DONALD DANFORTH
PLANT SCIENCE CENTER

## OUR MISSION

Improve the Human Condition
through Plant Science

# 2017 ANNUAL REPORT

Feed the hungry and improve human health

Preserve and renew the environment

Enhance the St. Louis region as a world center for plant science

**WITH THE BIRTH OF AGRICULTURE, HUMAN BEINGS FLOURISHED.**

Today, the intimate balance between people, planet and plants is threatened.

We must find a way to make sure we have enough food and energy for people while preserving a livable, sustainable environment now and for the future.

At the Donald Danforth Plant Science Center we work to harness the power of plants to make this balance possible.

Today, as this challenge grows more critical, our work grows more urgent.

## TABLE OF CONTENTS


| | |
|---|---|
| INVESTING TO ACCELERATE DISCOVERY | 2 |
| GROWING THE NEXT GENERATION OF SCIENTISTS | 6 |
| SCIENTIFIC DISCOVERY AND ACHIEVEMENT | 10 |
| BUILDING A STRONGER INNOVATION ECOSYSTEM | 20 |
| COMMUNITY ENGAGEMENT AND CONTRIBUTIONS | 26 |
| SELECTED FINANCIAL DATA | 40 |


## LETTER FROM THE CHAIRMAN

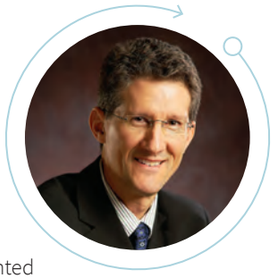
There's been a resounding theme around the halls of the Danforth Plant Science Center this year. It's been a year truly brimming with "big ideas." Many of the ideas that literally altered the course of human history started out as tiny seeds of thought – seeds that when nurtured and given the room to grow, did just that. Whether we're giving voice to scientist trainees who are imagining world-changing ideas such as using mathematics to "interpret" the language of plants so that precise recommendations can be made to increase farmers' harvests; or, envisioning technology that creates an instantaneous social community of farmers, plant scientists and agricultural specialists from around the entire world – big ideas grow here every day.

The mission of the Center is to improve the human condition through plant science. It is a simple statement that articulates an extremely challenging and worthy goal. Through research, education and outreach we unlock the power and possibility of plants so that people can be fed, our environment can be healthier, and our world can continue to sustain us and the generations to come. This work requires creative, purposeful use of plant science as well as the ingenuity and commitment of bright, talented people.

Obviously, we cannot do this work alone. Since its inception in 1998, the Danforth Plant Science Center has received vital and magnanimous support from individuals, corporations and organizations, both locally and globally, that recognize the significance of the challenges facing our world, and share a deep commitment to improve lives everywhere.

2017 was indeed a year of many big ideas, achievements and progress, moving us even closer to our shared vision of a healthy, bountiful world for all. To our generous donors, volunteers and supporters, I thank you for your inestimable contributions to this world-sustaining effort.

John F. McDonnell



## LETTER FROM THE PRESIDENT

While this Annual Report highlights our work from 2017, I want to reflect upon some achievements since the Danforth Center was founded. We celebrate our 20th anniversary in 2018, so let's consider some of the Center's impact over those two short decades.

Let's start with scientific discovery. Did you know that Center scientists have documented over 1,100 scientific discoveries and contributions since inception? These include discoveries showing how plants resist disease-causing microbes, or as shown by Sona Pandey's lab this past year, how plants use molecular "switches" to adapt to changes in the environment. These and other discoveries have contributed to dozens of technologies that have either found their way into the private sector, or are being applied to solve problems facing the developing world through humanitarian partnerships. Work of the Nigel Taylor and Todd Mockler teams are turning fundamental discoveries about RNA biology and plant genomes into food security for smallholder farmers and their families in East Africa.

How about the next generation of scientists? The Danforth Center has hosted nearly 670 trainees from around the world. They are now professors at major U.S. universities, lead scientists at research centers in Uganda and Tanzania, and innovators in St. Louis startup companies.

Speaking of companies, have you seen what has happened in 39 North, the innovation district surrounding the Danforth Center? Approximately 50 agtech companies have started up in, or moved to, BRDG Park, Helix Center, the Danforth Center campus, or neighboring facilities. Many of these companies, like NewLeaf Symbiotics, use Danforth Center technologies and employ former Center trainees.

Twenty years ago, the Danforth Center started as an idea to use plant science discovery and innovation to change our region and the world, and that idea has transformed into results. But just imagine what the next twenty years will bring. Thank you for your support!

James C. Carrington, Ph.D.

# INVESTING TO ACCELERATE DISCOVERY

## OUR MISSION

Improve the Human Condition through Plant Science

The center is growing to strengthen and expand priority research areas, provide the capacity and technology to accelerate outcomes and serve as a collaborative hub that connects regional, national and international partners to improve the human condition through plant science.

"OUR GRAND CHALLENGE IS NOT JUST PROVIDING FOOD AND ENERGY SECURITY FOR A GROWING, CHANGING WORLD, BUT RATHER DOING SO IN AN ECOLOGICALLY RESPONSIBLE WAY WITHOUT LONG-TERM DAMAGE TO THE ENVIRONMENT AND THE PLANET. LIKE THE MOONSHOT IN THE 1960S, OR A MARS SHOT IN THE DECADES AHEAD, WE CAN'T GET THERE WITHOUT SCIENCE."

-JAMES C. CARRINGTON, PH.D.,
*President of the Danforth Center*

## LEADING THE WAY: IMPROVING HARVESTS AROUND THE GLOBE

Maize (corn) is a cereal crop with the highest dollar value in the U.S. and abroad. Maize yields have increased eight-fold in the past century due largely to selecting for optimal architecture at increased planting densities. However, yield gains have plateaued in recent years, imperiling progress toward meeting the world's growing food and energy needs.

A greater understanding of the important agronomic traits in maize is necessary to develop more productive cereal crops for a growing population with less inputs, thus preserving precious natural resources.

To meet this need, the National Science Foundation awarded a $3.4 million grant to Andrea Eveland, Ph.D., to lead a multi-institutional team working to develop a detailed knowledgebase of the complex gene networks that control plant structure in maize.

A primary target is the domestication and improvement of many crops. For example, breeding for upright leaves allows light capture within the lower canopy in dense fields, while optimizing the structure of the grain-bearing panicle improves seed set, grain fill and harvestability.

Funding will also support an education component featuring interactive curriculum in quantitative genetics and genomics for high school and rural community college teachers and students.

"WITH THIS PROJECT, WE HOPE TO MAKE SIGNIFICANT ADVANCES IN DECODING GENE REGULATORY MECHANISMS CONNECTING IMPORTANT AGRONOMIC TRAITS."

-ANDREA EVELAND, PH.D.

## ACCELERATING INNOVATION FROM LAB TO MARKETPLACE

TechAccel, the Kansas City-based technology and venture development company, expanded its St. Louis presence in 2017 with an office located in the William H. Danforth Wing at the Danforth Center.

TechAccel made two grants to research programs in 2017 under the *Path to Commercialization* grant program which is designed to support research to demonstrate proof-of-concept or commercial feasibility studies with principal investigators at or affiliated with the Danforth Center.

The first grant supports a project to demonstrate a sprayable technology to apply RNA interference (or RNAi) technology in a biopesticide targeting the diamondback moth. The diamondback moth attacks cruciferous vegetable crops like broccoli, brussels sprouts, cauliflower and cabbage, and is responsible for billions of dollars in crop losses every year worldwide. The research program is led by Nigel Taylor, Ph.D., Dorothy J. King Distinguished Investigator.

The second investment supports the development of a new class of antimicrobial peptides to fight fungal diseases. Fungal pathogens are responsible for an estimated one-third of all crop losses globally. Fungi are also developing resistance to commonly used chemical fungicides, and there is a demand for safer and more environmentally friendly solutions. Dilip Shah, Ph.D., research associate member and principal investigator is leading this research.

TechAccel Technology Acceleration Partners™

"ST. LOUIS, WITH ITS CONCENTRATION OF PLANT SCIENCE STARTUPS, RESEARCHERS AND ESTABLISHED INDUSTRY LEADERS, IS THE OPTIMUM LOCATION FOR TECHACCEL'S EXPANSION."

-MICHAEL HELMSTETTER, PH.D.,
*President and Chief Executive of TechAccel*

# ENTERPRISE RENT-A-CAR INSTITUTE FOR RENEWABLE FUELS

## MOVING BIOENERGY CROPS INTO THE MAINSTREAM

Replacing fossil fuels with sustainable sources of energy is imperative for our future. Solar and wind power are part of the solution, but not a complete answer. Current sources of biofuels compete with food crops and cannot be scaled to provide the sustainable sources of energy the world's growing population needs.

At the Enterprise Rent-A-Car Institute for Renewable Fuels, a research unit within the Danforth Center, scientists are exploring how plants harness the energy of sunlight. They are using that knowledge to develop technologies to increase the potential of oilseed crops, algae and bioenergy grasses to sustainably replace fossil fuels. The ultimate goal is to see production of sustainable bioenergy crops that won't take up land needed for growing food, as the demand for both increases. The Enterprise Rent-A-Car Institute for Renewable Fuels was established in 2007 with a generous gift from the Taylor family.

## ENHANCING SORGHUM FOR BIOENERGY

The U.S. Department of Energy (DOE) awarded the Danforth Center a five-year $16 million grant supporting work to deliver water and nitrogen-efficient sorghum lines as part of the DOE's renewable energy initiative. The development of a low-input, environmentally safe and highly productive sorghum germplasm will also help establish a biomass energy economy that can provide jobs to rural communities, ensure energy security and benefit the environment.

"Understanding the network of genes involved in photosynthesis and drought tolerance will provide targets for plant breeders and genetic engineers to re-design an energy sorghum specifically as a high value bioenergy feedstock to be grown on marginal soils and thus not compete with food crops," said Thomas Brutnell, Ph.D., director of the Enterprise Rent-A-Car Institute for Renewable Fuels.

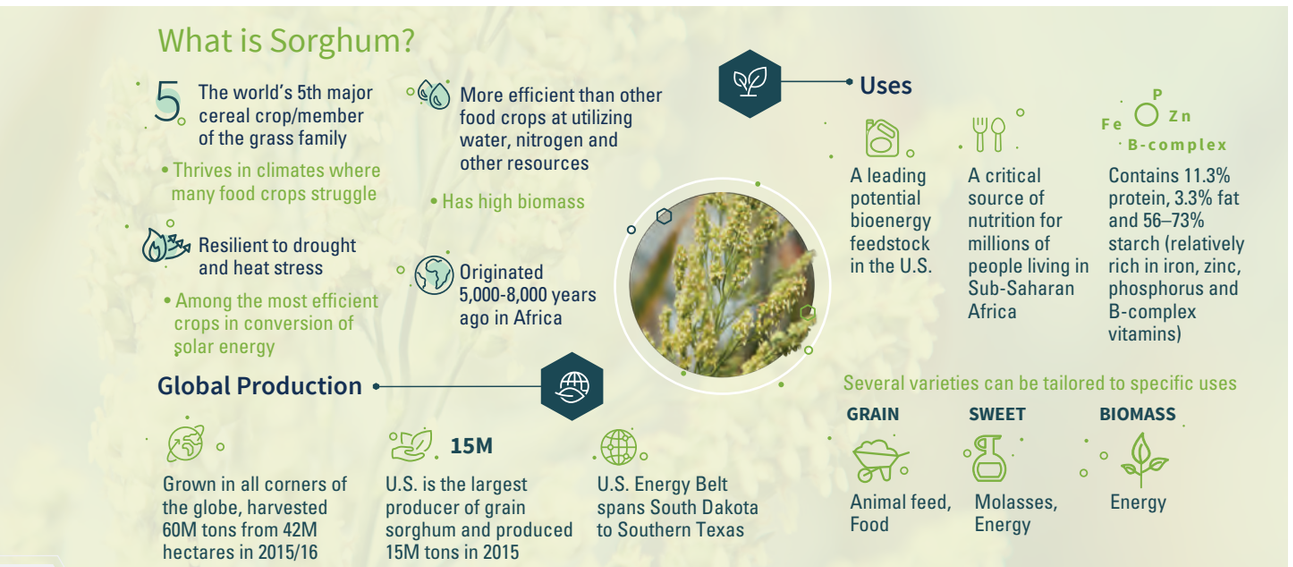
## EMPOWERING FARMERS IN THE DEVELOPING WORLD

The Enterprise Institute received a three-year $6.1 million grant from the Bill & Melinda Gates Foundation to expand and accelerate the development and deployment of advanced sorghum phenotyping and breeding technologies in support of improved grain varieties of sorghum for smallholder farmers.

