a sampling of undergraduate and graduate projects, and a list of our industry partners.

For specific information regarding these projects, please contact the faculty members directly or contact SEEDS at seeds@osu.edu.

agbioscience: the integration of scientific disciplines to address critical needs of food security, safety and health; environmental sustainability; and biobased energy, fuel and products
Objectives

**Increase the competitiveness of scientists in extramural grant programs.**

- Total OARDC funds awarded: **$24,762,327**
- Extramural/Matching/Agency funds generated: **$145,583,880**
- Return on investment (1998-2016): **$5.87 : $1.00**

**Encourage partnerships with industry and other stakeholders.**

- Invested **$5.2 million** in projects requiring matching funds, generating **$8.9 million** in industry matches.

**Encourage international collaborations.**

- Teams from **10 colleges and 31 departments** were awarded **$8.5 million** in SEEDS funding and reported **$29 million** in extramural funding.

**Provide undergraduate students with research experience.**

- Funded **67** undergraduate student projects out of **107** submissions.

**Provide graduate students with the opportunity to take part in the grant-writing/review process.**

- Funded **303** graduate student projects out of **734** submissions.
2016 IN REVIEW

The 25 proposals completed in 2016 represent:
- $997,210 invested by OARDC
- $5,753,082 in extramural funds received
- $462,363 in matching funds from industry partners
  - 40 publications and 52 presentations
  - 7 graduate dissertations/theses
- 2 patent applications and 2 invention disclosures
  - A return on investment of $10.61

OTHER ACCOMPLISHMENTS

Published 979 peer-reviewed scientific manuscripts, abstracts, popular press articles, bulletins and/or book chapters.

Made more than 1,579 presentations throughout the world.

Secured a funding percentage of approximately 41 percent for faculty proposals.

Produced 74 doctoral dissertations and 115 master’s theses.

Obtained 9 patents, 20 invention disclosures, and 6 licensing agreements.
Advanced Bioenergy and Biobased Products

As the importance of renewable sources for energy and materials increases, research and industry partnerships come together in this signature area to develop biomass-based advanced energy technologies and value-added biobased products such as fuels, specialty chemicals and fiber products.
Isolation and characterization of industrial butanologenic strains of solventogenic Clostridium species

Thaddeus Ezeji, Animal Sciences*
Venkat Gopalan, Chemistry and Biochemistry

Owing to fast depletion of fossil fuels, concerted efforts are being taken to produce alternative renewable liquid biofuels whose characteristics resemble gasoline. Butanol is an ideal substitute because it is less corrosive, miscible with gasoline/diesel and comparable to gasoline in energy content. However, two major factors impede commercialization of fermentative butanol production: availability of substrates at a competitive price and butanol toxicity to microbial strains, which generate this solvent. In this regard, inexpensive substrates such as lignocellulosic biomass and municipal wastes have been proposed as viable alternatives to first-generation (corn/sugarcane) feedstocks. Ohio is endowed with vast biomass resources, and creating biofuels and chemicals from biomass can positively affect its economy. The goal of this project was to develop industrial hyper-butanol producing strains of solventogenic Clostridia that efficiently use a wide spectrum of substrates.

Prior published reports found that successful use of yeast alcohol dehydrogenase (ADH)-coupled colorimetric nitroblue tetrazolium (NBT) assays in 96-well plates to screen chemically-mutagenized C. acetobutylicum (Cac) cultures for overall alcohol production was not capable of identifying butanol producing mutants of C. beijerinckii, as the yeast-derived ADH was unable to discriminate butanol from ethanol. After cloning and characterizing ADH from four different microorganisms, OARDC and CFAES researchers successfully isolated an ADH that favors butanol over ethanol oxidation, an important advancement towards developing a high-throughput assay for screening hyper- or hypo-butanol production in C. beijerinckii mutant libraries.

A hyper-butanol producing C. beijerinckii strain with the ability to efficiently use lignocellulose-derived sugars (LDS) as substrates was also isolated. The isolated strain was determined to be tolerant to lignocellulose derived microbial inhibitory compounds (LDMICs), compounds known to impede and limit the use of LDS as fermentation feedstock. Tolerance to LDMICs significantly improved LDS utilization, bringing butanol fermentation using non-food feedstock closer to commercialization.

Identification of phenolic regulators in the grasses

Erich Grotewold, Horticulture and Crop Science / Molecular Genetics*

Phenolic compounds include polymers like lignin, but also flavonoids with nutritional properties, which also participate in the response of plants to pathogens and other stress conditions. Given the importance that gene regulation has on biological processes, OARDC and CFAES researchers are interested in understanding how maize phenolic compounds, including lignin, are controlled in maize.

This project intended to determine whether specific phenolic compounds in maize protoplasts were able to be activated or repressed. The researchers standardized the conditions to accurately follow the accumulation of 34 phenolic compounds (19 phenylpropanoids and 15 flavonoids) by liquid chromatography coupled with tandem mass spectrometry. This was applied to a set of transcription factors in two maize inbred lines to establish which metabolites change. A number of transcription factors that control phenolic biosynthesis genes were also identified.

