2016 ANNUAL REPORT

DONALD DANFORTH
PLANT SCIENCE CENTER

OUR MISSION | Improve the Human Condition through Plant Science

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.

The Donald Danforth Plant Science Center was founded in 1998 to harness the power of plants to make this balance possible.

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

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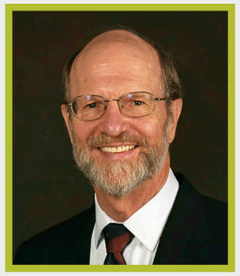


LETTER FROM THE CHAIRMAN

For the first time in Earth's history, a self-aware natural force – namely humanity – is shaping the present and future of our planet for better or worse. Our unprecedented control of our Earth is giving rise to tremendous global challenges, including a rapidly growing population that is consuming the world's resources at a rate greater than Earth's ability to replenish them.

Nearly twenty years ago Bill Danforth recognized the significance of these challenges. However, where some may have seen only insurmountable problems, he saw opportunities for human ingenuity to make a positive difference in the world. Inspired by scientific advances including the Green Revolution that saved millions of people from starvation, he and others founded the Donald Danforth Plant Science Center. Their vision of an institution that would help the planet and its people, while sparking new industries and strengthening the St. Louis region, guides the Center to this day.

From the start, the founders of the Center anticipated that collaborative efforts—with both commercial and other not-for-profit organizations—would be critical to achieving its mission. The past year saw outstanding examples of these efforts in partnerships between the Center and leading bioscience companies; in new initiatives to transfer scientific discoveries from the laboratory to the marketplace; and in science education programs for students in St. Louis Public schools. Furthermore, the plant science and ag tech innovation district that is forming around the Danforth Center now has a name: 39 North, signifying the 39th latitude parallel on which the Danforth Center resides and which is a productive agricultural zone around most of the world. You will find more information about the master plan for the district in Jim Carrington's "Letter from the President" as well as in the pages that follow.

In addition to vision and collaboration, another factor is essential to ensuring human health and a sustainable environment through plant science: the support and dedication of donors and volunteers. Without your willingness to contribute your "wealth, wisdom, and work," the achievements and highlights described in this report would not be possible. I hope you find them as exciting and inspiring as I do.

LETTER FROM THE PRESIDENT

I have been thinking a lot recently about technology and how it has evolved in agriculture over our lifetimes. Many with whom I speak ask, why do we even need technology in agriculture? The answers are fairly straightforward.

Without technology developed since 1960, the year I was born, we would need twice as much farm land - an *additional* 900 million acres - because agriculture today yields over twice as much product per acre. We would also need nearly twice as much irrigation water from lakes, rivers and groundwater sources, because technology has given us far better ways to use and manage water. And without innovations in plant breeding since 1960, allowing much faster development of climate-resilient and disease-resistant crops, we would have had decades of instability in production of most of our crops and livestock.

As human populations increase and consumer expectations for better diets rise around the world, technology that has yet to be invented will be needed to sustainably increase food supplies by nearly 70% after one more generation. Our Grand Challenge is not just providing food security for a growing, changing world, but rather, doing so while also preserving environmental health around the planet.

The Danforth Plant Science Center is here to meet this challenge, through the creative and purposeful use of plant science, and I am proud of recent achievements highlighted in this report. But meeting this challenge will also require aggressive investment in the private sector, including innovative start-up companies, and implementation of high-yielding, nature-compatible technologies that grow and maintain yields while also building soil, preserving water, and reducing greenhouse gas emissions. To this end, we are excited that the Danforth Center helps anchor 39 North, the innovation district encompassing nearly 600 acres around the Center (see p. 25). The district shines a bright light at the intersection between technology, the environment, and the farm.

Thank you to all of our scientists, staff, volunteers, partners and supporters for your hard work and dedication, and for contributing to a community that is changing the world.

INVESTING TO ACCELERATE DISCOVERY

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

"WE ARE UNIQUELY CAPABLE OF TRANSLATING DISCOVERIES IN BASIC PLANT SCIENCE TO THE REALITY OF FOOD SECURITY FOR PEOPLE AND ENERGY TO POWER PROGRESS WHILE PRESERVING OUR LIFE-SUSTAINING ENVIRONMENT THROUGH SCIENTIFIC INNOVATION AND THE GENEROSITY OF THE HUMAN SPIRIT."

-JIM CARRINGTON, PH.D.
President of the Danforth Center

NEW SPACE TO SPEED THE PACE

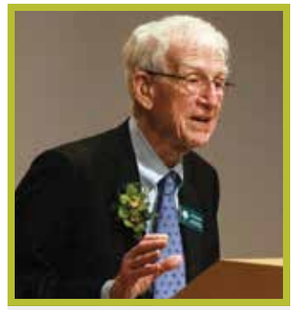
On April 15, leadership, scientists and supporters of the Danforth Center dedicated the new William H. Danforth Wing, named in honor of the Founding Chairman whose vision catalyzed the formation of the Center in 1998.

The enthusiasm generated by the events of dedication week—including a scientific symposium, the installation of two distinguished investigators and an open house for the public—remind us that the Danforth Center is not simply a research institute. It is a community of scientists, supporters, volunteers and staff who share the belief that scientific discovery and the generosity of the human spirit have the power to create a better world for people everywhere.

The $45 million addition will strengthen and expand priority research areas, provide the capacity and technology to accelerate outcomes and advance the Danforth Center as a collaborative hub that connects regional, national and international partners. "Completion of the new wing is a major step in our long-range plans to increase our impact through plant science," said James Carrington, Ph.D., president of the Danforth Center. "The new space will increase our capacity for research in crop improvement, sustainable agriculture and plant biology. The new facilities will also help attract the best scientific teams as we grow in the years ahead."

The overall expansion project includes a significant redesign of the Danforth Center's landscape through reconstruction of a native Missouri tall grass prairie. The six-acre prairie will showcase the vital connections between native landscapes, biodiversity and agriculture and provide an enhanced ecosystem for beehives located on campus. Renovation of the Kemper Water Garden features aquatic grasses and a boardwalk.

The ongoing expansion is funded entirely through private donations and $4.5 million in Contribution Tax Credits from the state of Missouri. "What better way to celebrate Bill Danforth than by contributing to the institution he conceptualized, founded and nurtured to its present status as one of the leading plant science research organizations in the world – and a critical contributor to sustainably providing the food and energy the world will need during the next 100 years or more," said John McDonnell, chairman of the board of directors.



"WE SEE GRAND OPPORTUNITIES TO USE SCIENCE TO BENEFIT HUMANKIND – TO FEED THE HUNGRY, TO PROTECT THE WORLD'S ENVIRONMENT AND TO PROVIDE DISCOVERIES THAT WILL HELP SPARK THE NEXT GENERATION OF SCIENCE-BASED INDUSTRY."

-DR. WILLIAM H. DANFORTH
Founding Chairman

DISTINGUISHED INVESTIGATORS INSTALLMENT

-NIGEL TAYLOR, PH.D.
Dorothy J. King Distinguished Investigator

-ELIZABETH (TOBY) KELLOGG, PH.D.
Robert E. King Distinguished Investigator

OUR MISSION | IMPROVE THE HUMAN CONDITION THROUGH PLANT SCIENCE

THE SYSTEM IS THE FIRST OF ITS KIND IN THE U.S. ACADEMIC RESEARCH SECTOR DEDICATED TO PLANT SCIENCE.

VALENT BIOSCIENCES AND DANFORTH CENTER COLLABORATE IN UNIQUE ROOT SCIENCE INITIATIVE

Historically, plant scientists have focused on plants from the ground up with the result that comparatively little is known about roots, which play a key role in absorbing nutrients and moisture necessary for plant growth and overall health.

Valent BioSciences Corporation (VBC) and the Danforth Center are collaborating in the area of root science and the rhizosphere. VBC is a wholly-owned subsidiary of Sumitomo Chemical Company and a global leader in the research, development and commercialization of biorational technology for agriculture, public health and forestry.

"We are pleased to be entering into this agreement with a partner that has such demonstrated success in plant science innovation," said James Carrington, Ph.D., president of the Danforth Center. "We view our imaging work as a potentially game-changing technology that warrants a collaborator with a global view and a full complement of proven, effective technologies to help us improve the human condition through plant science."

"THIS PROJECT WILL ALSO ADVANCE RESEARCH IN ROOT AND TUBER CROPS SUCH AS CASSAVA, POTATO, GROUNDNUT AND OTHERS THAT ARE IMPORTANT FOR FOOD SECURITY IN MANY REGIONS AROUND THE GLOBE, BUT ARE ESPECIALLY HARD TO STUDY."

-CHRISTOPHER TOPP, PH.D.

Until now, the only way for plant scientists to observe in-field root development has been to extract plants from the soil. Today's advanced imaging technology allows real-time data gathering in a way that is non-destructive and non-disruptive to future plant development.

Danforth Center Principal Investigator Chris Topp, Ph.D., was awarded a grant from the National Science Foundation (NSF) to support his work combining root phenotyping technologies with computational analysis, quantitative genetics and molecular biology to understand root growth and physiology.

The NSF and VBC agreements jointly funded the large-scale X-ray imaging system for non-invasive root measurements, the first of its kind dedicated for plant science in the U.S. academic research sector.

"X-ray imaging has been a mainstay in medical and industrial research and diagnostics for many decades, yet it is rarely used in plant science," said Topp. "The X-ray CT system allows us to 'see' roots in soil and study plants as a connected system of roots and shoots growing in diverse environments. From there we can tackle the big problems like growing crops with less water and fewer other inputs or on marginal soils, since solutions to these problems all start with the roots."

The partnership includes installation of an industrial-scale X-ray Computed Tomography (X-ray CT) system at the Danforth Center. Keith Duncan, a research scientist in the Topp Lab who serves as the manager of the new facility, noted that, "This system is unlike any other in the United States. It gives us a great deal of control over the X-ray conditions and will allow us to gather structural data on any object we put into the machine. It provides us with an internal look at not only the root systems, but what's going on inside the stem and other parts of the plant. "

The agreement between Valent and the Danforth Center is designed to maximize outcome potential by integrating core competencies from within the two organizations: The Danforth Center focuses on discoveries and technologies for improving agricultural productivity with minimal environmental impact including new research on non-destructive imaging technology for root growth dynamics; over the last two years, VBC has made significant commitments to rhizosphere technologies including the acquisition of Mycorrhizal Applications, LLC (MA) and several licensing and research agreements designed to accelerate its root zone portfolio.

