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The Leaflet is a publication for partners, friends and supporters of the Donald Danforth Plant Science Center.
The Impact of Collaboration and Technology on Research and Commercialization

Jim Carrington: What drew you to the Danforth Center?

Todd Mockler: The Center’s goals to improve agriculture with advancements in genomics and computational biology were aligned with my research at Oregon State University (OSU). Upon visiting, I quickly realized that access to state-of-the-art technology would rapidly advance our work to understand the genomic underpinnings of plants and their response to environmental stress. Even now, I am still awe of this incredible facility. Meeting Dr. Danforth whom I deeply respect was very motivating. His impressive background is well known, but his commitment to plant science and the Danforth Center will be one of his major legacies to the region and the world.

JC: At OSU your focus was genomics and stress response, when you moved to St. Louis what did you think you could do better or differently?

TM: I did not anticipate any big changes in genomics, because sequencing was becoming so commoditized. However, in one of the Department of Energy (DOE) grants that I received while at OSU, I had proposed using high-throughput phenotyping to measure stress response. I planned on doing it with homemade camera set-ups in growth chambers. Here, I had access to the Bellwether Phenotyping Plant Facility which we quickly incorporated into the project. The technology provided the platform to quantitatively gain a greater understanding of the genomic underpinnings of stress responses like drought, cold and heat, which was monumental.

JC: What are the benefits of these discoveries, say, to develop more water efficient agriculture?

TM: We can learn things faster and have more statistical power which has advantages. We are trying to use these tools to dissect the genomic responses of plants. A good example is genomic underpinnings of stress responses like drought, cold and heat, which was monumental.

JC: Why sorghum?

TM: I always wanted to work on a crop even as a grad student, but I recognized that working with a crop is much harder than a model system for a lot of reasons. Several years ago, I was invited to be a moderator at an international sorghum meeting serving as a genomics expert, even though I knew nothing about the crop. After the meeting, I ended up contributing to a project funded by DOE, the vision is for sorghum to become a premier U.S. bioenergy crop, akin to sugarcane in Brazil. Also, to grow sorghum where there is a lot of land available, primarily in the southeast and from the gulf coast through Texas. In the developing world it is absolutely a staple to diets.

JC: Can that knowledge help improve grain sorghum to benefit small holder farmers in the developing world?

TM: Absolutely! All of the technologies we are developing are directly applicable to grain sorghum and corn, that’s what’s so exciting about it; being able to translate what we develop to other important food crops. In the future, I hope my lab can pursue that aspect.

JC: Any notable highlights outside of the lab since moving to St. Louis?

TM: I had the opportunity to throw the first pitch at a St. Louis Cardinals game thanks to the Center’s coordination of Bioscience Day at the Ballpark. Going behind the scenes at the stadium was incredible and to this day, one of the coolest things I’ve ever done.

JC: You are the Robert and Geraldine Virgil Distinguished Investigator. How would you describe your experience with Bob and Gerry?

TM: I have enormous respect for their incredible support of the Danforth Center. They are an impressive couple, and I had the pleasure of meeting their children. I see why the Virgil family is highly regarded for their many achievements and contributions to this community.

JC: The Danforth Center is growing, what are your expectations for the expansion?

TM: I’m really excited! That’s another thing, you look at a lot of places, in the scientific world and they are contracting, and we are in the midst of a phenomenal expansion, that’s a testament to the formula, and what’s happening here – quality science.

JC: You co-founded Benson Hill Biosystems with Tom Brunelle, Ph.D., Director of the Enterprise Institute for Renewable Fuels and Matt Crisp in 2012. How did that come about?

TM: When I was still at OSU and Tom was at Cornell we met periodically at scientific meetings and had talked about doing something in the ag-biotech space. Of course that is kind of hard to do when you are working 3,000 miles apart. A couple years passed, and we found ourselves all under the same roof and began to revisit the idea.

Tom connected with Matt at a photosynthesis meeting. We were fortunate to be aligned with someone in business, in fact, he already had taken steps to start a company, but he didn’t have the science team.

We immediately started fundraising. Within a few months we raised 5.5M in seed money. This key step was a direct result of our association with the Center, because we were introduced to a major supporter who became our angel investor.

Benson Hill has grown from an idea with three co-founders to a company with 10 employees and about $20 million in funding. The scientific team is located at the Helix Center Biotech Incubator but 8 to 10 employees spend the majority of their time here, either in our greenhouses or the tissue culture lab. Because Benson Hill can rent our facilities and computational services as many companies do, we are able to be very efficient with capital.

JC: You also have a role in NewLeaf Symbiotics, a startup located at BRDG Park. How did that come about?