The funding broadens the impact of the TERRA-REF program launched in June 2015 by the Center with support from the DOE's Advanced Research Projects Agency-Energy (ARPA-E). Both research programs are led by Todd Mockler, Ph.D., Geraldine and Robert Virgil Distinguished Investigator.

# SORGHUM FOR FOOD AND FUEL

### An Ideal Crop to Meet Increased Global Demand with Less Impact on the Environment






# INSTITUTE FOR INTERNATIONAL CROP IMPROVEMENT

## TURNING DISCOVERIES INTO FOOD SECURITY FOR PEOPLE

In many places, crops that hundreds of millions of people depend on for their lives and livelihoods are threatened by floods, drought, pests, diseases and more. Lack of key nutrients stunts the lifetime health and well-being of many more millions of children. The Institute for International Crop Improvement at the Danforth Plant Science Center was established in 2012 with a generous gift from the JS McDonnell Foundation.

Danforth Center scientists seek to translate discoveries in plant health, disease and pest management, genomics, advanced breeding and nutrition, to staple crops that impact food security and are underserved by commercial agriculture.

In addition to feeding the hungry, these efforts have the potential to contribute to environmental health. They reduce the use of harmful chemicals and stabilize communities by empowering farmers to become self-sufficient. Recent work has focused on cassava, sweet potato, rice, corn, cowpea, sorghum, banana and millet.

In addition, teams of research scientists, Danforth Center field specialists and support staff collaborate with international and local partner organizations on issues critical to delivering these improved crops to places where people are in the most need. As that need continues to grow, the need for discoveries that positively impact these communities grows with it.

## CUTTING-EDGE TECHNOLOGIES FOR SMALLHOLDER FARMERS

DuPont Pioneer and the Danforth Center entered into a multiyear public/private partnership, including licensing and research collaboration agreements, to jointly develop improved food security crops.

Pioneer will provide the Danforth Center access to its intellectual property, technology capabilities and scientific expertise related to methods for using CRISPR-Cas. This advanced plant breeding technology will be used to create new varieties of improved food security crops with enhanced native traits. Technology access includes developmental genes, which facilitate the production of gene-edited plants.

**"THE SUITE OF TECHNOLOGIES DUPONT PIONEER IS PROVIDING FOR THIS RESEARCH IS REVOLUTIONARY." - NIGEL TAYLOR, PH.D.**

"Adapting this technology to cassava and other food security crops such as teff, sorghum and millets provides exciting new possibilities for enhancing food security, nutrition and economic stability for smallholder farmers and their families," said Nigel Taylor, Ph.D., associate member and Dorothy J. King Distinguished Investigator, Danforth Center.

The Danforth Center is applying CRISPR-Cas technology to staple food crops such as cassava and sorghum to produce planting materials with improved disease resistance, nutritional value and enhanced resilience to biotic stresses. Gene editing is also being employed as a powerful tool to increase understanding of the biology of these underserved, but vital crop plants. Through collaboration with African scientists, the Danforth Center is committed to delivering the benefits of gene editing to farmers and breeders in Africa. Combining developmental genes with CRISPR-Cas will significantly accelerate these efforts.

VIRCA PLUS

The VIRCA Plus project aims to develop and deliver virus resistance and nutritionally enhanced cassava to benefit smallholder farmer families in Uganda, Kenya and Nigeria. In 2017 the VIRCA Plus team in Uganda and Kenya continued conducting a series of regulatory field trials as a major step towards deployment of cassava varieties that can resist devastating crop losses from both Cassava Brown Streak Disease and Cassava Mosaic Disease. The team has collected samples and is generating data to produce regulatory dossiers that will be used to seek approval from the respective authorities in both countries to release VIRCA Plus plants to farmers for planting and consumption.

Field development and testing of the new cassava varieties also continued at multiple locations in Kenya and Uganda to ensure that they control both plant diseases while producing good yields and maintain farmer preferences for taste, texture, processing and storage practices.

# GROWING THE NEXT GENERATION OF SCIENTISTS

## OUR MISSION

Improve the Human Condition through Plant Science

Danforth Center scientists are involved in training and mentoring young scientists, as well as supporting regional science educators and students. Programming provides a variety of educational opportunities for people of all ages and is designed to heighten awareness that plant science applications play a central role in modern agriculture, global food production, human health and nutrition, green energy and environmental sustainability.

**"BOEING IS PROUD TO SUPPORT PROGRAMS THAT ENSURE STUDENTS IN THE ST. LOUIS REGION ARE BEING EXPOSED TO STEM. WE ASPIRE TO BE A TOP PERFORMER IN EVERY AREA OF OUR BUSINESS, AND THAT INCLUDES LEADING IN THE COMMUNITIES WHERE OUR EMPLOYEES AND THEIR FAMILIES LIVE AND WORK."**

-BRITTANY DOUGLAS,
*Community Investor for Boeing's St. Louis Region*

## INSPIRING YOUNG MINDS

Science and Education Outreach programs at the Donald Danforth Plant Science Center seek to inspire students to become scientists through a variety of hands-on experiences. The curriculum teaches important skills such as critical thinking, developing and testing hypotheses, observing outcomes, communicating results, lab etiquette and teamwork. The programs reached 2,500 students in 2017, many of them from disadvantaged families, and include:

### GREEN MEANS GROW

Helps students understand the origin of their food, appreciate food choices and farming practices throughout the world and grasp the importance of global food security.

### MUTANT MILLETS

Multi-state program offers high school students the opportunity for hands-on, observation-based scientific research.

### TECH TRUNKS

Provides enrichment opportunities for St. Louis-area high school students to conduct experiments in biology, biotechnology and genetics.

### MO DIRT

Crowd sources soil analyses and data collection to Missouri citizens, including K-12 students, who record relevant data about the physical, chemical and biological properties of soils to assess the current state of soil health across Missouri.

### GIRLS STEAM AHEAD

This partnership with the Girl Scouts of Eastern Missouri seeks to encourage the pursuit of careers in science, and to increase diversity within STEM fields.

**2017 EDUCATION AND OUTREACH PROGRAM REACHED**

**2,500**
STUDENTS IN
**88**
SCHOOLS AND HOSTED
**17**
PROFESSIONAL DEVELOPMENT AND TRAINING WORKSHOPS

## BRINGING STEM TO ELEMENTARY STUDENTS

Boeing awarded the Danforth Center a $85,000 grant in support of Green Means Grow, a centerpiece of the Danforth Center's STEM education and outreach program.

"Boeing has been a supportive sponsor of the Danforth Center's science education and outreach efforts for more than a decade. This new generous investment will empower us to expand our educational training to more students and schools in the area while helping to guide the next generation of scientists," said Terry Woodford-Thomas, Ph.D., the Derick and Sally Driemeyer Director of Science Education and Outreach.

The Danforth Center's Green Means Grow curriculum serves about 700 elementary-level students annually in multiple schools throughout the region and supports education in plant science and agriculture. The program provides equipment and instructional materials for students to plant and grow tomatoes, kale, chard, lettuce and other vegetables in their classrooms. Students learn a range of science and math concepts through a variety of STEM activities including planting, cultivating and harvesting crops. Included in this program are "STEM Days," in which Danforth Center scientists provide immersive learning in science, technology, engineering and mathematics for hundreds of students in under-resourced elementary schools.

"THINKING THINGS THROUGH AND UNDERSTANDING WHAT I'M DOING BEFORE EVERY EXPERIMENT – THAT'S SOMETHING THAT DR. ALLEN REALLY EMPHASIZED AND IS THE MOST IMPORTANT THING I'M TAKING AWAY FROM THIS EXPERIENCE."

-LAUREN JENKINS, *REU intern in the laboratory of Douglas Allen, Ph.D., USDA Research Scientist and associate member*

## TRAINING THE NEXT GENERATION OF SCIENTISTS

As part of the Danforth Center's commitment to developing next-generation scientists, the Center provides rigorous training for undergraduate students through the *Research Experience for Undergraduates*. This 11-week intensive summer program funded by the National Science Foundation (NSF) combines hands-on training and mentoring from top-tier scientists helping to create a pipeline of plant scientists prepared to address both current and future global challenges.

The goal is to give each student insight into the research environment, as well as to teach valuable research skills. Center staff work to facilitate connections among interns and their scientific colleagues through discussion forums, research presentations, workshops and social gatherings.

### SUMMER INTERNSHIP PROGRAM BY THE NUMBERS:

- The Center hosted 20 interns, an increase of 25% in class size since 2003.
- Individuals were selected from a competitive pool of 237 applicants, five times the number since inception in 2003.
- 13 interns were supported by NSF funding, and seven through principal investigators.
- 50% of the interns were from schools that have limited research opportunities.
- 25% of the interns were from underrepresented minority groups.
- A recent survey shows 87% of former interns are working in a STEM career or pursuing an advanced degree in STEM.
- From 2009 to 2016, 17 out of 144 interns received the prestigious NSF graduate research fellowship award.


### THE PROGRAM IS MADE POSSIBLE THROUGH GENEROUS SUPPORT FROM THE NATIONAL SCIENCE FOUNDATION.

The 2017 REU Summer Internship Program was organized by Sona Pandey, Ph.D., REU Co-Director, Associate Member and Principal Investigator; Chris Topp, Ph.D., REU Co-Director, assistant member and principal investigator, Cathy Kromer, Grants Manager and Shannon Rapp, Administrative Assistant.


### 2017 REU SUMMER INTERNS

**Jessica Adams,** *University of Connecticut*
**Sarah Johns,** *Colorado State University*
**Mayla Ayers,** *Harris-Stowe State University*
**Allison Kemph,** *Saint Louis University*
**Preston Bruce,** *Claflin University*
**Miranda McLaughlin,** *Brigham Young University*
**James Eckhardt,** *Gustavus Adolphus College*
**Kaley Nieters,** *Rockhurst University*
**Seth Edwards,** *Saint Louis University*
**Kaleb Patania,** *Truman State University*
**Rachel Foister,** *Lindenwood University*
**Jesus Preciado,** *California State Polytechnic University, Pomona*
**Bretton Hale,** *Arkansas State University*
**Jennifer Probst,** *Missouri State University*
**Krystina Hird,** *Miami University*
**Kelsey Reed,** *Southern Illinois University Carbondale*
**Eric Hobson,** *Jackson State University*
**Kelley Renninger,** *Purdue University*
**Lauren Jenkins,** *University of Missouri-St. Louis*
**Julie Gauthier,** *University of Missouri-Columbia*



## 2017 WILLIAM H. DANFORTH PLANT SCIENCE SCHOLAR PROFILE

### ADAM BRAY

*A second-year Ph.D. student at the University of Missouri, 2017 William H. Danforth Plant Science Scholar*

Adam Bray, a second-year Ph.D. student at the University of Missouri, was named the 2017 William H. Danforth Plant Science Scholar, the third graduate student to receive the designation which supports outstanding Ph.D. students whose research demonstrates great promise for advancing plant science. The fellowship was endowed in honor of Dr. Danforth by Dr. P. Roy and Diana Vagelos, longtime leaders in philanthropic giving for scientific medical and education.

