DONALD DANFORTH
PLANT SCIENCE CENTER

the Leaflet

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PLANT SCIENCE FOR THE NEW MILLENNIUM

The Leaflet is a publication for partners, friends, and supporters of the Donald Danforth Plant Science Center.

DONALD DANFORTH
PLANT SCIENCE CENTER

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The Platinum Seal of Transparency is awarded to fewer than 1% of the 1.8 million nonprofits profiled on Candid's leading charity-rating website, GuideStar.org.

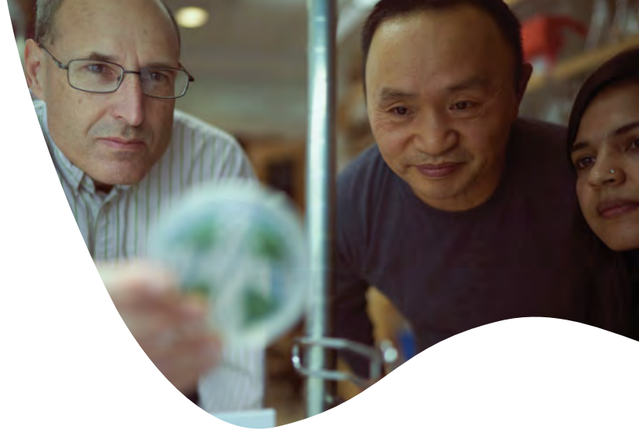
Leadership

Mission & Vision

MISSION: Improve the human condition through plant science

VISION: As a world center for plant science research, our discoveries will help feed the hungry and improve human health, preserve and renew our environment, and enhance the St. Louis region.

VALUES: Collaboration • Diversity and Inclusion • Innovation • Integrity and Respect • Environmental Sustainability • Stewardship



Plant Science for the New Millennium

Since 1998, the Donald Danforth Plant Science Center has brought together the best and brightest plant scientists from around the world to address humanity's most profound challenges. Today, the Danforth Center is the largest organization of its kind, an independent nonprofit determined to *improve the human condition through plant science*.

More than 300 scientists from 35+ different countries work in teams focused on research at the nexus of food, energy, and the environment. We seek to feed the hungry and improve human health, while preserving and renewing our environment. We believe in the power of science to lift families, communities, and nations from poverty and empower people everywhere to enjoy better health and a higher quality of life. Our work is changing the world for the better, and St. Louis too. In 2021, the annual economic impact generated by the Danforth Center, BRDG Park, and EDGE@BRDG, was $412M. We've come a long way.

As we prepared to celebrate our quarter-century anniversary, the Danforth Center was confronted by the mutability of life: a towering figure in our research and innovation community, Todd Mockler, PhD, Geraldine and Robert Virgil Distinguished Investigator and co-founder of Benson Hill, passed away. We will dedicate a portion of our fall issue to a celebration of our first 25 years. In this issue, we remember our colleague.

News & Events

READ MORE NEWS & EVENTS AT DANFORTHCENTER.ORG.

NEW BOARD DIRECTORS

Three new directors assumed their roles on the Danforth Center Board this January, bringing extensive business, innovation, and scientific expertise. They are Lisa Ainsworth, PhD, professor of plant biology at University of Illinois; Olympian and nonprofit founder Jackie Joyner-Kersee; and William L. Polk, Jr., managing partner of Egis Capital Partners. One former director resumed the role: Christopher B. Danforth, President of Kennelwood Pet Resort. With their unique talents and expertise, these visionaries will strengthen our research, ensure our accountability, and serve as ambassadors for the Center's mission.

YANG ELECTED AAAS FELLOW

Principal Investigator **Bing Yang, PhD**, was elected a 2022 fellow of the American Association for the Advancement of Science (AAAS), the world's largest general scientific society. Yang earned his place in this prestigious group due to his distinguished contributions to plant pathology and gene editing. The Yang lab seeks to lessen the impact of diseases in rice, and his methods have inspired the creation of new technologies for gene and trait discovery in plant research. Read more about Dr. Yang's work on pp. 12-13 of this issue.