The researchers are now in the process of identifying maize mutants (derived from transposon insertions) in these transcription factors. The knowledge gained will permit them to determine which specific metabolites should be assayed. Ultimately, the goal is to be able to manipulate the accumulation of these important compounds in the plant, leading to nutritionally superior maize and paving the way for future research on phenolic compounds.
Cryomalleable, biobased, polymeric materials and products
Katrina Cornish, Food, Agricultural and Biological Engineering*

In 2015, $1.7 billion worth of natural rubber was imported to the United States. Developing domestic alternatives to natural rubber is essential to increasing the economic security of the country. Additionally, developing niche product applications can attract higher prices and ultimately support the expansion of crop acreage and processing capacity.

Guayule, one rubber alternative being produced at the OARDC, possesses a unique property – it is malleable at extremely low temperatures. Because guayule retains flexibility below the materials’ apparent glass transition temperature, OARDC and CFAES researchers have addressed underlying causes by testing physical properties of components of guayule rubber and hevea rubber under a wide range of temperatures.

Findings show that guayule rubber is softer and more flexible than hevea rubber at -100 C, which may partially be due to the branching structures between the two rubbers. Guayule also had the greatest rubber memory, the ability to return to its original size following deformation. Purified rubbers behaved similarly at -100 C indicating that non-rubber compositional differences contribute to the cold temperature flexibility of guayule rubber.

Research on the manufacturing and testing of compression molded and extruded alternative rubber products continues, and these results will be applied to current rubber products. Successful creation of rubber alternatives that are flexible at low temperatures may generate valuable intellectual property and create high demand in both commercial and federal manufacturing sectors.

Oilseed crops and value chains
Casey Hoy, Entomology*

Biofuels produced from oilseed crops offer a promising alternative to fossil fuels. However, more research needs to be done on the capacity to grow sufficient quantities of oil-producing crops and their fit with Ohio agricultural production.

Small to mid-sized farms can incorporate oilseed crops to diversify crop rotations and produce their own fuel on-farm, an approach that is being promoted as a sustainability project by an industry partner. Growing oilseed crops can lower input costs for farmers while improving soil health and diversifying farm products. Four different oilseed crops – spring canola, flax, camelina and sunflowers – were planted in one-acre demonstration plots and monitored for growth characteristics, key ecosystem services and the nutritional content of the resulting oil and meal.

During the year of the study, growing conditions were poor, particularly due to heavy spring rains. Early spring planting for camelina and flax is recommended to reduce competition pressure from weeds, a strategy that was successful for camelina but less so for flax. The sunflower and camelina plots yielded the most seed and oil per acre, offering promise for spring plantings on Ohio farms, whereas canola and flax had lower yields. Sunflower and camelina oil also have potential culinary uses and the pressed meal has good potential as an animal feed additive. Additionally, sunflower and canola crops supported diverse populations of pollinating insects.

Results were shared firsthand with farmers and Ohio agricultural organizations during a field day, where oil was pressed in a mobile oil press. The results of this project will inform future projects focused on diversifying small and mid-sized farms, particularly with camelina and sunflower as options for diversified crop rotations.
Environmental Quality and Sustainability

Work in this signature area seeks to understand, protect and remediate the environment and ecosystems to ensure long-term sustainability. At the core of this effort is the realization that sustaining population and economic growth must be balanced with the preservation of natural resources and environmental assets.
Environmental impacts of shale oil exploration in Ohio and Pennsylvania: Capacity building and economic analysis
Sathya Gopalakrishnan, Agricultural, Environmental, and Development Economics*
H. Allen Klaiber, Agricultural, Environmental, and Development Economics
Brian Roe, Agricultural, Environmental, and Development Economics

Large reservoirs of previously inaccessible energy offered by underground shale deposits have the potential to fundamentally change the energy makeup and outlook for the global economy. The U.S Geological Survey estimates that Marcellus shale alone contains over 84 billion cubic feet of undiscovered natural gas resources. In Ohio, Pennsylvania, West Virginia and New York, development of the natural gas industry has rapidly progressed in the past decade. Although public benefits of large domestic reserves of energy are well understood, independent research documenting the likely effects of expanding shale gas exploration in Ohio is needed to inform both public policy and private decision-makers.

As the natural gas industry continues to move forward, understanding the potential impact on surrounding populations is a key component of creating effective policy. In this project, OARDC and CFAES researchers examined the economic and environmental impacts of shale development activity in eastern Ohio and Pennsylvania. Data was used to determine how consumers perceive the risks of natural gas drilling and how shale exploration has impacted land use and forest cover. The project supported one PhD student and two undergraduate students who assisted with the survey implementation.

The researchers assembled a unique dataset combining information on land use and land values with survey responses from 366 households in the Marcellus and Utica subsurface shale regions of eastern Ohio. The survey was used to determine risk preferences for shale drilling and its associated externalities. Examining both willingness to pay (WTP) and willingness to accept (WTA) measures, the researchers found that residents are willing to pay up to $42 to avoid risk from one additional shale well in northeastern Ohio.

Using geospatial land cover data and data on shale gas activity in Pennsylvania, researchers determined that every additional shale drilling site results in approximately 50 acres of forest cover loss, concluding that a more concentrated clustering of shale wells would result in a forest conservation gain of over 112,838 acres in Pennsylvania alone. These findings can serve as an important reference for policies seeking to minimize negative externalities resulting from shale gas exploration.
Tracking petroleum hydrocarbons in stormwater: Use of carbon isotopes to analyze the efficacy of bioretention systems
Jay Martin, Food, Agricultural and Biological Engineering*
James Bauer, Evolution, Ecology and Organismal Biology
Yu-Ping Chin, Earth Sciences

Rain gardens are increasingly used to reduce stormwater runoff and improve stormwater quality. While successfully employed in many aspects of stormwater management, researchers are still investigating how these systems reduce the total range of petroleum hydrocarbons typically found in stormwaters. Exceedingly high hydrocarbon (HC) concentrations from sources such as driveway dust and oils from parking lots exacerbate the need to find effective methods to remove these carcinogenic and mutagenic pollutants from stormwater before they accumulate in downstream water bodies.