Bray's passion for plant science began while growing up in central Georgia on a Christmas tree farm. He developed his interest in novel techniques for plant phenotyping at the University of Georgia, which led him to the lab of Christopher Topp, Ph.D., at the Danforth Center and enrollment in the Ph.D. program in the Division of Plant Sciences at the University of Missouri (MU). His dissertation research is focused on dissecting the genetic components that dictate root system architecture in maize.

"I think Adam understands the needs of the farmer just as well as the need for basic research into the fundamental laws that govern plant health and productivity. To top it off, he has a knack for communicating his work with the public - it's hard to overstate how important this trait is to the advancement of all science," said Topp.

The Topp lab utilizes a wide array of cutting-edge root phenotyping methods to characterize root system architecture (RSA) across diverse varieties of maize. Bray is screening maize lines adapted to drought prone regions of the world to explore RSA response to drought and identify genes responsible for drought tolerance.

"I want to develop an understanding of key genetic components of maize RSA in water scarce environments," said Bray. "This work will not only provide key knowledge on the genetics responsible for root architecture but will also be at the forefront of advancing plant phenotyping tools."

Because medical and other kinds of research receive significantly more federal and foundation funding than plant science, the William H. Danforth Graduate Fellowship is especially important for enabling talented young scientists like Adam Bray to pursue careers in this critically important field. Thanks to Roy and Diana Vagelos, Bray and others will have the opportunity to conduct their research with the guidance of outstanding principal investigators at the Danforth Center.

"ADAM STRIKES AN EXCEPTIONAL BALANCE OF INTELLECTUALISM AND REAL-WORLD PRAGMATISM IN HIS PURSUIT OF PLANT-SCIENCE BASED SOLUTIONS TO BIG PROBLEMS."

-CHRISTOPHER TOPP, PH.D.

# SCIENTIFIC DISCOVERY AND ACHIEVEMENT

"IT'S FULFILLING TO THINK THAT YOUR DISCOVERY MAY FIND ITS WAY TO BENEFIT HUMANKIND. IT'S WHAT WE LIVE FOR IN SCIENCE."

-TONI KUTCHAN, PH.D.,
*Member, Oliver M. Langenberg Distinguished Investigator, Vice President for Research*

## OUR MISSION

Improve the Human Condition through Plant Science

There is not enough land, water or soil to grow the food we will need in just a few decades without new discoveries. Plant science has the potential to generate solutions that can yield more food and energy for people while preserving our planet's environment.

## 2017 DANFORTH PRINCIPAL INVESTIGATORS

### DOUGLAS ALLEN, PH.D.

*USDA-ARS Research Scientist and Associate Member*

The Allen lab used isotopes to assess plant growth and development that contributes to seeds that make more lipids.

### REBECCA BART, PH.D.

*Assistant Member*

The Bart lab combined genetics with molecular and computational biology to develop strategies to control bacterial diseases of cassava and cotton.

### IVAN BAXTER, PH.D.

*USDA-ARA Research Scientist and Associate Member*

The Baxter lab focused on understanding how the interaction of a plant's genes and environmental variables allow it to grow in diverse conditions.

**100**
SCIENTIFIC PUBLICATIONS IN 2017, FOR A TOTAL OF
**1,113**
RESEARCH ARTICLES SINCE INCEPTION

## REPRESENTATIVE PUBLICATIONS FROM 2017 (selected listing below)


Feldman, M.J., Paul, R.E., Banan, D., Barrett, J.F., Sebastian, J., Yee, M.C., Jiang, H., Lipka, A.E., Brutnell, T.P., Dinneny, J.R., Leakey, A.D.B. and Baxter, I. (2017) Time dependent genetic analysis links field and controlled environment phenotypes in the model c4 grass Setaria. PLOS Genet 13, e1006841. doi: 10.1371/journal.pgen.1006841

Greenham, K., Guadagno, C.R., Gehan, M.A., Mockler, T.C., Weinig, C., Ewers, B.E. and McClung, C.R. (2017) Temporal network analysis identifies early physiological and transcriptomic indicators of mild drought in Brassica rapa. eLife 6, e29655. doi: 10.7554/eLife.29655

Huang, P., Jiang, H., Zhu, C., Barry, K., Jenkins, J., Sandor, L., Schmutz, J., Box, M.S., Kellogg, E.A. and Brutnell, T.P. (2017) Sparse panicle1 is required for inflorescence development in *Setaria viridis* and maize. Nature Plants 3, 17054. doi: 10.1038/nplants.2017.54

Odipio, J., Alicai, T., Ingelbrecht, I., Nusinow, D.A., Bart, R. and Taylor, N.J. (2017) Efficient CRISPR/Cas9 genome editing of phytoene desaturase in cassava. Front Plant Sci 8, 1780. doi: 10.3389/fpls.2017.01780

Phillips, A.Z., Berry, J.C., Wilson, M.C., Vijayaraghavan, A., Burke, J., Bunn, J.I., Allen, T.W., Wheeler, T. and Bart, R. (2017) Genomics-enabled analysis of the emergent disease cotton bacterial blight. PLOS Genet 13, e1007003. doi: 10.1371/journal.pgen.1007003

Roy Choudhury, S. and Pandey, S. (2017) Recently duplicated plant heterotrimeric G$\alpha$ proteins with subtle biochemical differences influence specific outcomes of signal-response coupling. J Biol Chem 292, 16188-16198. doi: 10.1074/jbc.M117.793380

Sidorenko, L.V., Lee, T.F., Woosley, A., Moskal, W.A., Bevan, S.A., Merlo, P.A.O., Walsh, T.A., Wang, X., Weaver, S., Glancy, T.P., Wang, P., Yang, X., Sriram, S. and Meyers, B.C. (2017) Gc-rich coding sequences reduce transposon-like, small RNA-mediated transgene silencing. Nature Plants 3, 875-884. doi: 10.1038/s41477-017-0040-6

Umen, J., Goodenough, U. and Heitman, J. (2017) Eukaryotic sexual reproduction evoked "with a little help from my friends". Cell 170, 1059-1061. doi: 10.1016/j.cell.2017.08.038

Yang, J., Thames, S., Best, N.B., Jiang, H., Huang, P., Dilkes, B.P. and Eveland, A.L. (2017) Brassinosteroids modulate meristem fate and differentiation of unique inflorescence morphology in *Setaria viridis*. Plant Cell. doi: 10.1105/tpc.17.00816

Yu, Y., Ji, L., Le, B.H., Zhai, J., Chen, J., Luscher, E., Gao, L., Liu, C., Cao, X., Mo, B., Ma, J., Meyers, B.C. and Chen, X. (2017) Argonaute10 promotes the degradation of miR165/6 through the SDN1 and SDN2 exonucleases in Arabidopsis. PLoS Biol 15, e2001272. doi: 10.1371/journal.pbio.2001272

## 2017 DANFORTH PRINCIPAL INVESTIGATORS

### THOMAS BRUTNELL, PH.D.

*Director of the Enterprise Rent-A-Car Institute for Renewable Fuels, Member*

The Brutnell lab developed new genetic and informatics tools to identify genes that will improve yield in crops through enhanced photosynthesis.

### JAMES CARRINGTON, PH.D.

*President, Member*

The Carrington lab focused on how plants resist viruses, mechanisms of epigenetics, and how crops can be improved to increase productivity.

### ANDREA EVELAND, PH.D.

*Assistant Member*

The Eveland lab used experimental and computational approaches to investigate the regulation of grain production in cereal crops.

### MALIA GEHAN, PH.D.

*Assistant Member*

The Gehan lab developed high-throughput phenotyping approaches to study mechanisms of crop resilience under temperature stress.

### ELIZABETH KELLOGG, PH.D.

*Robert E. King Distinguished Investigator, Member*

The Kellogg lab studied genomes, growth and development of sorghum, maize and their wild relatives, using biodiversity research to make ecosystems and agriculture more sustainable.



### TONI KUTCHAN, PH.D.

*Vice President of Research and Oliver M. Langenberg Distinguished Investigator, Member*

The Kutchan lab focused on the oilseed crop camelina for renewable fuels and on how plants produce medicinal natural products at the enzyme and gene level.

### BLAKE MEYERS, PH.D.

*Member, and Professor, Division of Plant Sciences, University of Missouri*

The Meyers lab used experimental and computational approaches to study plant reproduction and fertility to enhance yield gains in crop plants.

## AAAS ELECTS TONI KUTCHAN AS A FELLOW

As part of the Biological Sciences, Toni Kutchan was elected as an AAAS Fellow for her distinguished contributions to the fields of biosynthesis and engineering of plant natural products, and the promotion of STEM education and careers for women.

"In addition to Toni's work on pathways for plant natural products, I want to underscore Toni's contributions to expanding and enhancing the plant biology doctoral program at Washington University, her scientific outreach in the St. Louis community and her efforts to develop a decadal vision for plant biology," said James Carrington, Ph.D., president of the Danforth Center. "Toni has been honored by many local and international organizations, including Leopoldina, the German National Academy of Sciences."

Election as an AAAS Fellow is an honor bestowed upon AAAS members by their peers. This year, 396 members have been awarded this honor by AAAS because of their scientifically or socially distinguished efforts to advance science or its applications.

## ASPB RECOGNIZES BLAKE MEYERS WITH THE CHARLES ALBERT SHULL AWARD

The American Society of Plant Biologists (ASPB), a professional society devoted to the advancement of the plant sciences, named Blake Meyers as the recipient of the Charles Albert Shull Award for outstanding contributions in the field of plant biology. The award was initiated in 1971 by the Society to honor Dr. Charles A. Shull, whose personal interest and support were largely responsible for the founding and early growth of the Society.

"I'm thrilled, honored and grateful to be acknowledged by my peers and the ASPB with these awards, particularly for the dual recognition of both the work my lab has done, and my contributions to plant biology and the Society," stated Meyers. "I'd like to acknowledge my past and present lab members and our collaborators for their outstanding work and insights, essential components of our progress and success."

In addition, Meyers is a recipient of the Fellow of ASPB Award, recognizing meritorious research and service in plant biology.

## 2017 DANFORTH PRINCIPAL INVESTIGATORS

### TODD MOCKLER, PH.D.

*Geraldine and Robert Virgil Distinguished Investigator, Member*

The Mockler lab used genomics, high-resolution phenotyping and computational biology to understand plant responses to environmental stresses to improve productivity in food and energy crops.

### DMITRI NUSINOW, PH.D.

*Assistant Member*

The Nusinow lab found new genes that have the potential to increase productivity in response to daily and seasonal changes in light and temperature.

### SONA PANDEY, PH.D.

*Associate Member*

The Pandey lab used biochemistry, molecular genetics and functional studies to understand the mechanisms of stress tolerance and yield improvement in plants by G-proteins.

### DILIP SHAH, PH.D.

*Associate Research Member*

The Shah lab investigated modes of action of antifungal plant defensins and defensin-like peptides to enable development of fungal disease resistant crops for increased yields.