Through MA and SyMyco Inc., a joint venture in which MA participates, VBC brings the world's foremost experts in the study and propagation of mycorrhizae – beneficial fungi that colonize plant roots to enhance nutrient uptake and water efficiency.

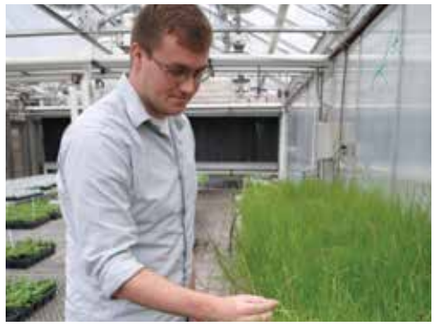
"THERE IS AN OBVIOUS OVERLAP IN MISSION AND PURPOSE BETWEEN THE TWO ORGANIZATIONS, AND OUR KNOWLEDGE AND RESPECTIVE TECHNOLOGIES ARE COMPLEMENTARY. TOGETHER, THEY HOLD TREMENDOUS POTENTIAL FOR OUR STAKEHOLDERS."

-WARREN SHAFER, PH.D.

President of R&D and Regulatory Affairs, Valent BioSciences

"IF WE NEED TO FEED MORE PEOPLE, PLOWING UP LAND IS NOT AN OPTION," SAID ELIZABETH KELLOGG, PH.D., LEAD ON THIS COLLABORATION WITH THE USGA TEAM. "IF YOU CAN KEEP CROPS GROWING ON (SALTY) SOIL, THEN YOU'VE EXPANDED YOUR AGRICULTURAL LAND."

UNITED STATES GOLF ASSOCIATION TAPS DANFORTH CENTER TO IMPROVE COURSE SUSTAINABILITY



The United States Golf Association (USGA), Turfgrass and Environmental Research Program is collaborating with the Danforth Center and Washington University in St. Louis to improve the highly salt-tolerant grass seashore paspalum. This turf grass is often used in coastal golf courses and was used at the 2016 Olympic Games in Rio de Janeiro, to improve turf varieties. Scientists are only beginning to understand the genetic basis of salt tolerance, especially in species that demonstrate salt-tolerance such as seashore paspalum.

- 2,000 hectares of land are lost to soil salinization globally each day.
- In 2014, over 150 million acres of irrigated land — roughly the size of France — was spoiled by salt.

Using genome mapping, scientists will seek to identify ways to produce turfgrass varieties that require less fresh water and fewer chemical treatments. This research also has the potential to be applied to other members of the grass family, including cereal crops, such as maize or wheat.

"Increasing the effectiveness of turfgrass breeding and genetic research and using whole genome data will provide genetic tools not commonly seen in recreational sports, which could have global impact," said Michael Kenna, Ph.D., research director, USGA.

STONY CREEK COLORS ESTIMATES BY THE YEAR **2021**, INDIGO WILL BE GROWING ON MORE THAN **26,000** ACRES AND INCREASE DEMAND FOR THEIR NATURAL INDIGO SOLUTION AS CUSTOMERS SHOP FOR MORE SUSTAINABLE AND NATURAL FASHION.

NSF SUPPORTS PARTNERSHIP OF DEVELOPMENT OF BIO-BASED INDIGO

Stony Creek Colors, a manufacturer of bio-based textile dyes, and Danforth Center researchers received a one-year grant of $224,676 from the National Science Foundation (NSF), Division of Industrial Innovation and Partnership (IIP) to make the manufacturing of blue jeans more sustainable by improving the available genetic resources for plant-based indigo dye production.

- Nearly all of the indigo dye used to dye yarns for denim jeans globally is chemically synthesized from petroleum derivatives and toxic chemicals.
- The Danforth Center will improve the understanding of the genetics of the existing indigo plant stocks through DNA analysis of specific high-yielding plant varieties.

"Our bio-based dyes improve profitability and ecosystem health for farmers, while empowering designers, brands, and mills with greater transparency and traceability," said Sarah Bellos, CEO and founder, Stony Creek Colors. "This allows us to innovate and scale-up natural dyes that clean up the fashion industry, tout full integrity and contribute to a thriving future."

BELLWETHER PLANT GROWTH FACILITY ADVANCES FOOD SECURITY AND SUSTAINABILITY RESEARCH

In mid-September, as part of its ongoing major expansion, the Danforth Center completed construction of the Bellwether Plant Growth Facility, which houses 34 walk-in and reach-in growth chambers. By providing much-needed space and advanced features that enable Center scientists to test plant productivity in virtually any terrestrial environment, the new facility is critical to accelerating the pace of scientific discovery in the areas of food security and renewable bioenergy. It is at the cutting-edge for both non-commercial and commercial organizations and was custom designed with input from Danforth Center research scientists and greenhouse and facilities staff.

The Bellwether Foundation provided generous funding for the plant growth facility, which builds on a strong partnership between the organization and the Danforth Center. In 2013, the Center opened the Bellwether Plant Phenotyping Facility, a high-tech facility comprised of a fully climate controlled growth house integrated with a multi-camera digital imaging system. The automated, high-throughput platform, which enables non-destructive image capture and analysis of up to **1,140** small to medium-sized plants, has been instrumental in helping Center scientists secure major grant funding for research on drought resistance in major crops as well as other projects that aim to make agriculture more environmentally sustainable.

FEATURES OF THE NEW GROWTH CHAMBERS:

- High and low temperature ranges that increase the Center's capacity for abiotic stress testing, including extremes of heat and cold
- The capacity to adjust CO2 levels from 100 parts per million to 3,000 parts per million
- LED lights that allow for manipulation of the light spectrum to test shade adaptation and other qualities
- A dark room that simulates night and low-light conditions for greater understanding of photosynthetic capability
- Dimensions that accommodate both short and tall plants such as maize and sorghum in anticipation of increased research interest in these important crops
- Auto-irrigation in each chamber for superior drought testing capacity

CORE TECHNOLOGIES:

State-of-the-Art Instrumentation and Expertise to Accelerate Crop Improvement

Bellwether Foundation Plant Phenotyping

Integrates high-throughput robotics, imaging, computer vision and analytic technologies of up to 1,140 plants in a custom platform to identify the key traits that affect plant productivity and resilience to environmental stress.

Integrated Microscopy

Provides high resolution imaging with both confocal and electron microscope analysis of cell biology, critical for understanding how proteins work within the community of molecules contained in plant cells.

Bioinformatics

Consists of 1,300 processors, 8 terabytes of memory and 288 terabytes of storage providing the essential horsepower to analyze vast amounts of information — big data — critical to understanding genome function in plants.

Plant Growth

Manages over 100 species in 47,530 sq.ft. of greenhouse space, 18 walk-in growth chambers, 33 reach-in growth rooms, along with expert plant care for 20+ Danforth labs internally and 15 external organizations' plants.

Proteomics & Mass Spectrometry

Collaborates with researchers from academia and industry to facilitate the exploration of complex biological systems through qualitative/quantitative proteomics and metabolomics analysis, and high-quality biomolecule analyses, producing first-rate publication quality results.

Tissue Culture & Transformation

Utilizes an array of in vitro cell and tissue culture systems to transform 13 crop and model plant systems.

GROWING OUR SCIENTIFIC COMMUNITY

The Danforth Center inspires trains tomorrow's scientists. Our internship and graduate student programs attract students from around the world. We serve more than **2,000** students locally through our education and outreach programs. Many of these students are inspired to follow careers in plant science.

"TRULY WE ARE LIVING IN A NEW AGE IN WHICH FOR THE FIRST TIME IN EARTH'S HISTORY A SELF-AWARE NATURAL FORCE – NAMELY US – IS SHAPING THE PRESENT AND FUTURE OF OUR PLANET – FOR BETTER OR FOR WORSE."

-JOHN MCDONNELL
Chairman of the Board of Directors

THE VISION FOR A PLANT SCIENCE LEGACY

On the occasion of the dedication of the William H. Danforth Wing at the Danforth Center, family and friends of the wing's namesake as well as Center scientists and supporters expressed their admiration and gratitude for the founding chairman's tireless efforts to make the Center a best-in-class organization. The Danforth Center—the largest independent, not-for-profit plant science research institute in the world—is the result of Dr. Danforth's vision that scientific knowledge when applied to solving critical challenges, has the potential to lift families, communities and nations from poverty and empower people everywhere to enjoy better health and a higher quality of life.

"THE DANFORTH CENTER STARTED IN A REALLY TYPICAL WAY. WHEN BILL CALLED ME AND SAID, 'I HAVE AN IDEA. WHY DON'T WE DEVELOP ST. LOUIS AS A CENTER FOR PLANT SCIENCES?' HE HAD A VISION, AND HE UNDERSTOOD THAT ONE OF THE REAL IMPERATIVES FOR THE FUTURE OF OUR WORLD WAS THE PROBLEM OF HUNGER AND HOW TO SOLVE IT,"

-VIRGINIA V. WELDON, M.D.,
Retired Senior Vice President, Monsanto Company

The Danforth Center aims to improve human health and protect the environment through creative science and its thoughtful application. Interactive teams of scientists develop unique platforms to discover underlying principles about how plants thrive. Then the Center works to convert that knowledge into useful crops and products, and partner with organizations that are best positioned to solve problems where they exist around the world. This approach is leading to more productive staple crops that provide better nutrition, more sustainable crops that have a smaller environmental footprint, new companies created to bring discoveries and innovative technologies to market and training of next-generation plant scientists who will advance plant science in the future.

"I think of him as a hero, because he could have done something else, but he chose to help other people through his vision and through his purpose for life," said Getu Duguma, Ph.D., research manager of the Institute for International Crop Improvement of the Danforth Center.

In remarks at the dedication of the new wing, Dr. Danforth expressed his appreciation for family, colleagues and friends who share their time, talent and generous gifts to enable the Center's continued progress.

Malia Gehan, Ph.D., assistant member, Danforth Center, noted, "When you have incredible facilities that are possible because of the generosity of our donors, it means that the community is behind you and supports you in your research. It is a very powerful thing."

"BILL NEVER STOPS THINKING ABOUT WHAT CAN BE DONE TO SECURE ST. LOUIS FOR THE FUTURE."