OARDC and CFAES researchers were the first to use natural carbon isotopes to quantify how effectively bioretention systems reduce the total range of petroleum hydrocarbons found in stormwaters. Past studies of the effectiveness of water treatment technologies have been limited because conventional approaches and analytical methods of analysis for petroleum HCs only track selected compounds present in stormwater. Because of the ability to differentiate “new carbon” from contemporary sources and “fossil carbon” from petroleum HCs, the isotope method can identify the contributions of all petroleum derived HCs present in stormwater. This research is the first to assess whether a stormwater treatment technology — in this case rain gardens — can reduce total petroleum HCs as opposed to conventional analyses, which track proxy subsets of these harmful compounds.

Results indicate that rain gardens have the ability to remove HCs from stormwater, and that stable isotopes can successfully be used to track HCs in stormwater. The next steps are to compare performance of stable isotopes with two conventional methods to track HCs in stormwater, and thoroughly evaluate the treatment abilities of rain gardens.

Listening in on water quality: Using big data platforms to monitor online conversations about water issues in Ohio
Annie Specht, Agricultural Communication, Education, and Leadership*

Agriculture is one of Ohio’s largest industries, with one in seven Ohioans employed in food and fiber production, processing or sales. In the last several years, maintaining a safe water supply has become a pressing issue. In 2014, dangerous algal blooms in Lake Erie led to a two-day shut down of Toledo’s water supply. High levels of phosphorous and other fertilizers have appeared in waterways in towns and cities around the state. These incidents have made water quality a hot topic for political and public conversation, having major implications for agricultural and environmental policy.

Implementing a social media monitoring platform allowed OARDC and CFAES researchers to gather real-time data from individuals, organizations and media outlets, as well as to identify which users influence the tone and content of online conversation. This knowledge allows agricultural organizations to target messages to specific individuals or groups and to create messages that are relevant, credible and shareable; the ultimate goal being to improve the response to environmental issues in ways that benefit both the industry and its stakeholders.

Analysis of Twitter conversations about water quality in Ohio showed that people engaged in these conversations prefer to receive information from sources they think are credible, including meteorologists, TV and print news outlets, and political figures. They also do not necessarily associate water quality issues with agriculture unless news reports link the two. The researchers also discovered that people who are not affiliated with special-interest groups are less concerned about the causes of water-quality crises than they are with short-term solutions to problems such as finding clean water to drink.
Linking economics and hydrology: A coupled model of the physical processes and economic decisions that impact non-point source pollution and water quality in the upper Big Walnut Creek watershed
Sathya Gopalakrishnan, Agricultural, Environmental, and Development Economics*
Brent Sohngen, Agricultural, Environmental, and Development Economics

Understanding the multidirectional feedbacks between human behavior and natural systems is a complex process. Economic agents directly and indirectly impact the quality of water resources by making land management decisions — often with unintended consequences. Nutrient and pesticide runoff from agricultural lands affect water quality by accelerating the growth of algae, potentially leading to harmful algal blooms (HAB) that are a serious concern for policymakers, scientists and residents. OARDC and CFAES researchers developed a coupled model linking agricultural decisions and hydrological processes that determine the fate and transport of pollutants in the Upper Big Walnut Creek watershed (UBWC).

The team developed a hydrologic model for the UBWC watershed using a Soil and Water Assessment Tool (SWAT), which was then used to simulate management practices and nutrient loading outcomes in the watershed. The model was validated using USGS stream gauge for the periods of 2000-04 and 2005-09, and closely fit the data. Water quality indicators generated through the SWAT model were then linked with economic data on housing transactions to estimate the impact of water quality changes on surrounding housing values. Their research shows that the value of an average property located within 5 kilometers of the Hoover Reservoir decreased by about $3,000 for each additional gram of algae production per square meters per day.

Through this project, researchers have developed a dynamic model to examine the trade-offs between agricultural decisions and water quality, controlling for soil characteristics. Results suggest potential welfare gains of 3 to 5 percent from spatially targeted policies that optimally manage the level of fertilizer application across the watershed. This work provides policy insights for improving best management practices to balance agricultural productivity and lake-ecosystem services.

A new tool for the rapid identification of pest-resistant trees
Enrico Bonello, Plant Pathology*
Luis Rodriguez-Saona, Food Science and Technology
Daniel Herms, Entomology

Fungal pathogens that infect trees can lead to devastating forest losses if not controlled. It is essential to identify which trees are resistant and which are susceptible to these pathogens as a first step in managing the diseases using genetic resistance.