### NIGEL TAYLOR, PH.D.

*Interim Director, Institute for International Crop Improvement; Associate Member and Dorothy J. King Distinguished Investigator*

The Taylor lab advanced virus-resistant cassava into regulatory field trials in East Africa as a critical step toward delivering enhanced planting materials to farmers.

### CHRISTOPHER TOPP, PH.D.

*Assistant Member*

The Topp lab implemented laboratory and field-based studies of corn and other root systems in an effort to develop more robust and sustainable crops.

### JAMES UMEN, PH.D.

*Joseph Varner Distinguished Investigator, Member*

The Umen lab investigated the genetics and cell biology of green algae to enable development of sustainable sources of biofuel and other high-value compounds.

### SAM WANG, PH.D.

*Member and E. Desmond Lee and Family Endowed Professor*

The Wang lab focused on signaling processes that mediate plant water and nitrogen use efficiency and seed oil production.

### TERRY WOODFORD-THOMAS, PH.D.

*Sally and Derick Driemeyer Director of Science Education and Outreach*

The team enhanced public understanding of plant science and new technologies used to improve agriculture and guided young scientists in research.

### RU ZHANG, PH.D.

*Assistant Member*

The Zhang lab studied how photosynthesis responds to high temperatures in order to engineer more heat-resistant crops and algae for improved food and biofuel production.

"THIS POTENTIAL PUBLIC HEALTH BREAKTHROUGH HAS BEEN MADE POSSIBLE BECAUSE OF THE TOOLS AND KNOWLEDGE-BASE OF MODERN MOLECULAR GENETICS. HOPEFULLY, BARRIERS CAN BE MINIMIZED SO THAT MILLIONS OF PEOPLE CAN SOON BE FREED FROM THE WELL-DOCUMENTED RISKS THAT COME FROM CONSUMING AFLATOXIN-CONTAMINATED FOOD. NOW THAT THE TECHNICAL BREAKTHROUGH IS COMPLETE, THIS BECOMES BOTH A LOGISTICAL AND A SOCIAL JUSTICE CHALLENGE."

-STEVEN SAVAGE, PH.D.,
*Forbes Contributor*

## BREAKTHROUGH PROVIDES HOPE IN THE BATTLE AGAINST MYCOTOXIN-INDUCED CANCER

Scientists at the Danforth Plant Science Center and the International Crops Research Institute for the Semi-Arid Tropics in Hyderabad, India, United States Department of Agriculture and Louisiana State University made a significant research breakthrough by suppressing the aflatoxin-producing fungus in groundnut. The discovery has the potential to drastically improve food safety and reduce losses caused by the contamination from the poisonous carcinogen, aflatoxin. The discovery was recently published in the *Plant Biotechnology Journal*.

Aflatoxins pose a major risk to human and animal health worldwide and result in an enormous amount of food waste. The molds, *Aspergillus flavus* and *Aspergillus parasiticus*, which infect groundnut, maize, cottonseed and chili, produce these toxins which suppress the immune system, hinder growth in children and even cause liver cancer. The fungus which produces these toxins can stay dormant in soil for years. It infects maize and groundnut during drought and heat stress. Contamination also happens when grain is stored in hot, humid and poorly-ventilated conditions.

"Plant defensins exhibit potent antifungal activity against several economically important fungal pathogens and it is exciting to see successful application of this technology for reducing the pre-harvest infection by Aspergillus and alleviating the burden of mycotoxins in genetically modified groundnut. If deployed commercially, this technology has significant potential to contribute to food safety in the under-developed and developing countries where mycotoxin contamination of groundnut, maize, chili and cottonseed pose a major threat to human and animal health," said Dilip Shah, Ph.D., principal investigator at the Danforth Center.

World peanut production totals about 29 million metric tons per year. The U.S. is the world's third largest producer, after China and India. Peanuts are the 12th most valuable cash crop grown in the U.S. with a farm value of over one billion U.S. dollars. American consumers eat more than 6 pounds of peanut products each year, worth more than $2 billion at the retail level. Worldwide peanut exports are about 1.25 million metric tons annually.

Collaborators plan to conduct field trials in India in coming years for further development of aflatoxin resistant groundnut.

## DROUGHT RESPONSE AS COMPLEX AS DAY AND NIGHT

Researchers identified a set of genes that help control early drought response in a popular global crop, *Brassica rapa*, which provides Chinese cabbage, turnips and vegetable oil. The plant is used extensively in Asia, Canada and Europe, and is of increasing importance in the United States. The pioneering study, conducted by Dartmouth College, the University of Wyoming, and the Danforth Plant Science Center, separates itself from previous research by focusing on the entire day-night cycle and by analyzing both genetic and physiological changes.

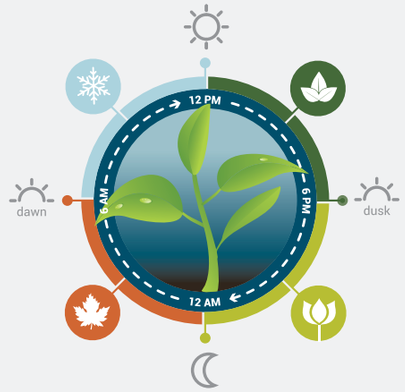
In the U.S. alone, water stress accounts for the largest proportion of crop loss; 45 percent of the nation's land surface suffers from low water availability. Yields for crops like corn and soybean are most sensitive to short-term summertime droughts.

The research, sponsored by the NSF-Plant Genome Research Program, could have major implications as the globe also grapples with an increasing population and food yields that may not reach projected targets.

"This is a landmark study that characterizes the connections between daily rhythms in gene expression and dynamic changes in gene networks in a crop plant and physiological changes associated with drought stress," said Todd Mockler, Ph.D., Geraldine and Robert Virgil Distinguished Investigator.

The research, appearing in the journal *eLife*, assessed change under less severe conditions. By tracking the plant's reactions to water stress, the research team was able to identify nighttime plant activity indicating that *Brassica* may respond to early-stage drought by closing the stomata more fully at night. Stomata allow for the exchange of carbon dioxide and water in a plant. The team identified genes that switched on and off consistently according to the time of day even when well-watered. During drought, the normal behavior of these genes was either amplified or muted.

Researchers hope that with continued success in identifying which genes are actually causing the changes that create drought response, they can help plant breeders improve drought resistance more quickly and more precisely while potentially improving fertilization efficiency at the same time.




## DEEP SEQUENCING REVEALS GENE THAT INFLUENCES GRAIN YIELD

In a paper published in *Nature Plants*, a team led by Thomas Brutnell, Ph.D., director of the Enterprise Rent-A-Car Institute for Renewable Fuels at the Danforth Center and researchers at the U.S. Department of Energy Joint Genome Institute (DOE JGI), discovered a gene that influences grain yield in grasses related to food crops.

"We have identified four recessive mutants that lead to reduced and uneven flower clusters," said Pu Huang, Ph.D., the lead author of the paper. "By ultimately identifying the gene in green foxtail, *Setaria viridis*, we identified a new determinant in the control of grain yield that could be crucial to improving food crops like maize."

The grass Setaria has been proposed as a model for food and bioenergy crops for its short stature and rapid life cycle, compared to most bioenergy grasses. After constructing a mutant population resource for the grass, the Brutnell lab screened 2,700 M2 families, deep sequenced a mutant pool to identify the causative mutation and confirmed a homologous gene in maize played a similar role.

"Identifying this new player in panicle architecture may enable the design of plants with either enhanced or reduced panicle structures," stated Brutnell. "By showing that this gene influences panicle architecture in Setaria and maize, we have expanded the tool box for breeders."

## DISCOVERING THE GENES THAT REGULATE PLANT HEIGHT

Researchers at the Danforth Plant Science Center, in collaboration with the United States Department of Agriculture-ARS, the University of Illinois and the Carnegie Institute for Science, published a paper in *PLOS Genetics* on conducting a high-throughput phenotyping experiment to map genes that regulate plant height in the model bioenergy grass Setaria. Specifically, they identified several loci controlling height in a population derived from a cross between the wild species and its domesticated relative to identify traits that may have been under selection during the domestication process.

"Growth is a dynamic process that responds to a changing environment. Most of the methods that we have for measuring are static, and collecting information throughout an organism's life cycle is extremely labor intensive and often prohibitively expensive. Advances in imaging and robotics technology have enabled novel approaches to understand how plants adapt to the environment," said Max Feldman, Ph.D., a postdoctoral associate at the Danforth Center and the lead author of the study.

The team of researchers identified many of the same major effect regions of the genome both in the field and in the highly controlled environments of the Bellwether Foundation Phenotyping Facility at the Center. Future agriculture research can apply the study's tools to other plant and food crops for more rapid translation analysis.



## NEXT-GENERATION MAPPING USED TO IMPROVE THE MAIZE REFERENCE GENOME

In cooperation with a global team of researchers and NRGene, the leading genomic big data company, Thomas Brutnell, Ph.D., director of the Enterprise Rent-A-Car Institute for Renewable Fuels at the Danforth Center and researchers assembled the W22 maize reference genome.

"We're excited to share the data with the research community to enhance our knowledge of maize beyond what the current B73 line allows us," said Brutnell. "Instead of spending our time assembling genomes, we can now devote our time to analysis."

By building an independent genome map of W22 using next-generation mapping (NGM) with BioNano's Irys® system, Dr. Kelly Dawe of the University of Georgia provided the independent assessment of this version. The Irys optical mapping system uses high-resolution, single-molecule imaging of labeled, long DNA to produce a long-range map of the genome, which can be used to correct or enhance a genome sequence assembly.

"99.4% of the scaffolds were collinear with our BioNano genome map, indicating that NRGene's DeNovoMAGIC3.0 has generated a very high quality reference assembly," said Dr. Dawe. By combining the BioNano data with NRGene's assembly, Dr. Dawe was also able to improve the N50 scaffold size to 75 MB.

"We are pleased to see next-generation mapping used to improve the maize reference genome," commented Dr. Erik Holmlin, CEO of BioNano. "This work supports what we have seen in other settings: combining next-generation mapping from BioNano with sequencing technologies provides significantly better results."

"True scientific breakthroughs only occur with significant collaboration," says Gil Ronen, CEO of NRGene. "We're pleased that our technology has once again been selected to be a critical part of the process by such a stellar group of researchers."

# BUILDING A STRONGER INNOVATION ECOSYSTEM


"FOR CENTURIES, MANKIND HAS BENEFITED FROM PUBLIC AND PRIVATE PARTNERSHIPS IN ORDER TO BRING FORWARD TRANSFORMATIONAL INNOVATIONS TO IMPROVE AND PRESERVE LIFE."

-ADRIAN PERCY, PH.D.,
*Head of R&D Crop Science, a division of Bayer*

## OUR MISSION

Improve the Human Condition through Plant Science

The Danforth Center is working to strengthen the St. Louis region as a bioscience powerhouse by attracting world-class talent, providing access to intellectual capital and infrastructure, generating new companies and creating jobs and investment opportunities in plant science, agtech and related fields.

## FARM, FOOD AND FEAST OF DATA TAKE CENTER STAGE AT 2017 AG INNOVATION SHOWCASE

The Danforth Center hosted a capacity crowd for the ninth annual Ag Innovation Showcase, the world's premier event focusing on the convergence of agriculture and technology.

The theme of this year's conference was "Farm, Food, and Feast of Data," focusing on agriculture and its influence on a range of issues of concern to our world: population growth, food traceability, security and productivity, soil health and use and management of inputs such as water and fertilizer.