-DR. ROBERT VIRGIL
Board of Directors of the Danforth Center

TRAINING AND DEVELOPMENT OF YOUNG SCIENTISTS

ALEXANDRA ASARO

2016 William H. Danforth Plant Science Fellow

Alexandra Asaro, a graduate student at Washington University in St. Louis, was named the 2016 William H. Danforth Plant Science Fellow. The fellowship was endowed in honor of Dr. Danforth by Dr. P. Roy and Diana Vagelos, longtime leaders in philanthropic giving for scientific and medical research and education and supports outstanding Ph.D. students whose research demonstrates great promise for advancing plant science.

Dr. Vagelos and Dr. Danforth share a long friendship and many interests, including the potential for science to improve human health and wellbeing. When the Danforth Center was established in 1998, Dr. Danforth recruited his trusted friend and colleague to join the Board of Directors, where they worked together to advance the Center's mission to improve the human condition through plant science. Vagelos retired from the Board in 2014.

When Asaro began her third rotation in the laboratory of Ivan Baxter, Ph.D., USDA-ARS research scientist and an associate member at the Center, she discovered a new interest in ionomics and computational analysis.

Asaro's work will develop an understanding of the mechanisms that shape ionomic variation among different environments. This knowledge is especially important for selective breeding, as optimization of specific traits requiring consideration of cases in which genetic loci have varying effects depending on the environment.

AFRICAN WOMEN IN AGRICULTURE RESEARCH

AWARD
African Women in Agricultural Research and Development

In June of 2016, the Danforth Center welcomed three outstanding scientists from Africa as part of African Women in Agricultural Research and Development (AWARD), a training and mentoring program for top female plant scientists from across sub-Saharan Africa.

Catherine Taracha traveled from Kenya to be a member of the Carrington Lab. She is working to improve food security and reduce poverty through research aimed at developing insect resistant maize.

"Women are a bit left behind in the field of science, so being surrounded by women in this fellowship has allowed us to share our experiences and build up our confidence," said Taracha. "AWARD maximizes your potential."

Ngozi Edoh from Nigeria worked in the Proteomics and Mass Spectrometry core facility on the Center's cassava research programs. In sub-Saharan Africa, more than 250 million people rely on cassava as a primary source of calories and as a source of income.

Ihuoma Okwuonu, also from Nigeria, worked in the Taylor Lab and Bart Lab to apply biotechnology approaches to improve cassava's agricultural productivity.

"I'm so thankful for the opportunity to study at the Danforth Center," said Okwuonu. "I want to work and work and work because the environment is so inspiring. Things are well organized and people are so willing to help – especially the senior colleagues. I've learned a lot working in both labs and in the Tissue Culture and Transformation core facility."

All three women agree that knowledge of the technologies acquired has been an essential part of their time at the Danforth Center. From CRISPR–Cas genome editing to genomics and metabolomics, the fellowship exposed them to cutting-edge techniques and procedures that they would not have the opportunity to learn elsewhere. "I'll be able to know the targeted varieties of cassava to work on when I return home. That will enable me to look further into the crop and cross it with other varieties to improve food security in my region," said Edoh.

"Being an AWARD member is about more than just the advanced scientific training," commented Okwuonu. "Yes, it gives you the opportunity to get practical, hands-on training through conferences, workshops and science-field training, but it's really all about impact. We take what we've learned here and share it with our colleagues back home to keep the momentum going."

2016 EDUCATION AND OUTREACH PROGRAMS REACHED

2,263

STUDENTS IN

78

SCHOOLS AND HOSTED

15

PROFESSIONAL DEVELOPMENT WORKSHOPS

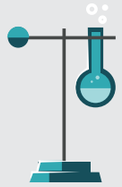
EDUCATION AND OUTREACH PROGRAMS

Hands-on, inquiry-based scientific learning experiences provided through Science and Education Outreach programs at the Donald Danforth Plant Science Center enable students to become scientists. The curriculum packages offered teach important skills such as critical thinking, developing and testing hypotheses, observing outcomes, communicating results, lab etiquette and teamwork.

GROWING OUR SCIENTIFIC COMMUNITY:
Educating and Training Young Scientists to Solve Global Challenges

UNDERGRADUATE AND GRADUATE EDUCATION

Training infuses all of the Danforth Center's research programs, and students come from around the world.



GRADUATE STUDENT EDUCATION

First-year graduate students at **Washington University in St. Louis, University of Missouri-St. Louis,** and **University of Missouri** have the opportunity to do short rotations in Danforth Center labs relevant to a variety of topics including genomics, biochemistry, chemistry, mathematics, statistics and engineering.

RESEARCH EXPERIENCE FOR UNDERGRADUATES

This **11-week** intensive summer program funded by NSF combines original research with educational experiences and mentorship.

90% of interns are currently pursuing degrees in science or are working full-time in the field of science.

K-12 & CITIZEN SCIENCE

The Center's outreach and education programs bring cutting-edge science to K-12 classrooms across the St. Louis region.

PROGRAMS

- GREEN MEANS GROW
- GIRLS STEAM AHEAD
- MUTANT MILLETS!
- MO DIRT
- TECH TRUNKS
- ST. LOUIS RASPBERRY PI JAM

LARGEST CLASS OF UNDERGRADUATE STUDENTS TRAINED IN 2016 INTERN PROGRAM

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 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 2016 REU SUMMER INTERNSHIP PROGRAM WAS ORGANIZED BY SONA PANDEY, PH.D., REU DIRECTOR, ASSOCIATE MEMBER AND PRINCIPAL INVESTIGATOR; CHRIS TOPP, PH.D., REU CO-DIRECTOR, ASSISTANT MEMBER AND PRINCIPAL INVESTIGATOR AND CATHY KROMER, GRANTS MANAGER.

Discover the *Research Experience for Undergraduates* (REU) 2016 by the numbers:

- The Center hosted 26 interns, an increase of 62% in class size since 2003.
- Individuals were selected from a competitive pool of 192 applicants, quadrupling the number since inception.
- 15 interns were supported by REU funding, four by a generous grant from the Mallinckrodt Corporation, six through Principal Investigators (non-REU); one intern received an individual fellowship.
- 58% of the interns were from schools that have limited research opportunities.
- 23% of the interns were from underrepresented minority groups.
- A recent survey shows 87% of former interns are working in a STEM career or pursuing a degree in STEM.
- From 2009-2015, 15 out of 188 interns received the prestigious National Science Foundation graduate research fellowship award.

THE PROGRAM IS MADE POSSIBLE THROUGH GENEROUS SUPPORT FROM THE NATIONAL SCIENCE FOUNDATION. WE ARE PROUD OF THE WORK COMPLETED BY OUR 2016 INTERNS, WHO CAME FROM A VARIETY OF COLLEGES AND UNIVERSITIES:

Sarah Bell
University of Missouri-St. Louis

Abigail Eaker
University of Missouri-St. Louis

Aidan Estelle
Oberlin College

Armahni Fearn
Saint Louis University

Halley Fowler
University of Missouri-St. Louis

Morgan Fuehne
University of Illinois at Urbana-Champaign

Luke Hayden
Indiana Wesleyan University

Allison Huskey
Missouri Baptist University

Lynsey Kovar
New Mexico State University

Laura Krings
Carthage College

Molly Kuhs
Washington University in St. Louis

Trevor Manz
Kenyon College

Kari Miller
Truman State University

Michael Miller
University of Nebraska-Lincoln

Rebekah Mohn
Miami University

Blake Oakley
North Carolina State University

Stephen Plassmeyer
Truman State University

Jacob Roth
Harvey Mudd College

Raj Singh
University of Central Arkansas

David Stroshein
Lawrence Technological University

Nicholas Talmo
Augsburg College

Monica Tessman
Milwaukee School of Engineering

Stephanie Theiss
University of Missouri-St. Louis

Hannah Thomas
Pittsburg State University

Sylvia Wilson
University of Kentucky

Kristina (Tina) Zudock
Washington University in St. Louis

SCIENTIFIC DISCOVERY AND ACHIEVEMENT

Addressing grand challenges at the nexus of food, water and energy starts with scientific discovery. Danforth Center scientists are committed to understanding how plants function and adapt to changing environments, and to converting that knowledge into more productive crops to sustainably feed growing populations and power a changing world.

"WE KEEP ADDING GOOD THINGS AND IT KEEPS GETTING EVEN BETTER. WE'RE ON THIS WONDERFUL CYCLE OF INCREASED POTENTIAL, INCREASED EXPLORATION, INCREASED INFRASTRUCTURE, INCREASED FACILITIES AND INCREASED TALENT."

-REBECCA BART, PH.D.
Assistant Member

2016 DANFORTH PRINCIPAL INVESTIGATORS

DOUGLAS ALLEN, PH.D.
USDA-ARS Research Scientist and Associate Member

The Allen lab developed a new method to quantify metabolites involved in fatty acid biosynthesis that is important for lipid production.

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 worked to overcome existing and emerging impediments to the free exchange of scientific ideas, tools and data while helping to advance the careers of young scientists.

119
SCIENTIFIC PUBLICATIONS IN 2016, FOR A TOTAL OF
685
RESEARCH ARTICLES PUBLISHED IN 7 YEARS

REPRESENTATIVE PUBLICATIONS FROM 2016 (selected listing below)

Asaro, A., Ziegler, G., Ziyomo, C., Hoekenga, O., Dilkes, B., and Baxter, I. (2016). The interaction of genotype and environment determines variation in the maize kernel ionome. G3 (Bethesda) 6, 4175-4183. doi:10.1534/g3.116.034827.

Campo, S., Gilbert, K.B., and Carrington, J.C. (2016). Small RNA-based antiviral defense in the phytopathogenic fungus *Colletotrichum higginsianum*. PLoS Pathog 12, e1005640. doi:10.1371/journal.ppat.1005640.

Couso, I., Evans, B., Li, J., Liu, Y., Ma, F., Diamond, S., Allen, D.K., and Umen, J.G. (2016). Synergism between inositol polyphosphates and TOR kinase signaling in nutrient sensing, growth control and lipid metabolism in Chlamydomonas. Pl Cell 28, 2026-2042. doi:10.1105/tpc.16.00351.

Hackenberg, D., McKain, M.R., Lee, S.G., Roy Choudhury, S., McCann, T., Schreier, S., Harkess, A., Pires, J.C., Wong, G.K., Jez, J.M., Kellogg, E.A., and Pandey, S. (2016). Gα and regulator of G-protein signaling (RGS) protein pairs maintain functional compatibility and conserved interaction interfaces throughout evolution despite frequent loss of RGS proteins in plants. New Phytol doi:10.1111/nph.14180.