OARDC and CFAES researchers worked to develop Fourier Transform-InfraRed (FT-IR) spectrometric (chemometric) models for the discrimination of trees resistant and susceptible to fungal pathogens. In practice, the researchers proposed to develop technology for field-based, “near real-time” identification of resistant and susceptible trees, which could potentially be applied to many important pest systems. For this project, a system was developed for two important forest diseases: root rot of Port-Orford-cedars and white pine blister rust. The researchers also worked with collaborators from the Swedish University of Agricultural Sciences and five European countries to test the technology on European ash for resistance to ash dieback (ADB). ADB has spread rapidly and has caused substantial forest losses in northern Europe.

Preliminary results strongly indicate that FT-IR can discriminate between different phenotypes and predict resistance-associated traits in the progenies of sampled trees in these pathosystems. The results also suggest that this technique could be used in many other pathosystems, including tree crops, such as cacao, coffee or eucalyptus. The technique could also be developed to distinguish morphologically similar tree taxa, further contributing to genetic conservation efforts worldwide.
Microbial inoculants as sustainable solutions to reduce chemical usage and decrease postproduction shrink within the greenhouse industry

Michelle Jones, Horticulture and Crop Science*

The commercial greenhouse industry relies heavily on chemical pesticides and growth regulators to produce ornamental plants. Growing concerns about environmental contamination as well as worker and consumer safety have led to increased interest in the use of more sustainable bio-based products. Ohio State’s Microbial Bioproducts Scale-up and Applications (MBSA) team is working to reduce agricultural dependence on synthetic chemicals by increasing the use of microorganisms and their fermentation products.

The greenhouse industry grows hundreds of different plant species in small containers of soil-less media. The team has identified a number of bacteria that confer tolerance to pathogens (including nematodes) and enhance growth in agronomic crops (including soybean). For these beneficial bacteria to be useful within the greenhouse industry, they must be able to confer stress tolerance and enhance the growth of many different species of ornamental plants that are growing in a soil-less media. Growing conditions are optimized for plants during production, but plants often experience low water stress during shipping, while in retail stores or after planting in the consumer’s garden. Botrytis cinerea, or gray mold, is a common fungal pathogen of ornamental plants that can cause plant losses during production, shipping and retailing. Experiments were therefore focused on evaluating growth promotion, drought tolerance and Botrytis infection severity in four bedding plant species treated with beneficial bacteria.

Researchers observed some positive effects of the beneficial bacterial treatments on plant growth and stress tolerance. The team will continue to identify the needs of the commercial greenhouse industry with regards to the use of bioproducts, including those that contain microbes, and investigate the efficacy of additional microbial strands under different greenhouse conditions.
Food Security, Production, and Human Health

This signature area focuses on improving agricultural production; enhancing the quality of food and feed; ensuring an adequate, affordable and safe food supply; and maintaining agrosecurity to ensure food security and the basics of nutritional health for a growing global population.
The evolution of fungal resistance to plant defense compounds
Jason Slot, Plant Pathology
Ana Alonso, Molecular Genetics
Enrico Bonnello, Plant Pathology
Thomas Mitchell, Plant Pathology

Fungi are the primary agents of decay of plant biomass and are also responsible for many plant diseases that can cause devastating economic losses. For example, just two fungal pathogens of wheat are responsible for $8 billion in losses annually in the United States. Plant pathogenic fungi are limited by their ability to overcome plant defense chemicals, which are also the primary factor reducing the efficiency of fungal conversion of plant biomass to biofuel. However, little is known about the precise mechanisms that most fungi use to overcome these defenses. This project was aimed at characterizing a cluster of genes predicted to be used for degradation of chemicals known as stilbenes, which are plant defense chemicals and accumulate as inhibitors of conversion of lignocellulosic biomass for biofuel production. Understanding the processes and limitations of this degradation is important to breeding plants with durable resistance to fungi and the development of new tools for increasing efficiency of biofuel production from agricultural byproducts.

The researchers isolated and determined the functions of seven enzymes from multiple species of pathogenic and biomass converting fungi. These enzymes confirmed that stilbene degradation gene clusters with somewhat specialized function were discovered. Further, the researchers successfully generated mutant rice blast fungi that lack the first enzyme in stilbene degradation, and are currently testing these for reduction of virulence on rice.

Approximately 1,000 novel gene clusters for the degradation of plant defense compounds were discovered using a novel data analytics pipeline developed in this project. These results will greatly transform the global knowledge of fungal decomposition and pathogenesis.

Regulators of tomato fruit shape
Esther van der Knaap, Horticulture and Crop Science*

Consumers often purchase fresh produce based on its physical appearance, partly because the size and shape are indicative of the vegetable’s culinary purpose. The shape of the grape tomato is controlled by a mutation in a gene called OVATE, which also controls the shape of most Roma tomatoes. However, the shape of globe tomatoes is controlled by different genes. OARDC and CFAES researchers focused on the identification of genes that work together with OVATE to create an elongated tomato fruit. Insights could lead to niche markets for new varieties of tomato or to ensure that shape remains unaltered when developing new varieties with improved yield, taste and disease resistance qualities.

Using biochemical methods, the researchers discovered a group of proteins, called TRMs, that physically interact with OVATE. However, to investigate the importance of this physical interaction in creating an elongated tomato, the researchers first needed to confirm the interaction of the proteins with one another using a plant cell-based system. This was accomplished by using tobacco leaves which visualized the colocalization of the proteins in the cell. Then, researchers investigated the physical interaction by evaluating whether they were localized in the same subcellular compartment. Altered versions of the proteins were also expressed, which were expected to abolish this physical interaction. The altered proteins that could not interact with one another were no longer able to colocalize to the same subcellular compartment, demonstrating that the interacting motifs were indeed important in plant cells.