PEPTYDE BIO A STARTUP TO WATCH

Peptyde Bio has been named one of the nine "2023 Startups to Watch" by the *St. Louis Business Journal*. Spun out of the Danforth Center in 2022, Peptyde Bio is pairing nature's abundance with the power of AI to develop novel biofungicides that are environmentally friendly, less expensive, and highly effective. Cofounded by Danforth Center Principal Investigators **Dilip Shah, PhD** and **Kirk Czymmek, PhD**, the company received initial investments from the Danforth Technology Company and the Wells Fargo IN^2 before completing an oversubscribed $1.2M pre-seed funding round.

DANFORTH CENTER @SXSW

The role of microbes in improving human heath was featured on the global stage when **Rebecca Bart, PhD**, Danforth Center Principal Investigator, presented at South by Southwest (SXSW), in March. Held annually in Austin, Texas, SXSW is one of the most sought-after annual conferences in the world, attended by leaders and innovators in business, entertainment, and culture. Economic development group Greater St. Louis Inc. led the effort to feature St. Louis. Bart spoke on links between microbiomes in plants and soil to microbiomes in the human gut.

CLIMATE SUMMIT

The Midwest Climate Collaborative (MCC) held its first annual summit this February in St. Louis. The 3-day gathering was attended by 325 people (80 virtual) from 12 Midwestern states and featured keynotes and workshops on topics ranging from renewable energy and public health to sustainable ag and climate communications. The Danforth Center, a founding member of the collaborative, hosted a tour and workshop. The MCC includes local and regional governments, universities, corporations, and nonprofits focused on coordinating and accelerating climate action.

VISITING DIGNITARIES

Japanese Consulate: In February, visitors from the Consulate General of Japan in Chicago came to St. Louis to learn more about innovation in agriculture, geospatial technologies, healthcare, and plant research. Representatives met with President and CEO **Jim Carrington, PhD**, who spoke about how the Danforth Center is driving the technologies that will change the future for the better.

MO Legislators: In December 2022, newly elected Missouri freshmen legislators embarked on a bus tour of the state, stopping at the Danforth Center to learn about plant science research. They toured the Center's cutting-edge facilities and heard from leaders in the innovation community about education, job creation, and agricultural partnerships supported by the Center's work.

• Jackie Joyner-Kersee

• Japanese Dignitaries

• MCC Summit

• @SXSW

• Bing Yang, PhD

Big Dreams, Big Data, and Beyond

REMEMBERING TODD C. MOCKLER

The Danforth Center community was deeply saddened by the passing of **Dr. Todd C. Mockler** on January 6, 2023. Todd had been the Geraldine and Robert Virgil distinguished investigator at the Danforth Center since 2011 and was a wonderful colleague, collaborator, and friend to many. He was a scientist-entrepreneur who had a positive impact on plant science and successfully translated his discoveries into real-world solutions for food and agriculture. His legacy in St. Louis and beyond will be felt for a long time.

Jim Carrington and Todd Mockler with Geraldine and Robert Virgil when Todd was named the distinguished investigator.

A LIFE IN SCIENCE

As a child, Todd loved math and science and "figuring out how things work." He thought he wanted to be a medical doctor, but realized one day that "not everybody gets sick, but everybody eats." He received his PhD from UCLA in 2002 on light photoreception by plants and went on to do postdoctoral training at the Salk Institute, where he began analyzing plant gene expression networks using computational and genomics approaches.

In 2006, Todd was hired at Oregon State University, where he established himself as a fearless, computationally savvy plant scientist. By 2011, when Todd moved his lab to the Danforth Center in St. Louis, he was a well-known collaborator sought out by researchers around the world. Todd would go on to coauthor nearly 100 scientific research articles while mentoring dozens of technicians, undergraduate and graduate students, and postdoctoral fellows.