Huang, H., Yoo, C.Y., Bindbeutel, R., Goldsworthy, J., Tielking, A., Alvarez, S., Naldrett, M.J., Evans, B.S., Chen, M., and Nusinow, D.A. (2016). PCH1 integrates circadian and light-signaling pathways to control photoperiod-responsive growth in Arabidopsis. eLife 5, e13292. doi:10.7554/eLife.13292.

Kilgore, M.B., Holland, C.K., Jez, J.M., and Kutchan, T.M. (2016). Identification of a noroxomaritidine reductase with Amaryllidaceae alkaloid biosynthesis related activities. J Biol Chem 291, 16740-16752. doi:10.1074/jbc.M116.717827.

Li, Y., Liu, D., López-Paz, C., Olson, B.J., and Umen, J.G. (2016). A new class of cyclin dependent kinase in Chlamydomonas is required for coupling cell size to cell division. eLife 5, e10767. doi:10.7554/eLife.10767.

Mutka, A.M., Fentress, S.J., Sher, J.W., Berry, J.C., Pretz, C., Nusinow, D.A., and Bart, R. (2016). Quantitative, image-based phenotyping methods provide insight into spatial and temporal dimensions of plant disease. Plant Physiol 172, 650-660. doi:10.1104/pp.16.00984.

Sebastian, J., Yee, M.C., Goudinho Viana, W., Rellan-Alvarez, R., Feldman, M., Priest, H.D., Trontin, C., Lee, T., Jiang, H., Baxter, I., Mockler, T.C., Hochholdinger, F., Brutnell, T.P., and Dinneny, J.R. (2016). Grasses suppress shoot-borne roots to conserve water during drought. Proc Natl Acad Sci U S A 113, 8861–8866. doi:10.1073/pnas.1604021113.

Zhang, Y., Xia, R., Kuang, H., and Meyers, B.C. (2016). The diversification of plant NBS-LRR defense genes directs the evolution of microRNAs that target them. Mol Biol Evol 33, 2692-2705. doi:10.1093/molbev/msw154.

THOMAS BRUTNELL, PH.D.

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

The Brutnell lab developed novel computational tools and model systems 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, epigenetic mechanisms and how crops can be improved to increase productivity.

DAN CHITWOOD, PH.D.

Assistant Member

The Chitwood Lab focused on creating a comprehensive theory of plant morphology, accounting for cellular, developmental, evolutionary, genetic and environmental factors affecting the plant form.

ANDREA EVELAND, PH.D.

Assistant Member

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

ELIZABETH KELLOGG, PH.D.

Robert E. King Distinguished Investigator, Member

The Kellogg lab studied the genomes of prairie grasses and crop 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 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 studied plant reproduction and fertility, as well as signaling in disease resistance, using experimental and computational approaches.

TODD MOCKLER, PH.D.

Geraldine and Robert Virgil Distinguished Investigator, Member

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

DANFORTH CENTER EXPANDS WITH NEW PRINCIPAL INVESTIGATORS

MALIA GEHAN, PH.D.

The Danforth Plant Science Center welcomed the addition of two principal investigators, Ru Zhang, Ph.D. and Malia Gehan, Ph.D. Both scientists bring significant expertise in plant genomics and phenomics, and strengthen the Center's focus on agricultural productivity and sustainability in changing environments.

"We are implementing the next phase of our expansion with the hiring of two terrific scientists," said James Carrington, Ph.D., president of the Danforth Center. "They both bring new technologies, approaches and expertise that fit well with the priorities of the Center, and they are exceptional collaborators who will build strong scientific research programs."

Gehan will focus on understanding and improving temperature stress tolerance of plants, including cereals and underdeveloped crops like quinoa, and will develop new technologies that expand the Center's investment in phenotyping. From 2012 to 2015, she has served as a National Science Foundation Plant Genome Initiative postdoctoral fellow in Todd Mockler's laboratory at the Danforth Center. She co-founded the Center's Maker Group and has made many contributions to education and outreach programs. Gehan received a Ph.D. in plant biology at Michigan State University and a bachelor of arts in biology at Willamette University, Salem Oregon.

RU ZHANG, PH.D.

"I am so excited for the opportunity to grow a research program here," stated Gehan. "It has been a privilege to work with the outstanding researchers and staff here at the Danforth Center. I am looking forward to expanding collaborations here and to continuing many of the outreach programs we have started."

Zhang's research focuses on understanding the mechanisms of photosynthesis in unicellular and multicellular plants. In addition to photosynthesis, her expertise lies in spectroscopic techniques, algal genomics and organelle evolution. "I am interested in how photosynthesis in higher plants and green algae respond to stresses, like high temperatures," said Zhang. "The understanding of photosynthesis in these organisms could help make the process more efficient and robust under challenging environmental conditions, which in turn can improve food and biomass production."

Zhang was named a Carnegie Institution for Science postdoctoral associate in 2010 and received her Ph.D. in plant physiology and biochemistry in 2009 from the University of Wisconsin, Madison.

"We are delighted Malia and Ru joined the faculty at the Danforth Center," said Toni Kutchan, Vice President of Research and Oliver M. Langenberg Distinguished Investigator. "They bring such high levels of energy and creativity to their scientific research, and that is central to the success of our mission as we go forward."

TONI KUTCHAN RECOGNIZED AS A YWCA LEADER OF DISTINCTION

Each year the YWCA of Metropolitan St. Louis honors women for their outstanding contributions in the workplace and the community. Toni Kutchan, Ph.D., vice president of research and Oliver M. Langenberg Distinguished Investigator was named a Leader of Distinction at the 36th annual YWCA Leader lunch. Kutchan was celebrated for her achievements in science and helping other women reach their full potential.

Kutchan specializes in medicinal plants and the biosynthesis of plant compounds. She was named to the prestigious German Academy of Science, the Leopoldina and has published some 130 peer-reviewed articles and sits on numerous international scientific boards.

She enjoys mentoring young people in the lab, especially young women and post-doctoral associates. Having no female role models in the lab herself, Kutchan makes sure that is not the case in her lab today. In addition, she leads a STEM program for the Girl Scouts of Eastern Missouri to introduce young minds to the joys of science.

DMITRI NUSINOW, PH.D.

Assistant Member

The Nusinow lab used biochemistry and genetics to determine the mechanisms that plants use to increase productivity in response to seasonal changes in the environment.

SONA PANDEY, PH.D.

Associate Member

The Pandey lab researched yield improvement in important food crops such as soybean and biofuel plants such as camelina by modulating G-protein levels.

DILIP SHAH, PH.D.

Associate Research Member

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

NIGEL TAYLOR, PH.D.

Dorothy J. King Distinguished Investigator, Associate Member

The Taylor lab developed gene editing in cassava to produce plants with tolerance to herbicides, disease resistance and accelerated flowering.

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.

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.

AAAS SELECTS TOBY KELLOGG TO SERVE AS CHAIR-ELECT FOR THE BIOLOGICAL SCIENCES

Elizabeth (Toby) Kellogg, Ph.D., member and principal investigator was selected by the American Association for the Advancement of Science (AAAS) to serve as chair-elect for the Biological Sciences Section. The AAAS is the leading organization that speaks for all science and engineering, as their mission states, “throughout the world for the benefit of all people.” The section provides expertise and input for association-wide projects and arranges symposia for the annual meeting. As Chair-Elect, Kellogg will succeed Danforth Scientific Advisory Board Member Dr. Pamela Ronald, who will step in to the office of Chair.

“It is an honor and a privilege to be elected to represent this notably broad and influential group of scientists and to participate in scientific leadership at the national and international level,” said Kellogg.

Kellogg joined the Danforth Center in 2014. Her research has led to the identification of genes that contribute to the diversity of the primary cereal crops used for food. Kellogg’s work on development and genomics of cereal grasses contributes directly to the Center’s focus on translating basic research into results that provide food and fuel for the U.S. and the world.

ENTERPRISE RENT-A-CAR INSTITUTE FOR RENEWABLE FUELS

WORKING TO MOVE BIOENERGY CROPS INTO THE PIPELINE

The development of environmentally sustainable sources of biofuels is through the Enterprise Rent-a-Car Institute for Renewable Fuels, a research unit within the Danforth Center. Researchers are exploring how plants harness the energy of sunlight and using that knowledge to increase the potential of oilseed crops, algae and bioenergy grasses to be sources of renewable bioenergy. This work is designed to enhance yield and quality, lower environmental impact and drive private sector development.

WORLD'S LARGEST FIELD PHENOTYPER MONITORS GROWTH OF 30,000 PLANTS.

Deployed the world's largest robotic field scanner to advance improvement of key bioenergy crop

- $8 million grant from the U.S. Department of Energy ARPA–E TERRA division to support a multi-institutional big data research program led by Todd Mockler, Ph.D., Geraldine and Robert Virgil Distinguished Investigator, to advance the development of sorghum, a key bioenergy crop.
- Deployed a LemnaTec Field Scanalyzer at the University of Arizona's Maricopa Agricultural Center, that provides high-throughput phenotyping on 1.5 acres. The robot uses sensors and cameras to monitor the growth of 30,000 to 40,000 sorghum plants and captures data on physical characteristics such as height, leaf structure and speed of growth.

Collaboration with the University of Illinois focuses on enhancing nitrogen use efficiency to develop more efficient crops that will use less fertilizer to produce more yield

Thomas Brutnell, Ph.D., director of the Enterprise Institute for Renewable Fuels at the Danforth Center received a three-year grant from the U.S. Department of Agriculture's (USDA) National Institute of Food and Agriculture (NIFA) to enhance nitrogen use efficiency (NUE). The Center will collaborate with the University of Illinois to identify genetic variants impacting photosynthesis and nitrogen uptake.

Danforth Center and NRGene assemble a second maize reference genome using next-generation mapping

The Brutnell Lab, in cooperation with a global team of researchers and NRGene, the leading genomic big data company, enhanced knowledge of maize with the accurate assembly of the W22 maize reference genome.

Discovery of carbon storage signaling mechanism in algae offers new potential for sustainable biofuel production

James Umen, Ph.D., associate member of the Danforth Center, and colleagues have discovered a way to make algae better oil producers without sacrificing growth. The findings were published in a paper titled, *"Synergism between inositol polyphosphates and TOR kinase signaling in nutrient sensing, growth control and lipid metabolism in Chlamydomonas,"* in *The Plant Cell*.