TM: When we moved Intuitive Genomics, the company you and I co-founded in Oregon, to BRDG Park, one of our customers was NewLeaf Symbiotics, an agtech company that seeks to use natural occurring microbes in and around plants to increase productivity. As we were advising them on genomics and bioinformatics, we realized that their technology had tremendous potential. In order to do it justice they needed more than just a service provider, so we proposed that they consider acquiring the company. Since then, Intuitive Genomics has effectively become the genomics and bioinformatics department of their company.

JC: What’s next?

TM: I am living my dream, doing science at a top institution with great colleagues and starting and building companies. This keeps me very busy but I am already thinking about a company around sorghum, but it’s highly speculative at this point.

- Jim Carrington, Ph.D. is President and Todd Mockler, Ph.D. is Associate Member of Donald Danforth Plant Science Center

Department of Energy Taps Big Data Research to Advance Development of Sorghum for Bioenergy

The U.S. Department of Energy (DOE) ARPA-E is investing major resources to develop sorghum as a source of bioenergy for transportation through a new program, Transportation Energy Resources from Renewable Agriculture. To advance this work, DOE awarded the Danforth Center a five year, $8 million grant for research to accelerate breeding and the commercial release of economically viable bioenergy sorghum hybrids. Todd Mockler, Ph.D., Geraldine and Robert Virgil Distinguished Investigator at the Danforth Center, is the principal investigator of this multi-institutional project.

Identified by the U.S. Department of Agriculture as a key crop and grown worldwide, sorghum is a drought and heat tolerant member of the grass family. Sorghum’s adaptability to diverse environments, low fertilizer requirements, high biomass potential and compatibility with row crop production positions it to become a premier bioenergy crop in the U.S.

Precision phenotyping will be conducted in the Center’s Bellwether Foundation Plant Phenotyping Facility for this project. Information gained from the combined controlled-environment and field phenotyping systems will be used to accelerate crop improvements.

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This issue of the Leaflet is dedicated to highlighting the St. Louis ag innovation ecosystem. By bringing together top scientists from across the globe, technology and facilities that enable great science, a research park to foster innovation, and a workforce training program, the Center continues to help grow the region’s plant science innovation hub.
GIRL SCOUTS GROW THROUGH PARTNERSHIP AND SCIENTIFIC EXPLORATION

“I learned how to extract DNA from a strawberry with shampoo!” exclaimed Girl Scout Haley Huntley, a junior at Eureka High School who is very interested in biofuels and environmental science.

Haley is one of more than 60 Girl Scouts, grades 2-12, who in June, participated in the Girl Scouts STEAM (Science, Technology, Engineering, Arts and Math) Ahead program, a collaboration between the Girl Scouts of Eastern Missouri, the Danforth Center and the Center for Plant and Life Sciences at St. Louis Community College at BRDG Park.

Why do plants get sick, how do they grow, and who ate the cookies?

To answer these and other questions, through creative hands-on activities, the girls used beakers, microscopes, spectrometers, art supplies and Raspberry Pi computers to explore biodiversity, leaf structure, photosynthesis, DNA replication, extraction and modeling. They conducted experiments, created works of art, and captured images of plant growth, which they used to make a short movie of plants in action.

Using their new scientific skills in CSI-style, the girls were even able to identify which suspect stole and ate their Girl Scout cookies!

Shayla Jones, an eighth-grader at Central Middle School in Ferguson, said she didn’t like science before attending the program. “When I’m in class, science is boring, but being here I’ve learned it can be fun.”

“One day, these young girls will credit their experiences in this program as the catalyst for their love of science. We are so thankful for community partners like the Danforth Center for dedicating their time and efforts to the next generation of scientists,” said Bonnie Barczykowski, Girl Scouts CEO.

DANFORTH CENTER AND MISSOURI BOTANICAL GARDEN HOST THE FIRST JOINT FALL SYMPOSIUM

For the first time, the Danforth Center and Missouri Botanical Garden partnered to host the annual Fall Symposium, From Darwin to Borlaug: Biocomplexity in Natural and Agricultural Systems. The three-day event welcomed nearly 300 attendees for discussions, panels and poster sessions around the topic.

“It was very exciting to offer a symposium involving two of St. Louis’ leading plant biology institutions,” said Elizabeth Kellogg, Ph.D., member, Danforth Center. “The boundaries between basic and applied research are becoming ever more permeable.”

Research aimed at finding solutions to global agricultural challenges was addressed in presentations on a variety of adaptive strategies in plants; from the implications of Darwinian evolution – plant evolution, domestication and natural selection – to Norman Borlaug – who applied advanced breeding and genetic diversity to improve yield and disease resistance in crops.