"This event brings the agtech community together to create synergy between the multitude of products and projects that are contributing to the explosive growth of the industry," said Sam Fiorello, chief operating officer, Danforth Center and president, Bio Research & Development (BRDG) Park. The Danforth Center and BRDG Park partner with the Larta Institute in organizing the Showcase.

Keynote speaker Adrian Percy, Ph.D., head of research and development at Bayer Crop Science, shared his experience in crop science and protection, bringing a unique viewpoint to the Showcase with particular relevance to the event's audience of early-stage innovators. Percy emphasized the need for ag science and innovation to deliver real-world solutions to the world's most pressing problems.

Since 2009, the Ag Innovation Showcase has featured high-impact technologies and anticipated trends from around the world, stimulating discussions about the future of agriculture, as well as providing opportunities for effective networking. There is no shortage of challenges and innovative responses, and the Showcase continues to evolve to stay relevant and stimulating.

Drawing people from across the globe to St. Louis, this annual event features a diverse array of speakers, entrepreneurs, academics and industry leaders. Topics featured at this year's Showcase included cutting-edge approaches to improving agriculture productivity including microbials, genomics, phenotyping, data and machine learning, soil health and more.

We are tremendously thankful for the support provided by our sponsors.

Ag INNOVATION SHOWCASE
Breeding Scientific Innovations, Harvesting Global Commercial Breakthroughs

BE SURE TO PLANT SEPTEMBER 10-12, 2018 ON YOUR CALENDAR FOR THE TENTH ANNUAL AG INNOVATION SHOWCASE IN ST. LOUIS.

## 9 YEARS OF SUCCESS

## 39 NORTH: GROWING OUR INNOVATION COMMUNITY

39 North, a 600-acre innovation district surrounding the Danforth Plant Science Center, Bio Research Development & Growth (BRDG) Park, Helix Biotech Incubator, Yield Lab and the Monsanto Company.

### FIVE TRANSFORMATIVE GOALS WERE IDENTIFIED IN THE STRATEGIC MASTER PLAN THAT WAS ANNOUNCED IN DECEMBER 2016.

- Strengthen corridors and establish new traffic patterns
- Connect assets and opportunity sites
- Establish a cohesive development framework
- Create a mixed-use center of activity
- Communicate the district

"39 NORTH IS AN EXTENSION OF DR. DANFORTH'S VISION TO MAKE ST. LOUIS A WORLD CENTER FOR PLANT SCIENCE AND INNOVATION AND STRENGTHENS THE REGION'S EFFORTS TO GROW, ATTRACT AND RETAIN COMPANIES AND TOP TALENT."

-SAM FIORELLO,
*COO of the Danforth Center and President of BRDG Park*

### CURRENT INITIATIVES

39 North will be geared toward lifestyle preferences often sought by highly-skilled employees, including mixed retail, residential and office space connected by walking and biking trails and green space. Several projects were initiated in 2017.

Great Rivers Greenway awarded 39 North $400,000 to design an open space framework and biking and pedestrian paths that connect to the Centennial Greenway. After a formal bidding process for Phase I of the design, Reitz & Jens, Inc. was hired to provide engineering and planning services.

Funding for the redesign of the Olive and Lindbergh Boulevard interchange has been secured with $4 million from the Federal Highway Administration and $1 million from St. Louis County.

St. Louis County voted unanimously to approve $450,000 for preliminary planning for the redesign of Old Olive. The City of Creve Coeur is providing an additional $50,000. This funding will support the planning and design of Old Olive to give it a localized, main-street atmosphere. After a formal bidding process, Christner Inc. was to selected to analyze the existing conditions of Old Olive Street and develop a design for the project in accordance with the 39 North master plan.

## VENTURE CAFÉ NIGHT: 39°N

In February 2017, the Danforth Center and the St. Louis Economic Development Partnership teamed up to launch Venture Café @ 39 North. The gatherings were held from 4:00 to 7:30 p.m. on the third Tuesday of every month at the Danforth Center. The gatherings are designed to facilitate serendipitous collisions that drive creativity, foster collaboration and stimulate investment in innovation.

### SPONSORS

**LEAD SPONSOR**
Monsanto Company

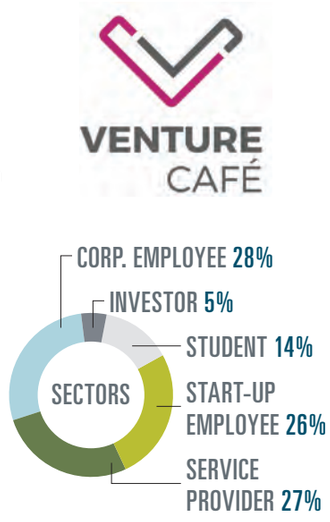
**PLATINUM SPONSOR**
Christner
Wexford
Polsinelli
Ventas Realty

**GOLD SPONSOR**
McCarthy Building Companies, Inc.
Clayco
Happy Medium
Reitz & Jens
Tarlton
KAI Design and Build

**SILVER SPONSOR**
Landmark Contract Management
Guarantee Electrical Co.
K&S Associates, Inc.
CRB
National Corn Growers Assoc.

**BRONZE SPONSOR**
Common Ground Public Relations
Enterprise Bank and Trust
Access Engineering
Color Art Integrated Interiors
Wynn O. Jones & Associates

**PROGRAM PARTNERS**
North Highland
St. Louis Economic Development Partnership
The Yield Lab
Isabee's Beekeeping
Monsanto Growth Ventures
Great Rivers Greenway
Donald Danforth Plant Science Center
March for Science St. Louis
Missouri Cures Education Foundation
Gateway Greening
City of Creve Coeur
Ag Sales Professionals, LLC
BRDG Park
Thompson Coburn
Better Weekdays
St. Louis Green Business Challenge
TechShop
CRB
ONESTL
Missouri Botanical Garden
AHC Consulting
Saint Louis Zoo
Precision Growth Strategies
Saint Louis Art Museum

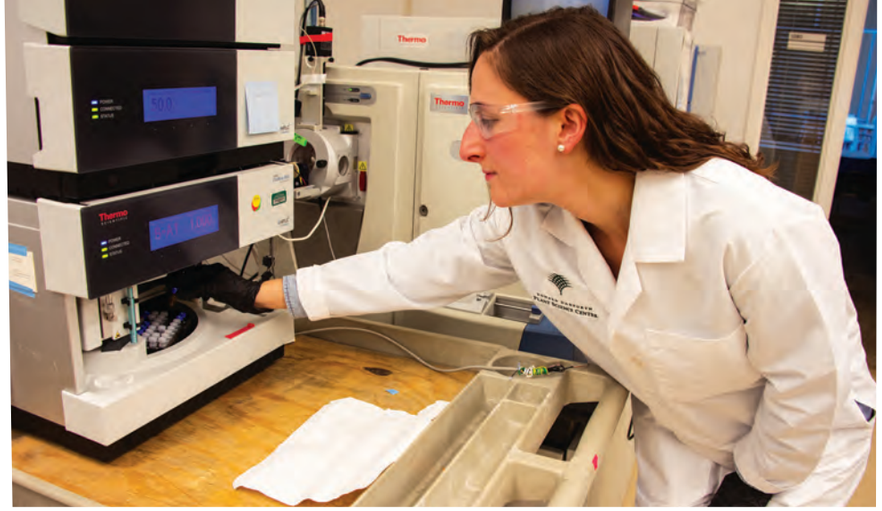



**12**
CAFÉ NIGHTS

**64**
SESSIONS

**2,305**
ATTENDEES

**30%**
1ST TIME ATTENDEES



## FROM THE LAB TO THE MARKETPLACE

The Danforth Center is unique in its commitment to both fundamental research and engagement across the spectrum from discovery to translation and application. We do this because it is necessary to meet the challenge in front of us and because it helps stimulate economic vitality for St. Louis.

### DANFORTH CENTER INTELLECTUAL PROPERTY TO DATE

#### 2017 Intellectual Property Summary

- 42 currently pending patent applications in the U.S. and internationally from a total of 24 patent technology families
- 13 issued patents
- 7 licensed technologies to for-profit companies
- 10 invention disclosures submitted in 2017
- 6 provisional applications filed in 2017
- 1 U.S. non-provisional application filed in 2017
- 3 patents issued in 2017
- 1 technology licensed to a for-profit company in 2017


## WONDERS OF TECH: ALTERNATIVE RUBBER FROM SUNFLOWERS

Edison Agrosciences, an agricultural biotechnology company dedicated to developing and commercializing innovative solutions for the production of plant-based industrial materials, licensed HAYSTACK, a technology developed by a team of scientists at the Danforth Center. Natural rubber is a nearly $50 billion global business. The technology will enhance the company's efforts to identify high-value gene candidates to improve natural rubber content in crops including sunflower, which is currently grown on nearly two million acres in the United States.

"Current production of natural rubber from rubber trees in Southeast Asia is rapidly becoming economically and environmentally unsustainable. I'm happy to collaborate with Edison and apply our genomics and informatics capabilities to the challenge of improving sustainable natural rubber production," said Todd Mockler Ph.D., Geraldine and Robert Virgil Distinguished Investigator, who led the research group that developed the technology.

Located in the Helix Center, the company has assembled a top tier team, raised a seed round of financing and is currently expanding its capability to identify and evaluate genes to substantially increase naturally produced rubber in sunflower. HAYSTACK is a tool for mining large gene expression data sets by searching for specific user-defined patterns of expression. HAYSTACK is designed to find rare occurrences of very specific patterns in large data sets and provides an alternative method for clustering expression profiling data by grouping genes whose expression patterns match the same or similar HAYSTACK models.

"EDISON IS EXCITED TO USE THIS UNIQUE TECHNOLOGY TO ENHANCE OUR ABILITY TO IDENTIFY GENES OF INTEREST AND SPEED PRODUCT DEVELOPMENT."

-TOM CHRISTENSEN,
*CEO of Edison Agrosciences*

# COMMUNITY ENGAGEMENT AND CONTRIBUTIONS


## REMEMBERING MARY AND OLLIE LANGENBERG

Mary and Oliver (Ollie) Langenberg were outstanding business, civic and philanthropic leaders. On June 8, family, friends and members of the Danforth Center's leadership gathered to honor their lives and to dedicate the Mary and Oliver Langenberg Theater. The theater is a major hub for events and activities that are advancing plant science discovery and generating new business and investment throughout the St. Louis region.

The Langenbergs had an extraordinary impact on both the business and nonprofit communities in St. Louis. Over the course of a legendary career, Ollie, a senior vice president at Wells Fargo Investment Advisors, became the longest serving active investment advisor in St. Louis. Mary founded the executive relocation firm ExecuTours. The Langenbergs' remarkable professional success was matched by their commitment to strengthening St. Louis' leading institutions and making life-changing educational and economic opportunities available to all residents of the region.

Mary and Ollie were visionary philanthropists whose generosity has been instrumental to the success of the Danforth Center and many local and national organizations. Reflecting on many years of friendship with the Langenbergs, Danforth Center Founding Chairman Dr. Bill Danforth describes Mary and Ollie as "great community citizens" and notes that Ollie played a leading role in establishing the Center's efforts to spark new industries.

The Langenbergs' support of the Danforth Center has been particularly important to advancing the plant biochemistry research of Toni Kutchan, Ph.D., the Center's vice president of research and Oliver M. Langenberg Distinguished Investigator. Notable outcomes of research in the Kutchan Lab include the development earlier this year of a breakthrough enzyme-manufacturing procedure that has a range of potential pharmaceutical applications.