Because the physical interactions of the proteins have been confirmed, the researchers can continue to evaluate the interactions of OVATE and TRMs in tomato fruits to determine whether its shape can be altered if the physical interaction is abolished. These findings will shed light on the genes important for regulating the elongated shape of tomatoes and possibly other vegetables and fruits.
Low-fat, saturated and trans-fat cheese products, enriched with essential polyunsaturated fatty acid
Farnaz Maleky, Food Science and Technology*

Cheese is a good source of protein, nutrients such as vitamins A, B and D, and is also rich in minerals and calcium. However, cheese is also high in solid fats. Although the harmful effects of some saturated fats are in debate, numerous studies suggest minimizing the daily intake of saturated fat. In response to this issue, many cheese manufacturers introduced a number of low-fat natural and processed cheese products, some fortified with dietary fibers. These products are nutritionally enhanced, but have not been well-accepted by consumers. Successful production of low-fat cheese products necessitates searching for a suitable replacement of solid fats which compensates for the lost flavor and texture.

OARDC and CFAES researchers investigated the usage of oleogels in cheese manufacturing and assessed the possibility of milk solid fat replacement by gelling essential polyunsaturated oils. The goal of the study was to create nutritionally enhanced cheese with similar textural and sensory attributes to natural cheese. The study was the first to show the utilization of oleogels in dairy products to produce high-quality cheese with altered fatty acid compositions. This work also characterized different matrices of oleogel and developed new processes that can address major quality issues in low-fat food. The research demonstrated a successful replacement of the solid fat with gelled essential mono- and polyunsaturated fatty acids while maintaining the desirable sensorial quality and texture characteristics.

The discoveries of the incorporation of oleogels into skim milk has the potential to be expanded into other dairy-based food products. This may encourage the future development of various low-fat and saturated fat-free desserts, butter, yogurt and hard cheese products.

The researchers plan to obtain a better understanding of the mechanism of gels, structure formation and will evaluate the structure-functions relationship of this healthy fat substitute with other food components. This will open up the possibility of engineering the food grade oleogels and facilitating the formulation of new nutritionally enhanced food materials.

Functional studies on the role of Chrdl1 gene in adipose development by generating transgenic quail
Kichoon Lee, Animal Sciences* Michael Davis, Animal Sciences

Excessive fat accretion is not only a major health issue for the human population, but it also causes decreased feed efficiency in livestock, leading to inefficiency and economic losses in the food animal industry. Adipose-specific genes have important functions in the processes of adipocyte development and metabolism. Therefore, there is a critical need to develop strategies for efficiently screening new adipose-specific genes and to understand their functions in order to fill a void in our understanding of the mechanism of fat accretion in food animals and the causes of obesity. OARDC and CFAES researchers aim to develop transgenic quail overexpressing a novel adipose-specific gene (Chordin Like 1, CHRDL1) in adipose tissue and to investigate the effect of the transgene on adipose growth and development.

The researchers found that embryonic chicken adipose tissue develops by hyperplastic mechanisms followed by hypertrophy. In addition, cell cycle inhibitors gradually increase and activators decrease during adipose development.

Because the fundamental biology of adipocyte development is very similar across most vertebrates, especially from avian to humans, the positive impact of the project findings would be the potential establishment of a new transgenic quail model for future research focusing on linking a new novel gene to the etiology of obesity in humans and rates of fat accretion in food animals.
Developing transgenic grapes with enhanced frost protectant sugars for freezing tolerance
Imed Dami, Horticulture and Crop Science* 
John Finer, Horticulture and Crop Science

Grapes are a high-value cash crop that contributes more than half a billion dollars per year to Ohio’s economy. Grapes are integral to the Ohio wine industry, which has significantly expanded in recent years. However, the grape industry in Ohio is limited by climatic constraints, primarily, seasonal freezing temperatures. Freezing injury has caused millions of dollars in revenue losses in Ohio over the past 10 years. The goal of this research was to improve the freezing tolerance of the most popular, but cold sensitive, grape cultivars, which constitute the majority of the newly planted acreage in Ohio.

First, CFAES and OARDC researchers were successful in generating tissue culture embryos of popular cultivars like Cabernet Franc and Chambourcin. Second, a stack of genes (proprietary information) that produce Frost Protectant Sugars (FPS) were successfully introduced into Chambourcin, an economically important wine grape cultivar. The multi-disciplinary team on this project successfully produced transgenic grape plants with enhanced FPS using gene transformation. The FPS quantity and quality were confirmed and their accumulation increased multi-fold in transgenic tissue culture (callus) as compared to the wild-type control. The next step is to evaluate fully grown transgenic vines for increased freezing tolerance. Improved survival against freezing stress will not only improve the economic sustainability of grapes in Ohio, but will also expand grape acreage in otherwise climatically unfavorable regions.

Anti-inflammatory activities of green tea during obesity-induced nonalcoholic steatohepatitis
Richard Bruno, Human Sciences*

Nonalcoholic steatohepatitis (NASH) is the most prevalent liver disorder in the western world, where it affects approximately 20 percent of adults, including more than 70 million Americans. Its incidence is largely attributed to obesity, consistent with 53 to 74 percent of obese children and adults afflicted by this disorder. Although NASH was first identified in 1980, effective treatments have yet to be developed despite the growing recognition that inflammation provoking liver injury is a strong causative mechanism.