“Ultimately, domesticated crops originated from natural variation found within the world’s abundant diversity of plant species,” said Dan Chitwood, Ph.D., assistant member, Danforth Center. “Just as knowledge of plant biodiversity led to the agricultural revolution thousands of years ago, evolutionary and ecological insights into the complexity of biological systems will inform the design of the next generation of crops and our efforts to feed the world sustainably.”

In addition to the scientific talks, participants toured the core facilities at the Danforth Center and the Missouri Botanical Garden campus. Poster sessions were held at both venues highlighting research projects to explore plant responses to salt, drought, cold, insect attack and ozone pollution.

“Conserving and sustainably using biodiversity is critical to the world’s food security, especially as we struggle to address the growing impacts of climate change,” said Peter Hoch, curator and director of the graduate program, Missouri Botanical Garden. “The team effort to host this first joint symposium was a wonderful way to enhance this collaboration.”

FROM DARWIN TO BORLAUG

EARLY AGRICULTURE

Domestication: Humans cultivate over 300 species of plants, but only three, wheat, rice, and millet, provide 60% of our calories.

Plant Evolution: Evolution has produced about 400,000 hard pliars, around 7,000 of which are edible.

Natural Selection: Through natural selection, wild plants have selected against diseases, insects, and pests.

Improved Solutions

Breeding: Breeders take wild relatives of crops to develop improved varieties.

Genetic Diversity: Plants with genetic diversity can more readily adapt to changing environments.

Agricultural Challenges

Drought: By 2050, 3/7 of the world’s population will be living in water-stressed conditions.

Salt Tolerance: 2,000 hectares of land are lost each day to salinity.

Cold Tolerance: Many major crops cannot tolerate freezing, frost affects growth and yield.

Heavy Metals: Contaminants cause major crop loss and hazards to human health.

Biocomplexity in Natural & Agricultural Systems
A crowd of more than 350 guests from 21 different countries attended the seventh annual Ag Innovation Showcase, September 14 – 16. The three-day event jointly presented by the Danforth Plant Science Center, Bio Research & Development Growth (BRDG) Park and the Larta Institute has become the signature event for “who’s who” in worldwide agriculture.

“Few forums exist where tech companies can rub elbows with investors and strategists and find both business partners and investors,” said Ag Innovation Showcase advisory committee member and closing keynote speaker Jim Budzynski, founder and managing principal, MacraeGain Partners. Panel discussions, keynote speeches and the highly anticipated company presentations rounded out the agenda. The competition to present was fierce. 19 companies were chosen from over 150 submissions to pitch their groundbreaking business concepts to some of the brightest minds in the industry.

Three St. Louis companies specializing in biological solutions and renewables were selected to make their pitch – Forrest Innovations Ltd, a new BRDG tenant working on stalling the effects of the Citrus Greening disease and mosquito diseases; Apea, a technology company working with RNA/RNAi; and GlucanBio, a company working with biomass conversion to create alternatives to petroleum-based chemicals.

In addition, four women-owned startups whose innovations are breaking new ground in renewables and sustainable were spotlighted. “This is the most women-owned enterprises we have had in our seven year history,” said Sam Fiorello, chief operating officer, Danforth Center and President, BRDG Park. “I hope the trend continues.” One of them, Amelia Swan Baxter, president and CEO of WholeTrees Architecture & Structure, a company that has internationally re-branded round timber for urban and commercial environments in place of steel, was chosen to receive the “Best in Show” award.

Since year one, four out of five presenting companies have found new investor leads and 97 percent of presenters were introduced to new partnership opportunities after taking the stage.

EXPANDED INNOVATION HUB TO CREATE OPPORTUNITY FOR FUTURE GROWTH

St. Louis continues to advance as the world center for plant science research and commercialization. The U.S. Department of Commerce recently awarded the St. Louis Economic Development Partnership a $500,000 grant to develop a comprehensive master plan for an expanded innovation hub in Creve Coeur that will increase opportunities for economic growth and globalization in bioscience research and commercialization, support entrepreneurship and collaborative innovation, create jobs at a range of levels, increase opportunities for investors in the region and accelerate product time to market.

The master plan will take approximately one year to develop and will include strategies for creating a thriving research community integrated into its surroundings, including a design framework, an economic impact study and traffic, pedestrian, biking circulation and sustainability strategies.

ISRAELI STARTUPS ATTRACTED TO LOCAL INNOVATION ECOSYSTEM

Widely regarded as second only to Silicon Valley as a source of new technology companies, Israel has emerged as an important innovator in a wide array of 21st-century industries, earning it the nickname “Startup Nation.” Recognizing a strong potential connection between the country and the St. Louis region’s innovation ecosystem, in the fall of 2014 BioSTL launched the St. Louis-Israel Innovative Connection (SLIIC) to identify potential candidates for relocation.

“Our goal is to identify specific Israeli companies that match St. Louis’ particular strengths,” said Donn Rubin, CEO and president of BioSTL. “That could be agriculture technology, medical, healthcare, financial technology and cybersecurity.”