DIVING DEEP INTO DATA

Todd was working mostly in model plants when he was invited to attend a sorghum conference as an external observer in 2012. He said later: "Sorghum is this amazing crop with innate drought and heat tolerance. I realized right then I wanted to work with it." Through funding from several federal agencies and foundations, sorghum eventually dominated research in the Mockler lab.

One project of which Todd was especially proud was the TERRA-REF field phenotyping system in Maricopa, Arizona. "In 4 years, we went from an empty field to operating the world's largest agricultural robot," said Todd. The data collected and analyzed is being used to accelerate sorghum breeding and to test new ways of capturing field performance data.

Through the years, Todd and his team generated tremendous volumes of genomic, transcriptomic, and high-throughput phenotyping data in plants. With his affinity toward quantitative analysis, Todd focused much energy on computational tools, including AI, to make sense of it all. Advances in these areas had unexpected applications and extensive entrepreneurial impact.

SCIENTIST-ENTREPRENEUR

While at OSU, Todd noticed that he was being showered with requests from collaborators to analyze high-throughput genome and transcriptomic data, using tools that his team developed. Sensing a broader opportunity, Todd co-founded a start-up company called Intuitive Genomics with Doug Bryant and others to help companies gain insights into their newly acquired genome expression data. When Todd moved to St. Louis, so did Intuitive Genomics. A few years later, the company was bought by NewLeaf Symbiotics, with Todd and Doug taking on data science roles.

In the summer of 2012, Todd met Matt Crisp and co-launched a company to improve crops by improving photosynthesis. With Matt as CEO of Benson Hill, Todd was the first CTO. Although photosynthesis faded from the company's sights over the next 10 years, Benson Hill became one of the most successful start-ups in agriculture and food technology. It is now a public company with more than 450 employees and headquarters on the Danforth Center campus.

The TERRA-REF high-throughput phenotyping gantry system developed by the Mockler lab was the "biggest ag robot in the world," wrote the Wall Street Journal.

Benson Hill Cofounders Todd Mockler and Matt Crisp in Times Square with Benson Hill advertising, October 2022. They were in town to ring the bell on the NYSE.

Sentiments left on the glass outside the Mockler lab.

Farmers with the cassava harvest. An essential food security crop, cassava is consumed daily by 3 of 5 people living in Africa, but has not been subject to the intense agronomic improvements of western crops. Danforth Center scientists are working to improve disease resistance.

Bacterial Blight Breakthrough

In a pioneering feat of research, Principal Investigator **Becky Bart, PhD**, and her collaborators, have demonstrated the effectiveness of a new technology to improve cassava's resistance to cassava bacterial blight (CBB), a disease that causes near-total yield losses for this essential staple crop. Their findings, recently published in *Nature Communications*, have the potential to help ensure food security for farmers and families around the world and could pave the way for stronger, healthier varieties of many other critical crops.

Cassava is one of the most important crops in the tropics, feeding half a billion people in more than 80 countries. However, it is susceptible to many diseases and CBB is considered among the most devastating. Dr. Bart, Danforth Senior Research Scientist and first author **Kira Veley, PhD**, and coauthors at UCLA and University of Hawaii at Manoa, have demonstrated that a new technology—epigenome editing—can reduce CBB symptoms in cassava plants while maintaining normal growth and development.

Epigenetics is a natural process that cells use to control gene expression without changing the DNA sequence itself. The research team deployed one epigenetic mechanism (DNA methylation) to deliberately improve disease resistance to CBB. The resulting cassava plants had smaller and less intense symptoms of the disease on their leaves.

"Food security crops like cassava are often left behind when it comes to new frontiers in technology. This is one reason we are particularly excited to have applied these tools in cassava first," said Bart.

This work was supported by a grant from the Bill & Melinda Gates Foundation, with funding from the National Science Foundation Graduate Research Fellowship Program and from Washington University in St. Louis through the William H. Danforth Plant Sciences Fellowship.