Discovery of cellular counting mechanism used for size control to improve yield of algal biofuels

The Umen lab and colleagues discovered a protein that enables the single-celled green alga Chlamydomonas to count cell divisions, a process that is critically important for its cells to maintain optimal size. The findings were published in a paper titled, *"A new class of cyclin dependent kinase in Chlamydomonas is required for coupling cell size to cell division,"* in the open access journal *eLife*.

THE INSTITUTE FOR INTERNATIONAL CROP IMPROVEMENT

SUSTAINABLY IMPROVING PRODUCTIVITY AND QUALITY OF FOOD SECURITY CROPS

The Institute for International Crop Improvement (IICI) works to turn discoveries into food security for people living in the developing world. The Institute works in partnership with international research institutions, NGOs, funding agencies and regulatory agencies. Members of the IICI connect leading scientists and cutting-edge technologies, train international scientists, and provide regulatory, biosafety and project management services.

International collaboration receives grant to advance improvements in cassava harvests and nutrition for smallholder families in Sub-Saharan Africa

- Virus Resistant Cassava for Africa (VIRCA) Plus, a consortium of institutions in the United States, Nigeria, Uganda and Kenya received a five-year, $10.46 million grant from the Bill & Melinda Gates Foundation to develop disease-resistant and nutritionally-enhanced cassava varieties to improve the livelihoods and health status of African farm families.
- VIRCA Plus builds on the success of two predecessor projects. The VIRCA project successfully developed strong and stable resistance to Cassava Brown Streak Disease in cassava, validated over four field trials and multiple cropping cycles in Kenya and Uganda. The BioCassava Plus project succeeded in developing and testing cassava plants that accumulated greater than 10 times more iron and zinc than comparable varieties. Both minerals are retained after processing into common foodstuffs at levels that could provide 40-70 percent of the Estimated Average Requirement for women and children.

Scientist honored by First World Congress on Root and Tuber Crops

Narayanan Narayanan, Ph.D., research manager in the IICI attended the First World Congress on Root and Tuber Crops, held in Nanning, Guangxi, China to give a presentation titled, *"Biofortification of Iron and Zinc in Cassava Storage Roots to Nutritionally Significant Levels,"* and was awarded the First Prize for his talk.

"In Africa, many people don't have easy access to vitamins or fortified food products, so they rely on the nutritional content of the food grown locally," said Narayanan. "We're on the right track, we're targeting the right population and we're doing something impactful for millions of people."

BILL GATES VISITS THE DANFORTH PLANT SCIENCE CENTER

In June, Bill Gates and a team of staff members from the Bill & Melinda Gates Foundation visited the Danforth Center to learn about its mission and work, particularly research funded by the Gates Foundation. The theme of the visit was giving smallholder farmers access to improved cassava as quickly as possible.

Gates discussed efforts to deliver virus-resistant and nutritionally enhanced cassava to Africa with Nigel Taylor, Ph.D., Dorothy J. King Distinguished Investigator and the principal investigator for VIRCA Plus and Getu Duguma, Ph.D., research manager in the IICI and several scientists from partner organizations in Kenya, Uganda and Nigeria.

NEW DISCOVERIES OFFER CRITICAL INSIGHTS FOR IMPROVING CROP YIELD

In 2016, Sona Pandey, Ph.D., principal investigator, and colleagues published a series of new papers on research funded by the National Science Foundation and the National Institute of Food and Agriculture. The publications shared information about how G-proteins evolved and clues to their role in regulating plant growth and abiotic stress response.

DISCOVERY HIGHLIGHTS:

Proteins are essential for the life cycle completion in moss, a non-vascular plant of basal plant lineage.

- *"Sporophyte formation and life cycle completion in moss requires heterotrimeric G-proteins,"* published in the journal, *Plant Physiology*.
- Prior to this work, the plant G-proteins were thought to be non-essential and modulatory in nature.

One of the key focus areas of the Pandey lab research is to uncover both conserved and unique signaling mechanisms and components of heterotrimeric G-proteins in plants.

- *"Gα and Regulator of G-protein Signaling (RGS) protein pairs maintain functional compatibility and conserved interaction interfaces throughout evolution despite frequent loss of RGS proteins in plants,"* published in the journal, *New Phytologist*.
- The Pandey lab performed a large evolutionary and structure/function analysis in collaboration with Toby Kellogg's lab at the Danforth Center and Jez lab at Washington University.
- Results of a large evolutionary and structure/function analysis conducted by the Pandey and Kellogg labs at the Danforth Center and the Jez lab at Washington University challenged the prevailing theory by confirming that RGS proteins are widespread in the monocot lineage, despite their frequent loss.

In an attempt to identify additional proteins that possess similar biochemical activities as the RGS proteins, the Pandey lab also identified the role of a type of lipid hydrolyzing proteins, the phospholipase Dα1 (PLD α1) in regulating G-protein cycle.

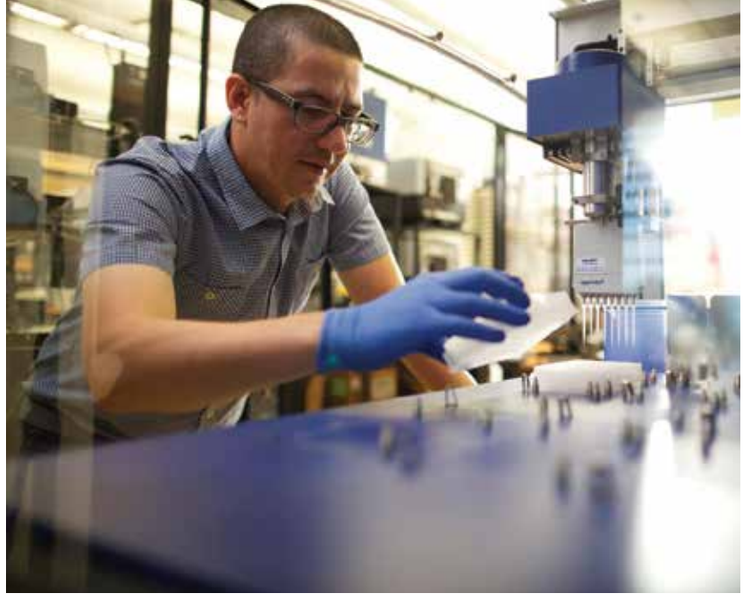
- *"The role of PLDα1 in providing specificity to signal-response coupling by heterotrimeric G-protein components in Arabidopsis,"* published in *The Plant Journal*.
- This research provided clues that additional proteins are involved in the regulation of G-protein signaling pathways in plants and added significantly to the diversity that may exist in plants' regulatory mechanisms.

The regulation of nodule formation in legumes such as soybeans and yield enhancement by controlling seed size and seed number.

- *"Phosphorylation-Dependent Regulation of G-Protein Cycle during Nodule Formation in Soybean,"* published in *The Plant Cell*.
- Discovered a signaling pathway where the receptors of Nod factor perception interact with phosphorylate G-protein components to control nodule number in plants.

ABOUT HETEROTRIMERIC G-PROTEINS

- Heterotrimeric G-proteins are present in all eukaryotic organisms from simple fungi to humans and plants.
- The proteins regulate critical growth and development processes in organisms by acting as molecular switches.
- G-proteins in green algae, confirm proteins appeared in the evolutionary history of plants.



SCIENTISTS DISCOVER HOW PLANTS TAILOR GROWTH TO THE SEASONS

Dmitri A. Nusinow, Ph.D., assistant member and researchers in his lab have discovered a gene that allows plants to remember daylight during the long nights of winter, helping them tailor their growth appropriately to the seasons. The gene, PCH1, accumulates at dusk and stabilizes light signals in the early hours of the night, keeping the plant from growing too much during extended dark periods. The findings were published in a paper titled, *"PCH1 integrates circadian and light-signaling pathways to control photoperiod-responsive growth in Arabidopsis,"* in the open access journal *eLife*.

"AS MUCH AS GLOBAL WARMING WILL AFFECT CLIMATE, IT WILL NEVER CHANGE THE ANGLE OF THE SUN." - DMITRI NUSINOW, PH.D.

Plants respond to seasonal change in day length by flowering and changing growth patterns. Because dawn can occur anywhere from eight hours after dusk in the long days of summer to sixteen hours after dusk in winter, plants must adapt to seasonal changes in day length to time their growth properly. PCH1 serves as a "molecular memory" of the light plants absorb during the day, delaying the start of growth during long nights. Without PCH1, plants grow more than is ideal during long nights, resulting in plants that are not as sturdy as those with PCH1.

In humans and other animals, light signals perceived in the eye train a "master clock" in the brain, which coordinates the daily cycles of many bodily processes. "Without a central nervous system, the coordinated response to day length and seasonal changes across the whole plant rely on each cell training itself to the sun," said Nusinow. "These behaviors include photosynthesis, flowering and growth."

To extend the impact of its discovery, the Nusinow lab will seek to determine if PCH1 regulates growth in crop species such as soybean, with the goal of adapting crop performance to any latitude. As a warming climate changes the temperature—but not the day length—at higher latitudes, this kind of adaptation may prove useful for ensuring that crops are productive.

NUSINOW AND HIS TEAM DISCOVERED PCH1 IN THE MODEL PLANT ARABIDOPSIS BUT FOUND THAT OTHER PLANTS, INCLUDING RICE, HAVE THE SAME GENE.

CONTRIBUTING TO A STRONGER INNOVATION ECOSYSTEM

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, biotechnology and related fields.

"BY CONNECTING REGIONAL ASSETS, IMPROVING MOBILITY, CREATING DEVELOPMENT OPPORTUNITIES AND ADDITIONAL GREENSPACE, WE WILL ENHANCE OUR ABILITY TO GROW, ATTRACT AND RETAIN COMPANIES AND TOP TALENT."

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

39 NORTH LAUNCHED

On December 7, 2016, 150 residents, scientists, entrepreneurs, community and business leaders gathered at the Danforth Center to unveil details of 39 North, the official name of the 600-acre innovation district that has been the focus of an 18-month strategic planning process.

The 39 North Master Plan presents a vision for an innovation district in St. Louis County that is uniquely positioned to advance the region's global leadership in plant and life sciences. The district 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. $400,000 in funding has been secured for the first project—design of greenway space. Community input was paramount to the process. More than 45 meetings, focus group sessions and two community open houses were held to gather feedback from stakeholders.

FIVE TRANSFORMATIVE GOALS WERE IDENTIFIED:

Strengthen corridors and establish new traffic patterns

Achieve an interconnected network of internal streets to improve mobility for vehicles, public transportation modes and pedestrians within the district and improve the existing road infrastructure on Warson Road and Olive Boulevard.