Bill Polk, Mary's son and Ollie's stepson, describes the Langenbergs' involvement with the Danforth Center as an expression of the values that guided much of their volunteerism and philanthropy. Mary and Ollie Langenberg left an unsurpassed legacy of keen intelligence, kindness and commitment to improving St. Louis and the world.

"FOR MY PARENTS, AN INVESTMENT IN THE DANFORTH PLANT SCIENCE CENTER WAS AN OPPORTUNITY TO PLAY THE TRIFECTA: FIRST, THEY DEEPLY VALUED RIGOROUS INTELLECTUAL INQUIRY, NEW WAYS OF LOOKING AT THINGS, AND OUTSIZED THINKING. THEY ALSO APPRECIATED EXCELLENCE IN WHATEVER FORM IT TAKES. AND THIRD, THEY LOVED BILL DANFORTH."

-BILL POLK

"MARY AND OLIVER WERE ROLE MODELS FOR HOW TO MAKE AN IMPACT THROUGH PHILANTHROPY. THEIR EARLY SUPPORT OF MY LAB ADVANCED THE DEVELOPMENT OF PLANTBASED MEDICINES AND SUSTAINABLE SOURCES OF ENERGY."

-TONI KUTCHAN, PH.D.

### OUR MISSION

Improve the Human Condition through Plant Science

The Danforth Plant Science Center partners with individuals, corporations and foundations that share its vision and commitment to using scientific innovation to address critical challenges of the 21st century. The Center hosts a variety of public events to share our science with the broader public. We are grateful to our many supporters who contribute to these efforts.

# BOARD OF DIRECTORS

**JOHN F. MCDONNELL**
*Chairman*
Retired Chairman of the Board, McDonnell Douglas Corporation

**WILLIAM H. DANFORTH, M.D.**
*Founding Chairman* and *Emeritus* Director
Chancellor *Emeritus*, Washington University in St. Louis

**PHILIP NEEDLEMAN, PH.D.**
*Vice Chairman*
Former Chief Scientist and Head of R&D, Monsanto/Searle/Pharmacia and Former Chairman, Department of Pharmacology, Washington University in St. Louis, School of Medicine

**BRETT D. BEGEMANN**
President and Chief Operating Officer, Monsanto Company

**SENATOR CHRISTOPHER S. "KIT" BOND**
Partner, Thompson Coburn LLP

**BLACKFORD F. "BEAU" BRAUER**
Executive Vice President, Hunter Engineering Company

**LEE BROUGHTON**
Vice President, Brand Marketing Enterprise Rent-A-Car, Enterprise Holdings, Inc.

**DANIEL A. BURKHARDT**
Partner, Oakwood Medical Investors

**CHRISTOPHER B. DANFORTH**
General Partner, Cultivation Capital Life Science Fund and Managing Director, The Yield Lab

**STEVEN M. FOX**
Managing Director, Harbour Group Industries, Inc.

**ROBERT J. JONES, PH.D.**
Chancellor, University of Illinois at Urbana-Champaign and Vice President, University of Illinois

**DAVID W. KEMPER**
Chairman and Chief Executive Officer, Commerce Bancshares, Inc.

**PENNY PENNINGTON**
Principal, Edward Jones

**TODD R. SCHNUCK**
Chairman and Chief Executive Officer, Schnuck Markets, Inc.

**MARY DANFORTH STILLMAN**
Executive Director, Hawthorn Leadership School for Girls

**MARK C. TRUDEAU**
President and Chief Executive Officer, Mallinckrodt Pharmaceuticals

**ROBERT L. VIRGIL, D.B.A.**
*Emeritus* Director
Retired Partner, Edward Jones

**ERIC R. WARD, PH.D.**
Co-Chief Executive Officer, AgBiome, Inc.

**MARK S. WRIGHTON, PH.D.**
Chancellor, Washington University in St. Louis

**PETER S. WYSE JACKSON, PH.D.**
President, Missouri Botanical Garden

**USHA BARWALE ZEHR, PH.D.**
Chief Technology Officer, Maharashtra Hybrid Seeds Company, Ltd.

## BOARD PARTICIPANTS

**CHIP LERWICK**
Managing Director, Aon

**WALTER L. METCALFE, JR.**
Senior Counsel, Bryan Cave LLP

**JAMES R. VON DER HEYDT**
President, InnoVentures LLC

# BOARD ELECTS TWO NEW DIRECTORS

**ALEXANDER N. CARTWRIGHT, PH.D.**
Chancellor, University of Missouri

**WESLEY JONES**
Managing Partner, Sage Capital, LLC



# REMEMBERING PIONEERS OF MODERN AGRICULTURE

## ERNEST ("ERNIE") JAWORSKI, PH.D., 1926 - 2017

On Tuesday, July 25, 2017, the agriculture and plant science communities lost a pioneer, Ernest ("Ernie") Jaworski, Ph.D., at the age of 91.

Ernie put together the first biotechnology group at Monsanto in the 1970s, with the aim to use modern genetics to develop useful traits and improve agriculture. Early ideas included using mutagenesis of crop plants to develop useful traits to improve farm productivity. Then, the world changed as Ernie's team pioneered the development and application of recombinant DNA techniques as a crop breeding tool in commercial agriculture. Among many other important outcomes, this work resulted in safer ways to control crop pests and dramatic reductions in pesticide use around the globe. In 1998, he was awarded the National Medal of Technology for outstanding contributions to plant science and agriculture.

Ernie worked at Monsanto Company for 41 years. After retirement, Ernie worked tirelessly in the St. Louis community, including with the Danforth Plant Science Center. He provided critical leadership in launching the Danforth Center, serving as interim president from August 1, 1998, to December 31, 1998. In the years that followed, Ernie served as a valued advisor, member of the Friends Committee and ever-present supporter at Center events.

Ernie will be missed deeply by his many friends at the Danforth Center, and by his friends and colleagues in St. Louis and around the world.

**ERNEST ("ERNIE") JAWORSKI, PH.D.**
IN 1998, HE WAS AWARDED THE NATIONAL MEDAL OF TECHNOLOGY FOR OUTSTANDING CONTRIBUTIONS TO PLANT SCIENCE AND AGRICULTURE

## B. R. BARWALE 1931 - 2017

B. R. Barwale passed away in Mumbai on July 24, 2017, at the age of 86. B. R. Barwale founded the first private seed company in India, Maharashtra Hybrid Seeds Company (Mahyco), in 1964, and was known as the father of the Indian seed industry. Mahyco used hybrid breeding technology to produce many crop varieties that were high-yielding, disease-resistant and extremely weather-resilient. Importantly, these seeds were affordable and accessible, providing a means to raise incomes and living standards for millions of Indian farmers. Through his training, he nurtured farmers to develop as entrepreneurs and empowered them on a new path of advanced seed production with hybrid seeds.

B. R. Barwale was awarded the World Food Prize in 1998 for his immense contributions to food security in India. His daughter, Usha Barwale Zehr (Joint Director of Research and Director, Mahyco) is a frequent visitor to the Danforth Center through her service on our Board of Directors.

**B.R. BARWALE**
IN 1998, HE WAS AWARDED WORLD FOOD PRIZE FOR HIS IMMENSE CONTRIBUTIONS TO FOOD SECURITY IN INDIA

## SCIENTIFIC ADVISORY BOARD

The Scientific Advisory Board counsels the Danforth Center on scientific matters. It annually reviews and evaluates the nature and quality of scientific research being done by the Center. In evaluating such scientific research, the Advisory Board considers how it facilitates the development and retention of agricultural biotechnology, molecular biomedical and plant research-related industries in the St. Louis area and how the research compares with and achieves the Center's goal to be one of the premier plant research institutes in the world.

**JULIA N. BAILEY-SERRES, PH.D.**
Professor of Genetics
Director, Center for Plant Cell Biology
University of California, Riverside

**JOSEPH P. NOEL, PH.D.**
Professor and Director, Jack H. Skirball Center for Chemical Biology and Proteomics
Howard Hughes Medical Institute, The Salk Institute for Biological Studies

**JOHN C. WALKER, PH.D.**
Director and Professor,
Division of Biological Sciences
University of Missouri, Columbia

**EDWARD S. BUCKLER, PH.D.**
Professor, Plant Breeding and Genetics
School of Integrative Plant Science
Cornell University

**C. ROBIN BUELL, PH.D.**
Endowed Professor of Plant Biology
William J. Beale Distinguished Faculty
Michigan State University

**CRAIG S. PIKAARD, PH.D.**
Howard Hughes Medical Institute, Distinguished
Professor and Carlos O. Miller Professor
Department of Biology and Dept. of Molecular and Cellular Biochemistry
Indiana University

**RICHARD D. VIERSTRA, PH.D.**
George and Charmaine Mallinckrodt Professor
Department of Biology
Washington University in St. Louis



## CRISPR: USING PRECISION TOOLS TO ACCELERATE NEW PRODUCT DELIVERY

Clustered Regularly Interspaced Short Palindromic Repeats, or CRISPR, is the hallmark of a bacterial defense system that forms the basis for CRISPR-Cas9 genome editing technology. This efficient and customizable method has the ability to target multiple genes simultaneously, an advantage that sets it apart from other gene editing tools.

In 2012, Jennifer Doudna, an American biochemist based at the University of California, Berkeley showed CRISPR-Cas9 could be used to slice up DNA at any site. This was a significant moment in the science community. CRISPR genome editing technology is powerful in the sense it allows the precise and easy manipulation of the DNA in the nucleus of any cell and has the potential to eliminate genetic disease by making changes to DNA that will pass down from generation to generation.

"Gene editing is now as common in a lab as pipetting," said Jim Carrington, president of the Danforth Center to *Agri-Pulse* editor Sara Wyant during an interview in February 2018. The major difference is it is a precision tool that will benefit the agriculture community as widely as the medical community. Carrington went on to say, "Ag innovation of this kind is hypercharging research and development with the ability to move agriculture improvements to the market."

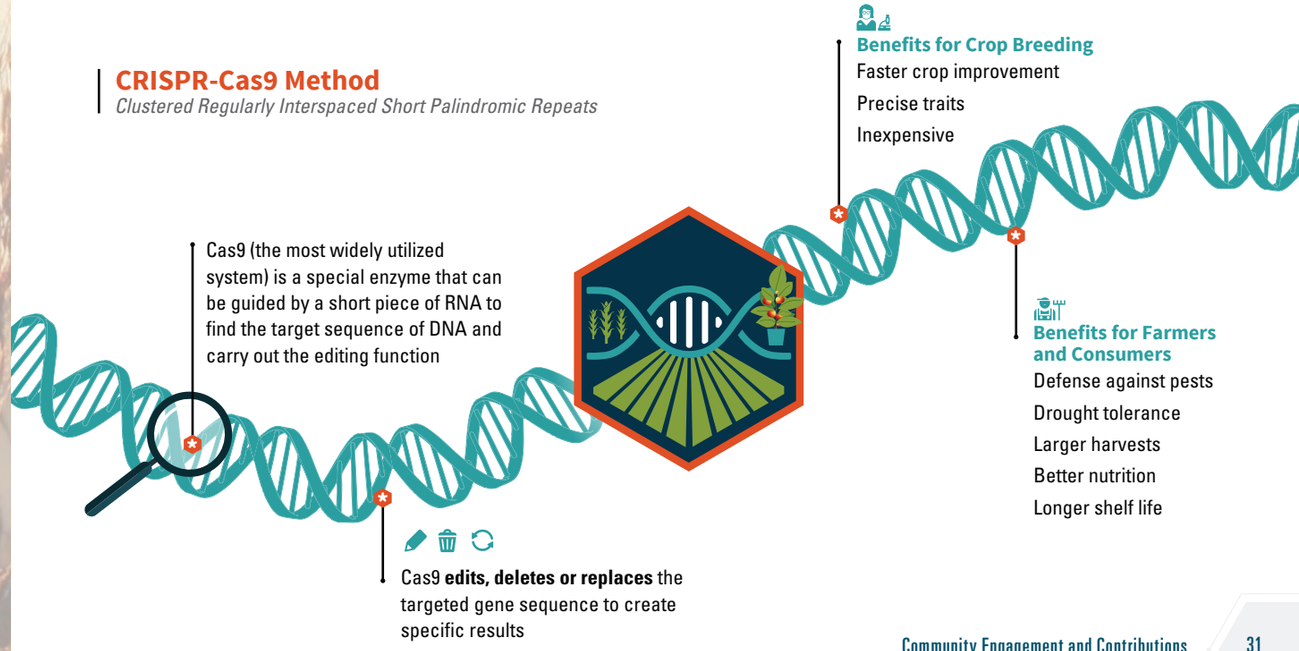
Gene editing can facilitate crop improvement by working with native characteristics of the plant. The tool is less costly, more precise than traditional breeding methods and can deliver improved crops to farmers faster. Examples include crops that are more tolerant to drought, heat, cold and pests, challenges that farmers around the globe face every day. CRISPR can also be used to develop crops with longer shelf life and more nutritional value.