Principal Investigator Dr. Bart (right), Senior Research Scientist Dr. Veley (center), and Postdoc Dr. Itumeleng Moroenyane. The Bart lab has published results of the first-ever use of targeted methylation in food crop improvement—and they did it using cassava.

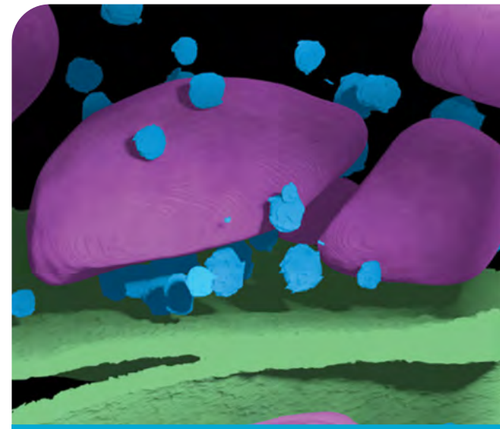
Saving Water with Sorghum

Water is a major limitation for crop production of all kinds, but especially bioenergy crops. To be economically viable and have environmental benefits, crops used for bioenergy need to grow where traditional food crops can't. That's why the US Department of Energy is funding Principal Investigator **Ivan Baxter, PhD**, to lead a five-year, multi-institutional project to deepen the understanding of water use efficiency in sorghum, a versatile bioenergy crop. The researchers are targeting enhanced acquisition of available water by roots, reduced water loss through plant pores, and improved photosynthesis. Scientists at the Enterprise Rent-A-Car Institute at the Danforth Center work to create green solutions for global challenges. Their findings could help make all bioenergy crops more cost-effective, better for the planet, and capable of growing in more regions around the world.

Sorghum is naturally drought tolerant and can grow where other crops cannot. Dr. Ivan Baxter's lab is leading a project to better understand and improve water use, so that all bioenergy crops can be more efficient.

Chan Zuckerberg Funds Bioimaging

The Chan Zuckerberg Initiative awarded a two-year grant to **Kirk Czymmek, PhD**, director of the Danforth Center's Advanced Bioimaging Laboratory, and an international team of scientists, to build a global community and training resources for volume electron microscopy (vEM). This cutting-edge imaging technology enables discoveries never before possible, allowing scientists to go beyond the standard 2D images that most microscopes provide, and instead view 3D images down to one nanometer. The team plans to produce multimedia outreach materials and training videos; develop vEM software platforms, plugins, machine learning models, and reference datasets; and build the infrastructure to maintain a network of vEM-trained scientists. The Danforth Center's new Helios 5 Hydra DualBeam will become one of a global network of vEM systems, advancing the frontiers of scientific discovery. Because it is so new, vEM is not widely available and has been nearly impossible for most scientists to access.



Volume electron microscope view of a plant cell with 3D perspective. This powerful new technology is not yet widely available. Dr. Kirk Czymmek's lab is leading a project to develop community and training around it.

Smallholder farmers tending the cowpea crop. Pod borer insects formerly caused losses of up to 80 percent, but a new resistant variety, brought to market by a team including the Danforth Center, is improving yields.

Protein for the People

EMPOWERING OUR PBR COWPEA PARTNERS FOR A SUSTAINABLE FUTURE

Cowpeas (*Vigna unguiculata*) are better known in the United States as black-eyed peas. They are protein-rich and drought-tolerant. They grow in semi-arid regions around the world, but especially in West Africa, where they are a vital food security crop for more than 200M people.

The crop was formerly susceptible to the pod borer—an insect pest that destroyed up to 80% of yield—and required farmers to spray pesticides up to 10 times during the growing season, often without protective gear, and at substantial expense and risk to their health. Seeing the need, a group of international organizations deployed an approach widely used in the US to control insect pests and developed a Bt version of cowpea that demonstrates nearly complete protection against the pod borer. The Danforth Center helped obtain approval for the new variety, and in 2019, Nigeria made history when it became the first country to approve pod-borer resistant (PBR) cowpea for use. Ghana followed in 2022.