The effort resulted in success almost immediately. The SLIIC delegation travelled to Israel last year to visit 19 thriving startups and initiated talks about technology adaptation, serving as a beta site and research collaboration. As a result of these talks, Kailma Bio-Agritech, an Israel-based plant genetics and breeding technology company, announced in November of 2014 it would establish its U.S. headquarters in St. Louis.

“St. Louis’ vibrant and collaborative entrepreneurial community impressed us,” said Kailma’s CEO, Dr. Doron Gal.

Two months after Kailma’s announcement, Evogene, a plant genetics company located in Rehovot, Israel, announced plans to invest $10 million to establish a research and development facility in St. Louis at the Bio Research & Development Growth (BRDG) Park.

“Our choice to locate at BRDG Park on the Danforth Center campus, a world leader in plant science research, is one we are very proud of as we join this innovative community,” said Ofir Haviv, president and CEO, Evogene. “We share the Danforth Center’s belief that plants hold the key to discoveries and products that will enrich and restore both the environment and the lives of people around the globe.”

Building on the momentum, a delegation from St. Louis, including representatives from BioSTL, the Danforth Center, KWS, Monsanto, Missouri Partnership and St. Louis Regional Chamber attended the AgriWest Conference on April 15 in Tel Aviv, Israel, to make the case for the St. Louis region as a preferred relocation site. Nearly 300 attendees along with the most promising and innovative Israeli agritech startups pitched their technologies and networked with venture capitalists and industry leaders. Sam Fiorello, CEO of the Danforth Center and president of BRDG Park, gave a talk during the program and sat on an expert panel discussing tomorrow’s agriculture solutions. During the conference, the delegation identified a variety of potential companies poised to benefit from access to markets, capital, networks and corporate partnerships in the U.S.

In June of 2015, SLIIC announced that Israeli agritech company Forrest Innovations selected St. Louis as the location for its U.S. headquarters. The company’s decision represents the third success in seven months for the initiative. “St. Louis is renowned for its leadership in plant science and top-notch scientific personnel, offering us a wonderful opportunity for recruiting highly qualified employees,” stated Nitzan Paldi, CEO of Forrest Innovations. “St. Louis also provides a great platform for promoting innovation and collaboration. We are very happy to become the latest members of this promising community.”

The initiative also has the backing of the Missouri Department of Economic Development. “Whether startup or international bioscience corporation, Missouri’s talented workforce, research institutions and supportive business community provides an environment that fosters growth and allows them to commercialize their innovations and create next generation jobs,” said Mike Downing, director of the agency.
THE COMPLEX SOCIAL LIFE OF BEES

The honeybee may be small, but it plays an enormously important role in agricultural production. In fact, pollination by honeybees makes possible approximately one out of every three bites we eat.

On August 28th nearly 300 guests attended the most recent installment of the Conversations series at the Danforth Center to learn more about the complex social life of bees. Gene E. Robinson, Ph.D., director of both the Carl R. Woese Institute for Genomic Biology and the Bee Research Facility at the University of Illinois, Urbana-Champaign, was the featured panelist for the event.

“BEES AND PLANTS HAVE CO-EVOLVED TOGETHER FOR YEARS,” SAID ROBINSON. “THESE EFFICIENT POLLINATORS DO THE WORK FOR US AND HAVE GIVEN US WONDERFUL DIVERSITY IN WHAT WE EAT. WE MUST APPRECIATE THE SPECIAL ROLE THEY PLAY IN OUR Ecosystem.”

During peak season, approximately 40,000 bees inhabit each honeybee colony, where they work together extremely efficiently to produce honey and use complex signals to communicate important information to one another, including the location of food sources. “Bees are a perfect, intricate model to study the social behavior and biodiversity of life,” said Robinson. “They are paradigms to understanding agriculture and health.”

In 2006, the dramatic decline in the honeybee population created a media buzz throughout the world. Although the drop in colony numbers, labeled Colony Collapse Disorder (CCD) by apiary experts, is partly attributable to the vicious Varroa Mite, other causes are likely involved as well. "CCD is a serious problem," said Robinson. "There is no one single factor that causes the disorder, but rather, it is caused by a combination of parasites, pesticides and poor nutrition."

"Bee health and their ability to thrive is essential not only to their survival, but to ours," said James Carrington, Ph.D., president of the Danforth Center, who served as moderator for the event.

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“Bee health and their ability to thrive is essential not only to their survival, but to ours,” said James Carrington, Ph.D., president of the Danforth Center, who served as moderator for the program. “Without bee pollination, almonds, peaches, oranges, sunflowers, blueberries, squash and scores of other crops would see a significant decline.”

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