The publication *Engadget* claimed CRISPR is a tool that could bring about the next agriculture revolution and could be used to develop gluten free wheat, helping the one in 100 people who suffer from celiac disease.

This new kind of tinkering around can edit the genetic code for development, "It's a much smarter way to do the kind of crop and livestock improvement we've done since the agricultural revolution," said Hank Greely, director of Stanford University's Center for Law and the Biosciences.

## GENE EDITING WITH CRISPR-Cas9

### Using Native Characteristics to Improve Crops to Benefit People and the Planet



# SEEDS of CHANGE
2017

"WE NEED A SPECTRUM OF INVESTMENTS AND WE NEED WHAT THE DANFORTH CENTER DOES TO SOLVE POTENTIAL PROBLEMS!"
-JEFF RAIKES,
*Co-Founder of the Raikes Foundation*

## SEEKING IMPACT AT SCALE

More than 300 guests attended the annual SEEDS of CHANGE event featuring Jeff Raikes, co-founder of the Raikes Foundation, who discussed how catalyst philanthropy, innovation and leveraging resources can transform systems that will create long-term sustainable impact. From 2008 to 2014, Raikes was the Chief Executive Officer of the Bill & Melinda Gates Foundation. Prior to that, he worked for Microsoft and is credited with driving much of the company's early work in business applications.

Raikes, who grew up on a farm in Nebraska stated, "We have an enormous challenge for our time in history building equitable systems that ensure food and water security for the most vulnerable and at the heart of solving this challenge is R&D. The Danforth Plant Science Center's mission is essential for bringing about this transformation; scientific knowledge applied to critical problems can help lift families out of poverty around the world and St. Louis has a role to play."

"His emphasis on farmers as early adopters of technology has paved the way for smallholder farmers to make informed decisions through technological improvements and promising innovations. This supports the concept of basic research improving agricultural productivity globally," stated Stephanie Regagnon, CEO at FieldWatch, Inc. and chair of the Danforth Center's Young Friends Committee.

Following his presentation, Wes Jones, chair of the Danforth Leadership Council and moderator for the event, highlighted Raikes' role on Microsoft's leadership team and contributions to their rapid development from an entrepreneurial company to industry leader while maintaining a culture of continuous learning.

While serving as the CEO, Raikes led the Gates Foundation's efforts to promote equity for people throughout the world. During his tenure, he set strategic priorities, managed significant growth and facilitated relationships with key partners. He then co-founded the Raikes Foundation in 2002 as a vehicle to help others by partnering with innovative organizations and creative thinkers who are making lasting, positive changes in the lives of young people.

The annual SEEDS of CHANGE program is hosted by the Danforth Leadership Council.

## 2017 DANFORTH LEADERSHIP COUNCIL

### CHAIR
Wesley Jones

### VICE-CHAIR
Chip Lerwick

### CHAIR *EMERITUS*
W. Scott Bush

### EXECUTIVE COMMITTEE
Christopher B. Danforth
Natalie DiNicola
James L. Johnson III
Michael Scully

"DANFORTH CENTER SCIENTISTS ARE WORKING TO SOLVE SOME OF THE WORLD'S MOST PRESSING LONG-TERM CHALLENGES IN FOOD, NUTRITION AND ENVIRONMENTAL SUSTAINABILITY. THE MEMBERS OF THE DANFORTH LEADERSHIP COUNCIL ARE PROUD TO SUPPORT THIS VITAL RESEARCH AND TO DO OUR PART IN EXPANDING THE PLANT SCIENCE ECOSYSTEM IN OUR COMMUNITY."
-WESLEY JONES, *Chair of the Danforth Leadership Council*

### MEMBERS
R. D. Todd Baur
Eleanor Peters Bergquist
Robert Brandt
Jason Brauer
Beau Brauer
Lee Broughton
Johannes Burlin
J. Powell Carman
John G. Cella
Vijay Chauhan
Robert J. Ciapciak
David Danforth
Charles H. Fendell
J. Spencer Finney
Blair L. Fortner
Steven M. Fox
Eric Gilbert
Marc D. Goldstein
Clifford Holekamp
Richard C. Holton, Jr.
William D. James
Brendan Johnson
Harold Rockwell Kroeger
John M. Lee
David Lemkemeier
Julie J. Lilly
Michael Loynd
Aditya Malhotra
Toby Martin
Saad Naseer
Charles A. Nicolais
Jack Oliver
William L. Polk, Jr.
Steven J. Ponciroli
Ryan Rippel
Mary D. Stillman
Christine Taylor-Broughton
Pat Tracy
Jay A. Williamson, IV
Heather Wood
Nancy Ylvisaker
Jackie Yoon

THE 2017 CONVERSATIONS SERIES IS SPONSORED BY ST. LOUIS PUBLIC RADIO AND HEC-TV. TO VIEW PREVIOUS PROGRAMS, VISIT HEC-TV.ORG.

## 2017 CONVERSATIONS SERIES

The discussion series is organized by members of the Danforth Center Friends Committee and offers individuals the opportunity to learn about the work of the Center and the partners who help to sustain it. Discussions are focused on topics of both regional and global urgency and feature leading experts in plant science and related disciplines.

### 39 NORTH: CULTIVATING AN INNOVATION ECOSYSTEM

39 North, the 600-acre innovation district is home to the Danforth Center, BRDG Park and other organizations that are helping to strengthen the St. Louis region's innovation ecosystem. The discussion centered around the strategic master plan for the district, which is geared toward enhancing the region's ability to grow, attract and retain companies and top talent.

**Date:** Thursday, May 11, 2017

**Panelists:** Barry L. Glantz, Mayor of the City of Creve Coeur, Travis Sheridan, President of the CIC Venture Café Global Institute, and Janet Wilding, Vice President Major Projects, St. Louis Economic Development Partnership.

**Moderator:** Sam Fiorello, Chief Operating Officer, Danforth Center and President, BRDG Park.

### DECREASING FOOD WASTE - FROM FARM TO MARKET

The program focused on preventing crop spoilage and reducing food waste, which will be critical to feeding a world population projected to grow to 10 billion people by 2050. The discussion highlighted how improved disease and pest resilience in major staple crops can preserve yield in sub-Saharan Africa and elsewhere. Panelists also pointed to initiatives to decrease loss and waste in the processing, transportation, storage, and sale of food products throughout the world, starting here in St. Louis.

**Date:** Thursday, August 24, 2017

**Panelists:** Joanie Taylor, Director of Consumer Affairs & Community Relations, Schnuck Markets, Inc., and Becky Bart, Ph.D., Assistant Member, Danforth Center.

**Moderator:** Chip Lerwick, Managing Director, Aon and Vice-Chair of the Danforth Leadership Council.

### BIG IDEAS - MEETING GRAND CHALLENGES

Three teams of scientists from the Danforth Center presented new ideas addressing big challenges in agriculture and the environment. The teams, composed of some of the best and brightest young scientists at the Danforth Center, engaged in a friendly competition to communicate their big ideas in creative, inspiring ways. A panel of interactive judges participated by selecting a top team to receive a grant to pursue their idea at the Center.

**Date:** Thursday, November 17, 2017

**Team Bart** (Becky Bart Lab) Dan Lin, Patricia Baldrich, Lee Douangkeomany

**Team Meyers** (Blake Meyers Lab) Anne Phillips, Ryan DelPercio, Nate Ellis

**Team Topp** (Chris Topp Lab) Jeff Berry, Margaret Frank, Mao Li

**Panelists:** Natalie DiNicola, President, DiNicola LLC, Vijay Chauhan, GlobalSTL Project Lead, BioSTL, and Tim Rodgers, former CEO and Co-Founder, Rodgers Townsend.



## 2017 FRIENDS COMMITTEE

### CHAIR
James R. von der Heydt

### CHAIR *EMERITUS*
Molly Cline, Ph.D.

### MEMBERS
A. Van Brokaw, III
Bruce Buckland
Harold R. Burroughs
Joan Culver
Ann Desloge
Adie Dietz
George Fonyo
Roberta (Robbye) Frank
Jane Goldberg
Gary Halls
Michael Kalishman
Ruth E. Kim
Jim Knight
M. Paul Kravitz
Ann Liberman
John W. Maupin
Jay Nouss, Jr.
Marie D. Oetting
Charles D. Van Dyke
Ambassador George Walker, III
Matt S. Wolfe

"IN 2017, THE FRIENDS COMMITTEE HAD A SUCCESSFUL YEAR OF ENGAGING OUR ST. LOUIS COMMUNITY AND BUILDING RELATIONSHIPS THROUGH CONVERSATIONS, OUR PLANTASIA GALA, AND OUTREACH ACTIVITIES, WHILE GROWING OUR DANFORTH SOCIETY MEMBERSHIP. CONTINUING TO BUILD THAT SUPPORT OF THE DANFORTH CENTER IS VITAL TO OUR REGION AND OUR WORLD. THANK YOU FOR YOUR CONTINUED SUPPORT."

-JAMES R. VON DER HEYDT,
*Chairman, Friends Committee*

## LEGACY ADVISORY COUNCIL

Kenneth J. Bower,
*Clayton Financial Group*
Stephen B. Daiker,
*Bryan Cave LLP*
Matthew G. Perlow,
*Husch Blackwell LLP*
Bud Strong,
*Husch Blackwell LLP*

## DANFORTH SOCIETY MEMBERSHIP COUNCIL

### CHAIR
Gary Halls

### MEMBERS
Molly Cline
Ann Desloge
Glenda Finnie
Glenn Fischer
George Fonyo
Roberta (Robbye) Frank
Timothy Halls
Phil Hellwege
Jim Knight
Paul Kravitz
John Maupin
James R. von der Heydt
Sarah Wendt
Kathleen Woodworth

"THE DANFORTH SOCIETY ENJOYED AN OUTSTANDING YEAR IN 2017, BOTH IN TERMS OF FIRST-TIME MEMBERS AND IN THE OVERALL GROWTH IN THE SOCIETY. IT IS A PLEASURE AND PRIVILEGE TO LEAD THE DANFORTH SOCIETY MEMBERSHIP COMMITTEE IN THIS EFFORT, WORKING WITH SO MANY COMMITTED INDIVIDUALS TO BETTER OUR WORLD AND OUR COMMUNITY. WE START 2018 WITH GREAT EXPECTATIONS TO CONTINUE THIS GROWTH."