SCALING SEED SUPPLY

When the first PBR cowpea seed became available in summer 2021, farmers bought all 7.5 metric tons within days. The demand was there, but the supply? For an improved crop to help the most people and have the most impact requires widespread adoption. Current cowpea seed systems in West Africa are limited in both the quantity and quality of seed they can produce. The goal of project partners is to produce annually 1,000 metric tons of seeds within the next five years. **This work simply will not be possible without empowered partners around the world.**

Dr. Don MacKenzie, head of the IICI, participated in an educational seminar for staff of Ghana's National Biosafety Authority in February. With regulatory assistance from the Danforth Center, PBR cowpea was approved in Nigeria in 2019 and in Ghana in 2022.

TRAINING & EXCHANGE

One of the first partners is the **Nigerian National Agricultural Seeds Council** (NASC). This January, the Danforth Center's **Don MacKenzie, PhD**, welcomed candidates to the first licensed seed inspector training in Kano, Nigeria. Among other presenters was **Tolulope Rebecca Mewase**, who provided an introduction to molecular diagnostics and trait purity testing. Mewase is a seed scientist who previously trained at the Danforth Center in 2018 and 2019 before returning to Nigeria and working to grow the seed certification community there.

In February, Dr. MacKenzie was in Ghana to participate in a training by **Ghana's National Biosafety Authority**. The seminar aimed at building the capacity and expertise of Ghanaian staff and stakeholders on genetically modified organisms and genome editing.

In March, the Danforth Center was honored to host **Professor Mohammad Ishiyaku**, executive director of the Institute for Agricultural Research (IAR) at Ahmadu Bello University, Nigeria. Dr. Ishiyaku has led the breeding and development of PBR cowpea in Nigeria for over two decades. He spoke on "Mitigating Hunger and Poverty through Effective Partnership" to the Danforth Center community.

Professor Mohammad Ishiyaku, head of PBR cowpea development in Nigeria, demonstrating cowpea pollination technique in the Danforth Center greenhouse to Danforth Center scientists Kemi Olofintila (left) and Dr. Getu Duguma (center).

LONG-TERM SUSTAINABLE SOLUTIONS

The Danforth Center's **Institute for International Crop Improvement** (IICI) is dedicated to a simple idea: that no matter where they live, farmers—and the people who depend on them—deserve better crops: crops that are resistant to pest and disease, crops that offer improved nutrition and higher yields, crops that can withstand a changing climate, crops that can lift communities out of poverty. Already the IICI is working with Nigerian farmers to determine the next generation of cowpea innovations. Scientists at the Danforth Center can apply discoveries, lead regulatory efforts, coordinate distribution and education campaigns. **But our in-country partners determine the long-term sustainability and ultimate success of these programs—and we are grateful for their partnership.**

"Whatever we need to achieve in the laboratory, we can learn to do it at the Danforth Center."

- Tolulope Rebecca Mewase, Principal Plant Molecular Scientist, National Agricultural Seeds Council, Nigeria

THANKS TO OUR PARTNERS

The Danforth Plant Science Center is thankful to be a partner in bringing improved cowpea to West Africa with: African Agricultural Technology Foundation (AATF); Commonwealth Scientific and Industrial Research Organisation (CSIRO); Institute for Agricultural Research (IAR) of Ahmadu Bello University, Zaria; Savanna Agricultural Research Institute (SARI), Ghana; Institut de l'Environnement et de Recherches Agricoles (INERA), Burkina Faso; National Agricultural Seeds Council (NASC), Nigeria; and the National Biotechnology Development Agency (NABDA), Nigeria. AATF facilitated the development with funding support from the United States Agency for International Development.

Smallholder rice farmers around the world feed and support their families and their communities, but harvests are down. Bacterial blight is an increasing scourge. Dr. Bing Yang and his collaborators hope to end the epidemic.