Connect assets and opportunity sites

Utilize open space and new internal road infrastructure to connect district anchors including the Danforth Center, Bio Research Development and Growth (BRDG) Park, Helix Biotech Incubator, Monsanto Company and adjacent community assets including the St. Louis Jewish Community Center, Warson and Stacy Parks and town centers in Creve Coeur and Olivette.

Establish a cohesive development framework

Outline a strategy for development of the district to accomplish near- and long-term success to realize the district in a sustainable manner.

Create a mixed-use center of activity

Define the heart of the district with amenities that will support an ecosystem of innovation both within the district and throughout the St. Louis region while providing neighborhood amenities to local residents that are welcoming and engaging.

Communicate the district

Establish distinctive gateways to the district and make visible to the community the cutting-edge research and products that are defining the future of the St. Louis economy through public art, innovative architecture and landscape design.

In the near term, dedicated staff at the St. Louis Economic Development Partnership will manage implementation of the plan for 39 North in coordination with a steering committee of essential stakeholders, all of whom shaped the Master Plan. In the longer term, an empowered nonprofit entity will be created to ensure the continuation of the district's mission.

39 NORTH'S CORE WORKING GROUP COMPRISED OF REPRESENTATIVES FROM:

- Danforth Center
- Bio Research Development & Growth (BRDG) Park
- Helix biotech incubator
- St. Louis Economic Development Partnership
- City of Creve Coeur
- Missouri Technology Corporation
- Monsanto Company

EIGHTH ANNUAL AG INNOVATION SHOWCASE PROVIDES INSIGHTS AND INSPIRATION

In September, the Danforth Center hosted the eighth annual Ag Innovation Showcase, which brought together innovators, investors, producers and entrepreneurs in the agtech space for three days of presentations, panel discussions, networking and dealmaking.

Six out of the 20 companies chosen to present their early stage technologies are led by women, an inspiring trend that continues to grow. Christina Davis, founder and chief science advisor of XTB Laboratories Inc., was chosen as the winner of the Ideas, Energized™ Prize, new to the Showcase this year. The prize included a $10,000 award. The two runner-up companies, Kiverdi and NeoGram, are also women-led.

A presentation on alternative systems for food and feedstocks by Lisa Dyson, CEO, board of directors of Kiverdi generated keen interest. Kiverdi is commercializing a technology that uses a special class of microbes to recycle carbon dioxide and other gases into protein, high-value oils and bio-based products that can be used in a variety of consumer and industrial applications.

During a special spotlight session, Matt Crisp, president and CEO of Benson Hill Biosystems, provided insight from an innovator's perspective. "The majority of value that's created is not about the core innovation. It's about what's done upstream and how the company and idea interact with the customer," said Crisp. He challenged the audience to "think boldly" and "take advantage of the sea of resources available at the Showcase" to come up with one significant idea before the event's conclusion.

PLANT
SEPTEMBER
11-13
2017
ON YOUR CALENDAR FOR THE NINTH ANNUAL SHOWCASE IN ST. LOUIS

BRDG PARK RECOGNIZED FOR ACHIEVEMENT IN BIOSCIENCE

More than 800 executives, elected officials and civic leaders attended the third annual Arcus Awards at the Hyatt Regency St. Louis at the Arch. A panel of distinguished business scholars and executives selected ten award winners based on categories representing the Chamber's One Plan for regional prosperity. The categories honor leadership in industry clusters that are critical to creating jobs today as well as community priorities that will secure an even brighter future.

The Bio Research and Development Growth (BRDG) Park was selected to receive the Award for Achievement in Biosciences sponsored by Bryan Cave, LLC.

"We were honored to receive the award for achievement in biosciences," said Sam Fiorello, president of BRDG Park and COO of the Danforth Center. "We first want to congratulate the other finalists in this category. They represent some of St. Louis' most innovative companies and we are humbled to receive this award among such an impressive group of enterprises. By creating jobs, attracting capital and developing solutions to major global challenges they make our region and our world better."

The Arcus Award for Achievement in Biosciences was created to honor a company or organization that creates an innovative product or service; achieves revenue or employment growth; raises investment capital; designs or constructs a significant building or infrastructure project; and/or provides other leadership to champion the region's excellence in biosciences. BRDG Park tenant NewLeaf Symbiotics and Benson Hill Biosystems, co-founded by Matt Crisp, CEO and two Danforth Center scientists, were also finalists for the award.

"The credit for this award truly goes to our tenants," said Mark Gorski, regional leasing director at BRDG Park for Wexford Science + Technology. "BRDG Park is able to be a catalyst for the life science industry because of the immensely talented tenants we have, our connection to the Danforth Center and the support we receive from the St. Louis region. Without it, we wouldn't be experiencing the success we are today, so this award is a win for us all."

"MORE THAN ANYTHING ELSE, WE OWE THIS AWARD TO THE SUCCESS OF OUR TENANTS."
-SAM FIORELLO
president of BRDG Park and COO of the Danforth Center

SCIENCE EDUCATION LEADER NAMED PRESIDENT OF ST. LOUIS AGRIBUSINESS CLUB

Richard Norris, Ph.D., director of the Center for Plant and Life Sciences at St. Louis Community College located at Bio Research and Development Growth (BRDG) Park on the Danforth Center campus, was named President of the St. Louis Agribusiness Club for 2016-2017. For the past 10 years, Norris has been a member of the 450-member organization. "I'm honored to have the opportunity to lead a great organization like the St. Louis Agribusiness Club," commented Norris. "The Club has a 35-year history of excellence and service to the agriculture industry within the St. Louis region."

Norris also joined the executive board of the Missouri Biotechnology Association (MOBIO) and assumes the duties as secretary. MOBIO is the state's premier professional business association dedicated to growing and protecting Missouri's bioscience and high tech companies.

FROM THE LAB TO THE MARKETPLACE

Since its founding, the Danforth Center has been dedicated to facilitating the rapid development and commercialization of promising technologies that will benefit human health and the sustainability of agriculture.

DANFORTH CENTER INTELLECTUAL PROPERTY TO DATE

2016 Intellectual Property Summary

- 34 currently pending patent applications in the U.S. and internationally from a total of 18 families
- 10 issued patents
- 12 licensed technologies to for-profit companies
- 3 invention disclosures submitted
- 4 provisional applications filed
- 4 U.S. applications filed
- 1 technology licensed to for-profit companies

TechAccel
Technology Acceleration Partners

TECHACCEL ALIGNS WITH THE DANFORTH CENTER TO ADVANCE AG INNOVATION

"WE ARE CONFIDENT THIS PROGRAM WILL ADVANCE SOME OF THE MOST PROMISING WORK UNDERWAY AT THE WORLD-CLASS DANFORTH CENTER."

-TERRY DUNN
chairman of the Board of Directors of TechAccel

TechAccel, a Kansas City-based technology and venture development company, and the Danforth Center announced a Path to Commercialization program with a primary goal of advancing agricultural innovations from the laboratory to the marketplace. The strategic partnership will initially provide up to $250,000 in grants to demonstrate proof-of-concept or commercial feasibility studies with principal investigators at or affiliated with the Center.

"This partnership with the Danforth Center is an important milestone for TechAccel and the agriculture ecosystem," said Michael Helmstetter, Ph.D., president and chief executive of TechAccel. "Agriculture research can and will change the world, but only if it has the backing to move from concept to proof to product. We bring capital coupled with science advancement to support that push to the finish line—the commercial market."

Supported projects are expected to produce new assets—license-ready technology, processes or products or new spin-off companies. Returns on program investments will be shared between TechAccel and the Danforth Center.

DANFORTH CENTER SCIENTISTS DEVELOP VERSATILE FIELD PHENOTYPING TECHNOLOGY TO BENEFIT FARMERS

Researchers at the Danforth Center leveraged expertise in crop phenotyping to develop the PheNode, a 'smart', farm-ready, solar-powered environmental sensor and phenotyping station for crops.

"With a suite of diverse sensors on the PheNode, we can continuously monitor field crops for growth rate, stem diameter, height, leaf shape, leaf angles, canopy closure, light interception and the relationship of these traits to enhanced canopy photosynthesis. The PheNode will help crop science innovators to identify ideal canopy architectural and leaf metabolic features to breed crops for increased yield," said Nadia Shakoor, Ph.D., research scientist. The prototype was developed by Shakoor, Mockler and colleagues, and was recently highlighted at the 2016 Ag Innovation Showcase and SXSW Eco in Austin, Texas.

MODULAR SENSORS AND CAMERAS ON THE PHENODE TAKE REAL-TIME MEASUREMENTS OF:

- WIND SPEED
- CANOPY IMAGING, CO2 MEASUREMENTS
- LIGHT QUANTITY AND QUALITY
- TEMPERATURE, HUMIDITY, BAROMETRIC PRESSURE
- SOIL MOISTURE, SOIL TEMPERATURE, NUTRIENT COMPOSITION

NEWLEAF SYMBIOTICS SECURES KEY PATENTS IN EUROPE AND JAPAN

NewLeaf Symbiotics, a venture-funded agricultural biologicals company located at the Bio Research and Development Growth (BRDG) Park, announced both the European and Japanese Patent Offices will grant patents on the company's foundational production process. In 2015, the U.S. Patent and Trademark Office granted U.S. Patent No. 9,181,541 to broadly cover NewLeaf's proprietary production technology. The technology disclosed in the patents permits rapid, cost-effective production of large quantities of Pink-Pigmented Facultative Methylotrophs, a naturally occurring beneficial bacteria which can improve yield and pest tolerance in treated crops.

Desmond Jimenez, vice president for product development at NewLeaf stated, "The grant of patents in Europe and Japan is significant for the company because we expect production and commercialization of our products to scale throughout the world. We are beginning sales in the U.S. and Canada and have conducted successful tests in South America. We see real opportunity in Europe and Japan as these markets are hungry for more sustainable agricultural practices and NewLeaf can fill that demand."

COMMUNITY ENGAGEMENT AND CONTRIBUTIONS

To advance its mission to 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.

JAMES CARRINGTON, PH.D., PRESIDENT OF THE DANFORTH CENTER, DISCUSSED THE SCIENCE IN OUR FOOD AT TEDXGATEWAYARCH, WHICH PLAYS A VITAL ROLE IN MAKING ST. LOUIS A LEADER IN TECHNOLOGY, INNOVATION AND GROWTH.