-GARY HALLS,
*Danforth Society Membership Committee Chair*


# PLANTASIA *gala*

## 2017

With a shared commitment to food security and the environment, more than 220 supporters, scientific innovators, and guests filled the AT&T Auditorium on Saturday, October 21st to honor two leaders in this effort: Todd R. Schnuck, recipient of the Danforth Distinguished Service Award and Vicki Chandler, Ph.D., recipient of the Danforth Award for Plant Science.

Before presenting the Danforth Distinguished Service Award, John F. McDonnell, chairman of the Danforth Center, expressed his appreciation for Todd Schnuck's extensive efforts on behalf of the Center, including his service on the Board of Directors, its Executive Committee, chairing its Finance Committee, and his generous philanthropic support.

As Chairman and CEO of Schnuck Markets, Inc. Todd oversees the company's extensive philanthropic efforts, which include donating nearly 800,000 pounds of food each month to St. Louis-area food pantries and other agencies. John concluded his remarks by saying, "Given Todd's leadership of Schnuck Markets and at the Danforth Center, it is clear he is playing a leading role in advancing solutions to hunger and food security."

After Todd's acceptance remarks, Danforth Center president James C. Carrington, Ph.D., reflected on Vicki Chandler's exemplary scientific career and determination to succeed. Of Vicki's groundbreaking research in the field of epigenetics, Jim said, "Vicki's work underscores the importance of understanding how genes work and how we can use that information to improve crops, and to improve agriculture around the world."

## A NIGHT TO CELEBRATE SERVICE & SCIENCE

After receiving the Danforth Award for Plant Science, Vicki described both the rewards of science as a vocation and the challenges she faced, including being a single mother who lacked a high school diploma at the outset of her career. She cited a supportive network of fellow students who were also parents and the affordable tuition at community colleges and public universities as key to her success: "I was able to pursue important scientific questions because of the exceptional public education that was available to me in California at that time. It wasn't easy, but it was possible."

After the program, guests moved to the McDonnell Atrium, to enjoy dinner, dessert, and music. All celebrated amid laughter, good conversation, and great company, until the evening was brought to a close by remarks from Danforth Center president Jim Carrington, followed by the 2017 *Plantasia* co-chairs, Cari Wegge and Molly Cline.

A special thank you to our *Plantasia* co-chairs, committee members and sponsors.

## 2017 PLANTASIA COMMITTEE

### CO-CHAIRS

Molly Cline, Ph.D.
Cari Wegge

### MEMBERS

Jeanie & Van Brokaw
Kathi & David Broughton
Bruce Buckland
Teri Carrington
Ann Case
Susie & Andy Corley
Joan & David Culver
Jeanne & Carl Deutsch
Laura Enghauser
Glenda & Bill Finnie
George Fonyo
Gretta Forrester
Michele Gorski
Gary & Bonnie Halls
Anna Harris
Shirley & Phil Hellwege
Sally Higginbotham
Suzanne & Jim Johnson
Francine & Paul Kravitz
Susan & Robert Levin
Ann Liberman
Marie Oetting
Roy Pfautch
Sue Rapp
Stephanie Regagnon
Beth & Donn Rubin
Marie & Walter Schmitz
Susan & Mike Scully
Susanne & Charles Shepherd
Nanne Simonds
Margaret & William Sly
Moir Stevens
Teg & Frank Stokes
Margaret & Joe von Kaenel
Nancy & Bob Wagoner

*The Danforth Center is grateful to everyone involved in the success of the 2017 Plantasia.*

## 2017 YOUNG FRIENDS STEERING COMMITTEE

**CHAIR**
Stephanie Regagnon

**VICE-CHAIR**
Logan O'Connor

**CHAIR *EMERITUS***
Michael Kalishman

**MEMBERS**
Tony Aiazzi
Jack Arnold
Melanie Bernds
David Culver
Erica Fishel, Ph.D.
Lyle Gulley
Kyra Hjelle
James Howe
Erin Jones
Anna Krane
Kevin Maher
Chip Mallin
Will McHargue
Davey Oetting
Molly Ortwerth
Harry Pettey
Teddy Potter
Andrew Rzonca
Dan Schindler
Carter Schmid
Tyler Short
Scott Smithson
Colin Tierney
Michael Williams
Irene Yu

## YOUNG FRIENDS RAISE AWARENESS AND SUPPORT

The Young Friends Steering Committee was founded to raise awareness of the Danforth Center's mission and impact among St. Louis professionals age 40 and under. At the Danforth Center, we aspire to improve the sustainability, availability, affordability and quality of food, especially for those in the world who are underserved.

Through hosting events, networking and personal engagement, the Young Friends Steering Committee is dedicated to increasing Danforth Center membership, active participation in Center sponsored events and the understanding of the Danforth Center's mission.

In 2017, the Young Friends hosted Party with the Plants on Friday, June 2. More than 175 guests enjoyed music, refreshments, networking and the opportunity to learn about our growing Missouri tall grass prairie. Proceeds from the event supported the Danforth Center Innovation Fund, which includes the Center's Community Garden.

On Thursday, October 5, Yoga Buzz, a non-profit organization committed to sharing yoga as a tool for increasing well-being and resiliency, teamed up with the Young Friends to host a night of stretching and breathing in an hour-long, all-levels yoga class followed by a cocktail reception with Danforth scientists and 50 yogis.

Concluding the year, the Young Friends took time out to assemble care kits for Operation Food Search, the partner and the recipient of food grown in the Community Garden on campus, followed by a lively happy hour celebration of 2017 activities.

"THE YOUNG FRIENDS COMMITTEE OF THE DANFORTH CENTER EXPERIENCED A TRANSFORMATIONAL YEAR IN 2017. IT'S AN AMAZING TIME TO BE ENGAGED WITH SUCH IMPORTANT AND NOBLE WORK. THE SCIENTISTS AND STAFF OF THE CENTER ARE WORKING TO CREATE A MORE PRODUCTIVE AGRICULTURE SYSTEM, A MORE RESILIENT ENVIRONMENT AND DOING IT ALL OUT OF A THRIVING PLANT SCIENCE AND INNOVATION ECOSYSTEM RIGHT HERE IN ST. LOUIS. THE YOUNG FRIENDS COMMITTEE IS PROUD TO HELP SPREAD THE WORD OF THEIR GLOBALLY SIGNIFICANT WORK TO YOUNG PROFESSIONALS IN OUR REGION AND BEYOND."

-STEPHANIE REGAGNON,
*Chair of the Danforth Center's Young Friends Committee*

If you are interested in becoming a member or want to learn more about the Young Friends Steering Committee, please contact Brigid Thayer, BThayer@danforthcenter.org or 314.587.1073.

## PRAIRIES, A NATURAL LABORATORY

Restoring native landscapes is a high priority at the Danforth Center and our six-acre native Missouri tall grass prairie showcases the vital connections between native landscapes, biodiversity and agriculture. The prairie includes many varieties of flowering plants and an enhanced ecosystem for 12 colonies of managed honey bees whose 500,000 foragers help pollinate thousands of acres surrounding the Danforth Center.

Tall grass prairies are a unique and complex ecosystem that protects the environment by providing rich soil, assisting healthy crops to thrive and providing thousands of products to our communities. Prairie grasses are hardy plants that tolerate drought and heat. They also have deep roots that store carbon and copious leaves that can be used for biofuels. The prairie grasses are close relatives of corn and sorghum; what we learn about one will ultimately apply to improving crops for food and fuel.

"The North American prairie is a natural laboratory for the identification of genes and traits associated with drought and heat resistance," said Michael McKain, an evolutionary biologist working in the Kellogg Lab. "Across the range of many prairie species, some of which are closely related to important crops like corn and sorghum, variation in precipitation and temperature has forced these plants to adapt to extreme heat and low water availability. By looking at evolutionary solutions to these increasingly common agricultural problems, we will be able to improve existing crops and prepare ourselves for climate change."

## NATIVE LANDSCAPES PRESERVING DIVERSITY

**1 of 8** Terrestrial ecozones of the Earth's surface

Grasslands covered **~25%** of Earth's land surface

**11,554** grass species

**30%** was Native Grassland

**Grasslands** occur naturally on all continents except Antarctica

**Benefits:**
- Preserve and renew biodiversity
- Reduce air and noise pollution
- Conserve water
- Protect wildlife habitats
- Low maintenance

**Conservation and Ecological Stewards:**
- **Intricate part of geobiochemical cycles:** Carbon, Nitrogen, Oxygen, Water, Phosphorus and Sulfur
- **Restore** diversity hot spots and **protect** endangered species
- **25-40 species** per square meter

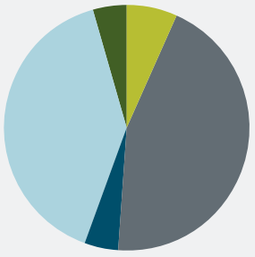
**Dynamic Global Native Landscapes:**
- African Savanna
- North American Prairie
- Central Eurasian steppes
- South America pampas
- Russian steppes
- Patagonia shrub steppes
- Mongolia grazing lands
- Australian grasslands

**The Soil Ecosystem Includes:**
Root systems, bacteria, fungi, microbes, mites, insect larvae, nematodes and earthworms

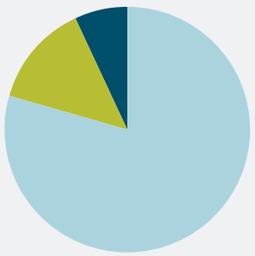
**All Naturally Enhance:**
Soil maintenance, fertilization, growth, minerals and water that enrich the plant community dynamics

# SELECTED FINANCIAL DATA

Fiscal year ended December 31, 2017
(Unaudited)



| UNRESTRICTED OPERATING REVENUES [1] | 2017 ($000's) Revenue | Source % |
|---|---|---|
| Donor Gifts | $2,015 | 6.7% |
| Research Grants and Contracts | $13,342 | 44.4% |
| Core Facility Fees | $1,397 | 4.7% |
| Draw from Endowment Appropriated for Spending | $12,002 | 40.0% |
| Other Income | $1,266 | 4.2% |
| Total Operating Revenues | $30,022 | 100.0% |



| OPERATING EXPENSES [2] | Expenditures | Expenditure % |
|---|---|---|
| Total Research/Science | $22,018 | 79.7% |
| Administration | $3,693 | 13.4% |
| Development and Public Relations | $1,910 | 6.9% |
| Total Expenses from Continuing Operations | $27,621 | 100.0% |

| CAPITAL EXPENDITURES | |
|---|---|
| Lab and Core Facility Equipment | $451 |
| Phase 2 Building | $482 |
| All Other | $115 |
| Total Expenditures | $1,048 |
| **NON-OPERATING EXPENDITURES** | |
| Debt Service Payments | $528 |
| **DEPRECIATION EXPENSE** | |
| Depreciation of Fixed Assets | $7,141 |

Notes:
1 Cash basis and excludes income (loss) on Endowment investments and reimbursement for subcontracted research.
2 Excludes subcontracted research on Grants and Contracts and Depreciation Expense.

This report was printed on a carbon-neutral, digital offset press using domestically made, recycled paper that is certified by the Forest Stewardship Council (FSC). The electricity used to produce this book has been offset 100% with Missouri wind energy credits procured from the Ameren Missouri PurePower program.



DONALD DANFORTH
PLANT SCIENCE CENTER

975 North Warson Road
St. Louis, Missouri 63132
**p. 314.587.1000**

www.danforthcenter.org