Better Rice for a Changing Climate

HOW DR. BING YANG'S RICE RESEARCH IS HELPING FEED THE WORLD

"Small farmers grow rice in the paddy field. There are no machines. It must be cultivated by hand. Sometimes you use water buffalo to help plow the field. You cut the rice by hand with a machete," says **Bing Yang, PhD**, Danforth Center principal investigator and professor of plant science at the University of Missouri - Columbia.

Yang is speaking from personal experience. He was raised in a smallholder rice farming family in Szechuan province. "Rice research is personal for me. Rice production and harvest matters to my family—and to millions of other small-scale farmers." Today, Yang is an internationally recognized expert on rice bacterial blight—and the developer of cutting-edge biotechnology tools that are helping speed rice research.

Rice is one of the world's most important staple crops, providing nourishment to billions of people around the globe, especially in Asia and Africa. In developing countries, smallholder rice farmers play a critical role in feeding the population, even while using traditional farming methods that have been passed down for generations. Rice is not just a source of food, but a way of life and a livelihood.

For Dr. Yang, rice is personal. He grew up on a small paddy farm in Szechuan. Today, he is a leading expert on rice bacterial blight—and the inventor of cutting-edge biotechnology toolkits to speed rice research.

FIGHTING THE BLIGHT

However, rice harvests are down. In 2022 rice production shrank by up to 10% in some countries. Rice farmers are already seeing the effects of a changing climate: there are more frequent floods and droughts. Droughts stress the plants and make them more susceptible to disease. Floods create the kinds of warm, moist environments in which many pathogens thrive.

One of the most destructive scourges is rice bacterial blight, an infectious disease created by the pathogen *Xanthomonas oryzae pv. oryzae (Xoo)*. The disease is most severe in southeast Asia but is increasingly damaging in West African countries, and results in substantial yield loss of up to 75%. There are no chemical remedies for rice bacterial blight, so inborn disease resistance in the crop is crucial.

The Yang lab has a dual focus: (1) understanding bacterial blight better, and (2) developing the gene-editing tools to do something about it. "With better understanding of how diseases infect plants, combined with advanced biotechnology tools, we can develop genetic resistance in rice varieties," says Yang. "Our goal is to give smallholder farmers seeds and tools to manage blight disease and reduce harvest losses."

In 2019, Yang and an international team of researchers successfully used CRISPR-Cas9 technology to edit the genes that makes the rice plant vulnerable to blight. Trials showed that the gene-edited rice lines were endowed with robust, broad-spectrum resistance. The findings were published in *Nature Biotechnology*.

Then in 2020, regulators in the United States and Colombia classified the gene-edited blight-resistant rice as equivalent to conventional varieties. The new blight-resistant varieties can now be used to introduce the resistance trait into many different types of rice via standard breeding strategies.

"We still face challenges ahead," says Yang, "But I believe we can help farmers effectively control bacterial blight and eliminate the epidemic."

WIDESPREAD IMPLICATIONS

Because rice is a model crop, the Yang lab can ultimately apply their research to the improvement of other grass species like corn, sorghum, wheat, and switchgrass. And the tools that the Yang lab is developing aren't just limited to his lab. "It's important to me that we share our knowledge. We make our biotechnology toolkits available to other scientists to use in their research, so these powerful tools can have a bigger impact in advancing plant science research," explains Yang.

Still from a video of the first-ever harvest of Golden Rice in the Philippines.

Seeing Is Believing: Golden Rice First Harvest

The first harvest of Golden Rice is in the Filipino history books. The beta-carotene-enriched rice was approved for commercial propagation in 2021 with regulatory assistance by the Danforth Center. Farmers harvested nearly 70 tons in the 2022 growing season. The rice was distributed to households with people at risk of vitamin A deficiency, including pregnant women, breastfeeding mothers, and preschool children.

Principal Investigators Mao Li and Chris Topp observing root structures in the photogrammetry shed. Dr. Topp developed mesocosms as a middle ground: "more realistic than a pot, but more conducive to root studies than the field."