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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.

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CUTTING-EDGE PLANT TECHNOLOGY INSPIRES FALL SYMPOSIUM

The Danforth Center's 18th annual Fall Symposium kicked off September 28th and ran through September 30th. The theme of this year's event was "Genetics and Genomics of Crop Improvement." This area is particularly timely after the Center's recent expansion.

Andrea Eveland, Ph.D., assistant member at the Danforth Center and co-host of the event, stated, "This an exciting time for agriculture right now. With unprecedented advances in genomics and phenotyping technologies, we now have the capacity to predict crop performance in various environments and use these predictions to design better-yielding varieties and inform breeding programs. This symposium brings together leading researchers from across the globe that are making great strides in both basic and applied approaches to enhance the productivity of important crop species, from food to fuel to fiber."

The symposium focused on various aspects of translational research that leverage genetics and genomics approaches to enhance crop productivity. Topics included biomass and yield traits, abiotic stress tolerance and disease resistance, nutrient allocation, plant architecture, and crop domestication and improvement. Research in these areas was discussed in the context of recent advances in quantitative genetics, genomic selection, network-based gene predictions, epigenomics and genome editing technologies.

"In recent years, due to remarkable advances in genomic technologies coupled with genetics, breeding, agronomics and detailed phenotypic data, our understanding of the molecular basis of agronomic traits has helped better explain how crops grow, respond to stress and can be more rapidly and efficiently improved," said Blake Meyers, Ph.D., member at the Danforth Center and professor of Division of Plant Sciences at the University of Missouri and co-host of the event. "This combination of genetics and genomics in agriculture promises to serve as the basis for the continued improvements to yield, production and quality that the world needs for sustainable agriculture."

The Symposium had 290 registrants along with 14 sponsors and 23 speakers including computer scientists, digital imaging specialists, crop scientists, toxicologists and behavioral scientists, quantitative geneticists and genome scientists.

IMPROVING AGRICULTURE FOR A SUSTAINABLE FUTURE

GLOBAL CHALLENGES

- Producing more food without using more land and resources to preserve forests, native landscapes and biodiversity
- Replacing fossil fuels with sustainable sources of bioenergy to meet a predicted doubling of demand by 2050
- Managing environmental challenges such as climate change, drought and pests
- Protecting our rivers, streams and oceans
- Reducing the amount of water, fertilizer and pesticides required
- Conserving the "living skin" of our planet, at current rates of loss, valuable topsoil could be gone in 60 years

USING SCIENCE AND INNOVATION TO ADVANCE SOLUTIONS

- Creating technologies that accelerate results
- Investigating how native plants evolved over time
- Exploring how plants harness the energy of sunlight to grow
- Employing big data approaches
- Pioneering the use of imaging
- Understanding how roots take up water and nutrients

GENETICS AND GENOMICS OF CROP IMPROVEMENT: The combination of genetics and genomics will serve as the basis for future sustainable agriculture

Benefits of Genetics

- Isolate genetic loci that confer desirable phenotypic traits
- Stack beneficial alleles to develop higher-yielding crop varieties
- Leverage naturally occurring diversity for crop improvement

Benefits of Genomics

- Identify genetic targets for increasing plant density and decreasing fertilizer use
- Improve crop productivity in adverse environments
- Enable and increase predictive breeding

1860's
Gregor Mendel demonstrated **plant genes confer visible traits** in a predictable manner

1900's
George Harrison Shull's research into "heterosis" advanced the development of **hybrid maize**

1960's
First publication of nucleic acid sequence, the ribonucleotide sequence of alanine transfer RNA

1970's
Norman Borlaug received the **Nobel Peace Prize** for the development of high-yielding varieties during the Green Revolution

1980's
The **first biotech plants** are developed

1990's
Arabidopsis thaliana was the **first plant completely sequenced**

2000's
Genome-based breeding practices take off, accelerating **gains in crop genetics**

2010's
Genomes of more than **400 plant species** have been sequenced to date

Impacts of Improved Crops

Improved plant varieties provide significant advantages in addressing societal challenges in:

- Decrease water usage through drought-resistant crops
- Reduce inputs with pest and disease-resistant crops
- Reduce environmental impact of agriculture by development of advanced genetic traits

SEEDS of CHANGE
2016

HOW TO FERTILIZE THE ST. LOUIS STARTUP ECOSYSTEM

More than 200 guests attended the annual SEEDS of CHANGE event to hear guest speaker, David Karandish, former CEO of Answers Corporation, discuss what it takes to plant the seeds of entrepreneurship and how to encourage entrepreneurship and the formation of successful new companies in the region. The event is hosted by the Danforth Leadership Council and sponsored by J.P. Morgan.

"The best entrepreneurs are usually the ones who are not taking their first major league swing," Karandish said during the SEEDS of CHANGE program. "We failed at a few things before we actually succeeded, but in the end, everything ended up connecting."

"WE HAVE TONS OF GREAT IDEAS, BUT WE NEED TO TEACH OUR KIDS PRODUCT DESIGN SO THEY CAN BRING THOSE IDEAS TO LIFE,"

-DAVID KARANDISH
former CEO of Answers Corporation

Karandish applauded the robust amount of investors in the St. Louis region that are putting capital into the hands of startups and the many corporate sponsors that are supporting the needs of these young companies in philanthropic ways. He also illustrated key areas of improvement to further develop the startup ecosystem in the region.

"We need to teach young kids to code," said Karandish. "Digital is thriving. You don't need a storefront anymore, because everything can be done online."

In addition to coding, the startup scene needs people who can transform innovative ideas into new products. Karandish emphasized that product design jobs are typically the most difficult to fill. "We have tons of great ideas, but we need to teach our kids product design so they can bring those ideas to life," he said. "We want to be a city of creators, not a city of managers."

Furthermore, all of the innovative companies and ideas will not originate in St. Louis. Therefore, importing entrepreneurs to our area is essential in order for it to thrive. Finally, Karandish emphasized the need to embrace and encourage diverse types of startup companies in our region. "We should always be thinking about what is missing and what other technologies we can be investing in," he said.

After Karandish's energetic presentation, he was joined on stage by a panel including Tom Hillman, founder and managing principal at FTL Capital and founder and managing general partner of Lewis & Clark Ventures; Jeff Peterson, managing partner of the Yield Lab; Cliff Holekamp, cofounder and general partner of Cultivation Capital and senior lecturer and academic director for entrepreneurship at Olin Business School. The discussion was moderated by Jack Gillis, executive director at J.P. Morgan Private Bank.

"We have to be the door openers who help make introductions and get young companies in front of the necessary people so they can get funded and off the ground," said Peterson.

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"ALONG WITH BEING A GLOBAL LEADER IN EFFORTS TO IMPROVE FOOD SECURITY AND ENVIRONMENTAL SUSTAINABILITY, THE DANFORTH CENTER IS AN IMPORTANT ENGINE OF ECONOMIC GROWTH AND DEVELOPMENT IN THE ST. LOUIS REGION. I AM HONORED TO WORK WITH FELLOW MEMBERS OF THE DANFORTH LEADERSHIP COUNCIL TO PROMOTE THIS REMARKABLE INSTITUTION IN BOTH THE LOCAL AND NATIONAL BUSINESS COMMUNITIES."

-SCOTT BUSH, *chair of the Danforth Leadership Council*

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2016 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.

NEXT GENERATION BIOENERGY

A distinguished panel reviewed the potential for alternative energy sources to transform major industries, including aerospace and aviation. They pointed to St. Louis' unique mix of talent and infrastructure working to find solutions to the world's growing energy demand.

Date: Thursday, May 12, 2016

Speakers: John Tracy, Ph.D., Chief Technology Officer at The Boeing Company; Jerry Steiner, CEO of Arvegenix and Toni Kutchan, Ph.D., Oliver M. Langenberg Distinguished Investigator and the Vice President for Research at the Danforth Center

Moderator: Chip Lerwick, member of the Danforth Center's Leadership Council and co-chair of the Marketing Committee

PEOPLE, PLANTS AND PARTNERSHIPS: THE MIZZOU CONNECTION

The program focused on the growing agtech industry and the strong tradition of plant science research in Missouri. The evening highlighted the partnership designed to ramp up collaborative efforts between the two institutions.

Date: Thursday, August 25, 2016

Speakers: Henry C. "Hank" Foley, Ph.D., interim chancellor of the University of Missouri and Blake Meyers, Ph.D., principal investigator at the Danforth Center and professor of the Division of Plant Sciences at the University of Missouri

Moderator: Dudley McCarter, former president of the Mizzou Alumni Association

TECHNOLOGY, TRUTH AND THE PUBLIC

The discussion gave an inside look at one reporter's personal journey of finding a story that surprised her and the public backlash that followed. Pulitzer Prize-winning Author and New York Times National Correspondent Amy Harmon shared her experience covering the intersection of science and society and the divide between public opinion and scientific data.

Date: Thursday, November 17, 2016

Speaker: Amy Harmon, Pulitzer Prize-winning Author and *New York Times* National Correspondent

Moderator: Jim Carrington, Ph.D., president of the Danforth Center

The 2016 Conversations Series is sponsored by **St. Louis Public Radio and HEC-TV**. To view previous Conversations programs visit HEC-TV.org.

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"THE FRIENDS COMMITTEE AND THE DANFORTH SOCIETY MEMBERSHIP COMMITTEE ARE DEDICATED TO HELPING SUSTAIN THE DANFORTH CENTER BY INTRODUCING NEW AND PROSPECTIVE DONORS TO ITS CRITICALLY IMPORTANT MISSION AND WORK. I KNOW I SPEAK FOR MY FELLOW COMMITTEE MEMBERS WHEN I SAY THAT I AM DEEPLY GRATEFUL FOR THE OPPORTUNITY TO BE PART OF AN ORGANIZATION THAT IS TRULY CHANGING THE WORLD FOR THE BETTER."

-GARY HALLS, *chair of the Danforth Society Membership Committee*

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If you are interested in becoming a member of the Friends Committee, please contact Suzanne Cavagna, 314.587.1076.