OARDC and CFAES researchers investigated the antioxidant, anti-inflammatory, and hypolipidemic activities of green tea extract (GTE) during the development of NASH. Findings from this project demonstrated that GTE supplementation in obese mice with NASH reduces inflammation under the regulation of nuclear factor kappa B (NFκB), a transcription factor that centrally controls pro-inflammatory responses. Collectively, hepatoprotective activities of GTE that prevent NFκB activation in NASH occurred consistent with a mechanism involving the gut-liver axis. Specifically, GTE ameliorated NASH by preventing the translocation of gut-derived endotoxin to the liver and lowered the expression of hepatic Toll-like receptor-4 (TLR4; receptor for endotoxin) to limit pro-inflammatory signaling otherwise induced by TLR4/NFκB activation. These novel and timely findings have positioned the researchers to successfully secure extramural funding from United States Department of Agriculture, National Institute of Food and Agriculture (USDA-NIFA) to better detail the anti-inflammatory mechanisms of GTE, and support the foundational basis to pursue translational studies in humans examining the benefits of green tea on liver health.
Effect of Citristim® supplementation on Salmonella clearance and immune parameters post-Salmonella challenge
Ramesh Selvaraj, Animal Sciences*
John Grimes, OSU Extension

Salmonellosis, a zoonotic disease caused by *Salmonella enterica*, has been estimated to cause 93.8 million infections globally each year, of which 80.3 million cases are food-borne, and result in 155,000 deaths. Because vaccines are not effective in clearing the persistence of *S. enterica* infections of chickens, the commercial poultry production industry attempts to control *S. enterica* infections by supplementing vaccination programs with several other procedures like probiotics or prebiotics. Further, these prebiotics are natural alternatives to dietary antibiotics in poultry production, and poultry producers will readily apply these solutions to decrease Salmonellosis in poultry.

The overall objective of this project is to decrease Salmonella colonization in broiler birds through supplementation of Citristim®, a yeast cell wall derived prebiotic. OARDC and CFAES researchers observed that feeding Citristim® decreased Salmonella colonization in the gut mucosa and increased anti-Salmonella IgG in the serum.

Though the Citristim® decreased Salmonella colonization, researchers observed that feeding Citristim® increased the total amount of Salmonella in the cecal content. This was an unexpected result and a follow-up experiment is currently underway to examine further.

Optimizing management of cucumber downy mildew with currently used fungicides and production methods
Sally Miller, Plant Pathology*

Widespread cucumber crop failures have occurred throughout the eastern half of the United States since 2004 due to a new aggressive form of the pathogen, *Pseudoperonospora cubensis*. The new strains of the downy mildew pathogen are resistant to many fungicides used in the past, and have overcome the genetic resistance of cucurbit cultivars. In Ohio, downy mildew distribution is erratic, and severe and early outbreaks occur in the northern part of the state, where most of Ohio’s processing cucumbers and a significant amount of fresh market cucumber and melon are produced.

Research has been focused on managing this disease with alternative fungicides, a costly but necessary approach. The project goal was to develop improved Integrated Pest Management approaches that are economically and environmentally appropriate. This experiment was established on the Ohio State’s OARDC Muck Crops Experiment Station in Huron County, using ‘Dasher II’ slicing cucumbers. The cucumbers were produced on the ground or trained on trellises. Cucumbers grown on trellises are less likely to be affected by soil-borne pathogens, increasing yield. Various fungicide combinations and two application frequencies (every seven or 10 days) were tested to determine the best treatment for downy mildew.

The results indicated that downy mildew can be controlled adequately with fewer fungicide applications than are commonly used by extending the application schedule from seven to 10 days. This approach will ultimately reduce expenditures by at least the cost of two fungicide applications per season. It is necessary to apply two fungicides, one of which is specifically targeted to downy mildew, to maximize disease control. However, growers may choose to tolerate a slightly increased level of disease on leaves (downy mildew does not affect the quality of fruit directly) and adopt a simpler application scheme – one broad spectrum fungicide applied on a longer schedule – to reduce costs.
Field trials on nanoparticle-based inactivated porcine reproductive and respiratory syndrome (PRRS) virus vaccine in growing pigs

Renukaradhya Gourapura, Food Animal Health Research*

Porcine reproductive and respiratory syndrome (PRRS) is an economically devastating swine disease, endemic in the United States and in most pork producing countries. PRRS is caused by PRRS virus (PPRSV), which infects pigs of all ages. In growing pigs, the virus causes respiratory disease resulting in reduced growth rate and sometimes death. In infected sows, it causes abortion, stillbirths, mummified fetus, and weak-born piglets.

PRRSV shows extensive genetic variation and causes periodic severe disease outbreaks. The widely used modified live PRRSV vaccine (PRRS-MLV) has not fully met expectations because it does not completely prevent infection, and it may revert to virulent virus under farm conditions, posing a safety concern. The only available strategy to better control PRRS outbreaks is by developing a potent killed PRRSV vaccine using an innovative vaccine development approach. OARDC and CFAES researchers evaluated the cross-protective efficacy and potency of biodegradable nanoparticle-based PRRS virus vaccine co-administered with a cost-effective adjuvant Mycobacteria derived whole cell lysate of *M. smegmatis* has the potential to elicit cross-protective immunity in pigs under field conditions.

Identification of an attenuated PEDV variant and examination of its immunogenicity in pigs

Qiuhong Wang, Food Animal Health Research*

Highly virulent porcine epidemic diarrhea virus (PEDV) was first detected in U.S. swine in April 2013. Since then, it has caused major economic losses. The most effective vaccines for enteric infections by RNA viruses are live attenuated vaccines. However, no such vaccine exists to defend against the emerging U.S. PEDV strains. This project aimed to identify attenuated PEDV strains that can be used for the development of live attenuated vaccines in the future.

OARDC and CFAES researchers isolated three genetically varied PEDV strains: the reportedly milder S INDEL strain Iowa106; a unique strain PC177 having a large (197 amino acid) deletion in the spike protein; and the original U.S. highly virulent strain PC22A at different high cell culture passage levels. The researchers grew the virus until it infected the cells, put a small amount in new cells and repeated.

It was determined that the PC22A-P120 variant is the best candidate for a vaccine because it did not cause severe disease or death in neonatal piglets and induced the highest protection rate. In addition, genomic sequence analysis revealed genetic differences that may contribute to viral attenuation. The researchers plan to investigate the molecular attenuation mechanisms by using reverse genetics technology. The knowledge obtained will advance the development of safe attenuated PEDV vaccines to prevent deadly PEDV outbreaks, and will aid in innovative vaccine design against other fatal animal and human coronavirus diseases.
Understanding the role of peppers (Capsicum annuum) in the epidemiology of bacterial canker of tomato
Sally Miller, Plant Pathology*

Bacterial canker is a very serious disease of tomatoes in the field and in production greenhouses. It is a systemic disease that moves in the water-conducting system of tomato plants, eventually causing plants to wilt and die. Because the pathogen can move up and down the plant from the point of introduction, it moves easily from plant to plant via workers or contaminated tools used for pruning and harvesting. The pathogen is also seed-borne, providing a means for long-distance spread from seed production areas to crop production areas worldwide. Bacterial canker has been observed in peppers occasionally, but the disease is not severe in this crop. There have been some conflicting reports of the identity of the pathogen causing the disease in peppers, as well as the extent of the disease.

OARDC and CFAES researchers aimed to understand bacterial canker development in peppers and how pepper canker influences outbreaks of canker in tomato. Specifically, one of the main goals was to compare the genotypic and phenotypic characteristics of Clavibacter michiganensis subsp. michiganensis (Cmm) strains isolated from pepper with those of Cmm tomato strains. In addition, the extent of systemic movement of Cmm in the vascular system of peppers, transmission to pepper seed and Cmm survival on pepper leaves in the absence of symptoms was determined.

Results demonstrated that peppers, while not seriously affected by Cmm, can serve as a rich source of inoculum for this pathogen. Tomato seed producers should be aware of the risk that they pose, especially because Cmm can survive for long periods of time on pepper leaves in the absence of symptoms. Tomato seed production should be isolated from pepper production areas to reduce the risk of accidental transmission of the pathogen from peppers to tomatoes.

In the future, it will be important to build on this study to identify other sources of Cmm that may pose a risk for tomatoes, particularly during seed production. This will include determining if Cmm can be transmitted from plant to plant via pollen or dried, infected plant material (dust). Additional experiments to determine how pepper seeds are contaminated with Cmm during seed production and harvesting will be conducted.
Student Projects

The Director’s Undergraduate Research Competitive Grants program, funded to a maximum of $3,300 per award, provides undergraduate students with a professional grant-writing, research and reporting experience. Projects are designed, submitted for review and carried out with a faculty mentor.

The Graduate Research Competitive Grants program offers two levels of funding. Single investigators may receive up to $5,000 per award, and team projects up to $10,000. Graduate students who receive awards are asked to serve on a panel to review applications in the following year’s competition. This experience provides students with an opportunity to develop their grant-writing and reviewing skills, which are essential to their careers.

Tiffany Atkinson
MaLisa Spring
Matthew Teegarden
Chidozie Agu
The relationship between turbidity and carotenoid-based coloration in Centrarchid fish (UNDERGRADUATE)
Tiffany Atkinson, Environmental Science
Suzanne Gray, School of Environment and Natural Resources (Advisor)

Agricultural and urbanization practices cause runoff of nutrients and sediments into aquatic systems, leading to elevated turbidity levels (the amount of suspended particles in the water) and loss of aquatic biodiversity. Increased turbidity can alter visual environments by scattering and absorbing underwater light. Therefore, in fish that use visual cues to find mates, the effectiveness of visual signals can be compromised by turbidity and interfere with mating systems leading to hybridization. Carotenoid-based (red and yellow) color patterns have been found to play a large role in mate selection, but they are energetically costly for fish to acquire from their diet. If signals are interrupted by increased turbidity, then the cost of obtaining and displaying red and yellow colors may not be profitable.

OARDC and CFAES researchers tested for a relationship between increased turbidity and carotenoid-based coloration in several centrarchid fish from degraded urban streams found in Ohio. Total body red and yellow coloration was evaluated using a standard photographic technique for bluegill, green sunfish and their hybrids. The researchers found that total red and yellow coloration of bluegill was influenced by season in clear sites, but did not find this relationship in high turbidity sites.