DANFORTH GLOBAL STEWARD AWARD
presented to
JOHN. F. MCDONNELL
November 12, 2016

PLANTASIA COMMITTEE

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Jeanie & Van Brokaw
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Kitty Drescher
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Beth & Donn Rubin
Mydie Sant
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Dale & Barry Sharon
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Moir Stevens
Teg & Frank Stokes
Bill & Barbara Van Luven
Anne & Jim von der Heydt
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Nancy & Bob Wagoner
Virginia Weldon & Francis Austin
Teresa Wheeler
Kathleen Woodworth

PLANTASIA*gala*
2016

EXTRAORDINARY SERVICE RECOGNIZED AT PLANTASIA GALA

The Danforth Center presented John. F. McDonnell with the Danforth Global Steward Award at the 15th annual Plantasia gala on November 12, 2016. More than 290 guests gathered to recognize and honor John for his extraordinary service and support of the Danforth Center, his efforts to strengthen the St. Louis region and his commitment to addressing hunger, malnutrition and other global challenges through plant science.

The Danforth Global Steward Award honors individuals whose extraordinary commitment and advocacy have advanced plant science for the benefit of humanity and the environment in areas that include food security, environmental sustainability and renewable energy. William H. Danforth, M.D., founding chairman of the Center, received the inaugural award in 2008.

"It is fitting to honor John with an A++++ for his service to our cause, saving humankind by helping to feed the world while sustaining our life-giving environment and by helping our region to be a leading center for plant science. Congratulations and thanks for being a great role model for us all," said William H. Danforth, M.D.

During his acceptance remarks, John provided his perspective on global stewardship: "I want to say how humbled and honored I feel to receive the Global Steward Award, especially since the only previous recipient is Bill Danforth, who is my role model and the exemplar of how we should live our lives."

Guests celebrated the evening while listening to the sounds of energetic jazz and dance music by Miss Jubilee backed up by a swinging horn-fueled rhythm section.

Plantasia is an opportunity to honor outstanding members of the plant science community and thank supporters for the exceptional dedication and generosity that enable the Danforth Center to advance scientific discovery, create technological innovation and educate next-generation scientists.

WARM RETIREMENT WISHES TO A COLLEAGUE AND FORMER EXECUTIVE DIRECTOR OF THE INSTITUTE FOR INTERNATIONAL CROP IMPROVEMENT

In April, 2016 we said farewell to Paul Anderson as he began a new phase of his life in retirement. Paul joined the Danforth Center in 2008, bringing with him 25 years of experience in corn, soybean and wheat improvement and plant biotechnology development. In 2011, U.S. Agriculture Secretary Tom Vilsack appointed Paul to serve on the Advisory Committee on Biotechnology and 21st Century Agriculture.

Paul contributed greatly to the Center as Executive Director of the Institute for International Crop Improvement (IICI), which was established in 2012 with a generous gift from the JS McDonnell Foundation. He guided the IICI as an applied product development arm of the Danforth Center that focuses on translating technology into improvement of orphan crops such as cassava. Paul's leadership helped advance the IICI as a unique organization among institutions working in the public domain.

Paul and his wife Barbara have our best wishes as they embark on a new chapter in their lives. They share a special appreciation for the world's diverse cultures, and they plan on experiencing more of them through their travels in the years ahead. Paul, and his boldly patterned shirts that made him recognizable from great distances, will be missed here at the Danforth Center. For all that Paul did on behalf of the Center, we say "Thank you!"

– Jim Carrington, Ph.D., president of the Danforth Center

YOUNG FRIENDS STEERING COMMITTEE

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VICE-CHAIR
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MEMBERS
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Erica A. Fishel
Davey Oetting

If you are interested in becoming a member of the Young Friends Steering Committee, please contact Brigid Thayer, 314.587.1073.

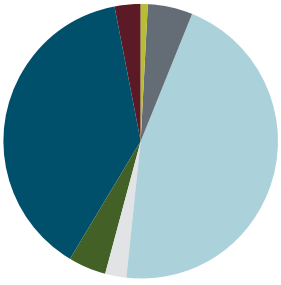
"THE DANFORTH CENTER EMBODIES THE FUTURE OF GLOBAL ENVIRONMENTAL SUSTAINABILITY AND ECONOMIC GROWTH IN ST. LOUIS THROUGH NEXT GENERATION PLANT SCIENCE RESEARCH, TECHNOLOGY AND ENTREPRENEURSHIP. THE YOUNG FRIENDS COMMITTEE AND I ARE HONORED TO RAISE SUPPORT AND ACTIVE ENGAGEMENT AMONG THOSE 40 AND UNDER."

-MICHAEL KALISHMAN, *chair of the Young Friends Committee and member of the Danforth Center Friends Committee*

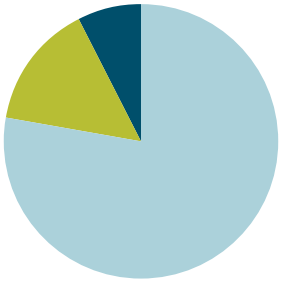
SELECTED FINANCIAL DATA

Fiscal year ended December 31, 2016

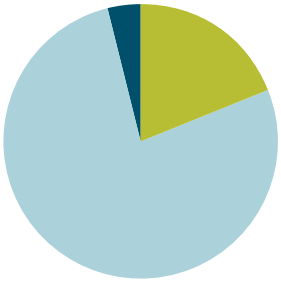
(Unaudited)



UNRESTRICTED OPERATING REVENUES [1]	2016 ($000's) Revenue	Source %
Corporate/Foundation Gifts	$292	0.90%
Individual Gifts	$1,649	5.30%
Grants & Contracts - Research	$14,183	45.50%
Grants & Contracts - Capital Acquisitions	$810	2.60%
Program and Service Income	$1,402	4.50%
Draw from Endowment Appropriated for Spending	$11,902	38.20%
Other Income	$923	3.00%
Total Operating Revenues	$31,161	100.0%



OPERATING EXPENSES [2]	Expenditures	Expenditure %
Total Research/Science	$21,472	78.0%
Administration	$3,996	14.5%
Development and Public Relations	$2,062	7.5%
Total Expenses from Continuing Operations	$27,530	100.0%



CAPITAL EXPENDITURES	
Lab and Core Facility Equipment [3]	$1,030
Phase 2 Building	$4,148
All Other	$197
Total Expenditures	$5,375

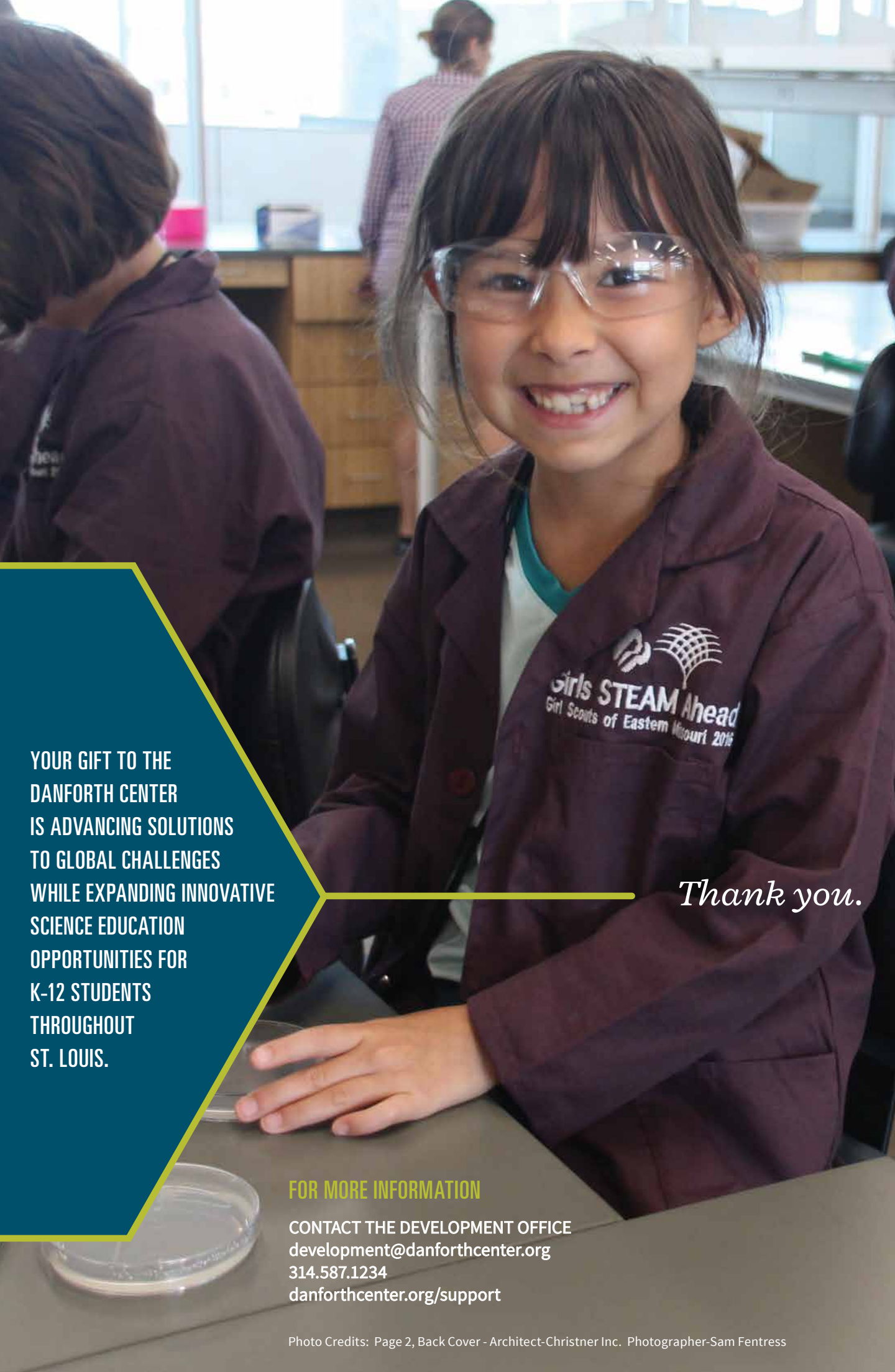
DEPRECIATION EXPENSE	
Depreciation of Fixed Assets	$5,991

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.

3 Includes equipment purchases funded by grants of $810,000



YOUR GIFT TO THE DANFORTH CENTER IS ADVANCING SOLUTIONS TO GLOBAL CHALLENGES WHILE EXPANDING INNOVATIVE SCIENCE EDUCATION OPPORTUNITIES FOR K-12 STUDENTS THROUGHOUT ST. LOUIS.

Thank you.

FOR MORE INFORMATION

CONTACT THE DEVELOPMENT OFFICE
development@danforthcenter.org
314.587.1234
danforthcenter.org/support

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