These results could be problematic for aquatic ecosystems, which are becoming increasingly turbid worldwide. Researchers found that turbid conditions influence carotenoid display in bluegill, which could affect mate selection. Additionally, because centrarchid fish have been found to prefer more saturated carotenoid displays, findings that hybrid fish display more coloration than bluegill and green sunfish could mean selection on these traits could lead to increased hybridization, especially in turbid conditions.

Do urban greenscape management practices impact pollinator efficiency and community structure? (MASTER’S)
MaLisa Spring, Entomology
Mary Gardiner, Entomology (Advisor)

In Cleveland, Ohio, several decades of economic decline have led to a dramatic increase in vacant land. With this influx of new greenspace comes the question of the best urban land management strategy for the local community that is both economically feasible and beneficial to the environment. Thus, research into the best greenspace management practice in terms of floral cover and mowing schedule is warranted. Specifically, the impact of urban design on pollinator communities is a factor of increasing importance in light of worldwide pollinator decline. OARDC and CFAES researchers compared five lawn treatment types to determine which is the most beneficial to pollinators.

The researchers found plants that are often considered urban “weedy” species actually support a wide diversity of bees. Chicory, Queen Anne’s lace, narrow leaf plantain, and red clover are all extremely important for both the number of bee species present and the overall abundance of the bees found in the sites. Over 72 families of arthropods and 71 species of bees were identified during this survey, vastly improving the understanding of urban insect diversity. Interestingly, the researchers found several uncommon species of bees that have been disappearing across the U.S. Moreover, the researchers report the first spread of two new invasive bee species to Ohio (Hylaues pictipes and Pseudoanthidium nanum). This is the earliest known record of H. pictipes in North America, an extremely new invader.

With the knowledge of the most beneficial management strategy, researchers hope to make recommendations to the city of Cleveland. These findings can also be applied to other urban regions grappling with how to best support both their citizens and their pollinators.
Targeted and untargeted metabolomics analyses of fresh and thermally processed black raspberries (DOCTORAL)
Matthew Teegarden, Food Science and Technology
Steven Schwartz, Food Science and Technology (Advisor)

More than 65,000 new cases of oral and esophageal cancers will be diagnosed in 2017. Black raspberries have been extensively researched for their cancer prevention properties in both animal models and human clinical trials. Most research on the health benefits of black raspberries has used minimally processed, freeze-dried black raspberry powder, yet consumers typically consume these berries in products such as jams and syrups. Due to the high temperature associated with the manufacture of these products, the chemical profile of the fruit is likely to change, which may affect its cancer prevention properties. Recently, a large clinical trial began at Ohio State to investigate how a black raspberry nectar drink may impact oral health. While this product is heat treated to allow long-term storage and ensure safety for clinical trial participants, a better understanding of how the manufacturing process influences the chemical profile of the drink is needed.

Metabolomics is an emerging, comparative technique for chemical analysis that aims to provide a broad chemical profile of a sample. This technique was used to acquire global chemical profiles of freeze-dried black raspberry powder and black raspberry nectar after heat treatment. Clear differences were noted between the nectar and freeze-dried black raspberry powder. It was found that 185 compounds were common between the groups, with most compounds having higher concentration in the nectar.

This research demonstrated differences between the global chemical profiles of freeze-dried black raspberry powder and nectar made from the same powder. This information will inform the interpretation of results from the clinical trial currently employing this product as well as the development of future black raspberry food products. Future research will focus on the effects of storage conditions on the chemical profile of this product, in the broader context of its in vitro bioactivity.

Metabolic engineering to enhance furfural tolerance during cellulosic butanol fermentation by glycerol-supplemented Clostridium beijerinckii (DOCTORAL)
Chidozie Agu, Animal Sciences
Thaddeus Ezeji, Animal Sciences (Advisor)

Due to the risk of depleting oil reserves and environmental concerns, concerted efforts are being made to produce alternative renewable liquid fuels and chemicals whose characteristics resemble gasoline and petroleum-derived chemicals. Despite extensive research efforts spent on the development of renewable fuels and chemicals, they continue to rank poorly in terms of production cost and sustainability. Amongst the major factors impeding commercialization of renewable liquid fuels and chemicals, substrate cost is the most significant. Therefore, inexpensive substrates such as lignocellulosic biomass (LB) and industrial wastes, e.g., biodiesel-derived glycerol, have been proposed as viable alternatives to first-generation (corn/sugarcane) feedstocks.

Unfortunately, the process for converting LB to fermentable sugars also generates lignocellulose-derived microbial inhibitory compounds (LDMICs). To lessen the inhibitory effects of LDMICs on fermenting microorganisms (Clostridium beijerinckii), OARDC and CFAES researchers developed a two-pronged innovative process that involved biological detoxification of acid pretreated LB (Miscanthus giganteus [MG]) prior to fermentation and co-utilization of biodiesel-derived glycerol and MG hydrolysates (MGH). This study represents a significant step towards consolidated bioprocess for bioconversion of LB and biodiesel-derived glycerol to butanol by C. beijerinckii.

Ohio is endowed with vast LB resources. Likewise, 6.7 million gallons of crude glycerol is available in Ohio annually as a potential fermentation feedstock for producing new specialty products and biofuels. Therefore, creating biofuels and chemicals from these non-food feedstocks can positively affect the economic landscape of Ohio.
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Industry Partners

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