Getting Your Hands Dirty

HOW DR. CHRIS TOPP'S LIGHTBULB MOMENT IS SHEDDING NEW LIGHT ON ROOTS

A few years ago, around 2016, Danforth Center Principal Investigator **Chris Topp, PhD**, was thinking about his proposals to a new ARPA-E program called ROOTS. As he was pacing and contemplating root studies, a construction dumpster full of shipping pallets caught his eye. "As I opened the side door on the dumpster and pulled out some pallets for my vegetable garden, it hit me: what if we had a big container full of plants and we could look in the side to see the roots?"

In December 2022, the Topp lab published an article in the journal *Frontiers in Plant Science* on their novel system to visualize, measure, and analyze full-size root systems. They built large (6-foot+) customized plant growth boxes, dubbed "mesocosms" and loaded them with sensors to measure environmental factors around the roots. The complete root system can be imaged and visualized in 3D through photogrammetry, the extraction of three-dimensional measurements from two-dimensional data (images). The mesocosms enable a better understanding of root traits and the impact of subterranean factors on crop plant growth and development than ever before.

Root studies in the field are mostly limited to digging trenches and soil cores. Root experiments in pots are often compromised because the roots become pot-bound, which is not their natural shape, and water and nutrients don't move the way they would in nature. "Mesocosms are a middle ground," says Topp. "More realistic than a pot, but more conducive to root study than the field."

Dr. Topp surveying rows of the over-6-foot-tall mesocosms in the Danforth Center greenhouse.

Fully assembled, the mesocosms are a seemingly messy DIY jumble of sensors and pallets. Once the dirt is carefully removed, however, what remains is the root architecture, which will be painstakingly imaged in 3D using photogrammetry and correlated to the sensor data.

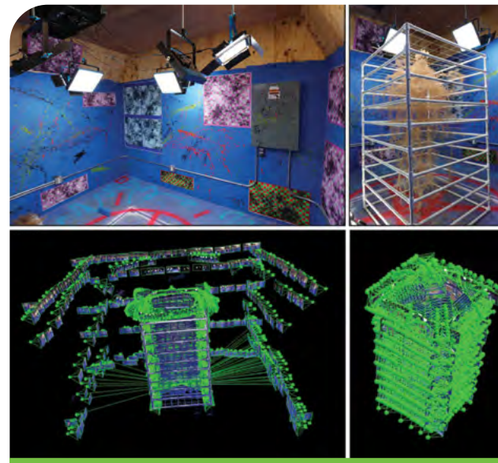
THE HIDDEN HALF

Hidden below ground, roots are the foundation of any plant's life and hold the key to solving some of our greatest global challenges—yet they remain mysterious. For most of human history, the question of how to study these complex living networks remained unanswered. Dr. Topp has made roots the focus of his research through a variety of innovative methods including field work, X-ray CT scanning, and mesocosms.

Through the study of roots, scientists in the Topp lab are learning about water and nutrient uptake, how plants respond underground to drought and other stressors, so that we can learn to grow plants in more places with less water and less fertilizer. They are figuring out how plants lock carbon in the soil—a vital service plants provide naturally that could be enhanced. They are investigating the symbiotic relationship between plants and the soil microbiome.

Topp is a co-director of the Danforth Center's new center of excellence, the **SINC Center** (Subterranean Influences on Nitrogen and Carbon). The SINC team is using mesocosms to carry out one of the Center's flagship projects: understanding how microbes can persist on root systems across space and time. "We sample roots from different parts of the box, the microbes there—how do they differ across root length, depth, temperature. We are trying to understand how and when the microbes hitch on to roots, so that we can minimize fertilizer use."

"Everything you see above ground is supported and nourished by what's underground," says Topp. **"Roots have enormous untapped potential to help solve our biggest challenges, especially climate change."**



Images and data from the photogrammetry shed. AI and machine learning algorithms developed by the Danforth Center's Data Science team help make sense of the voluminous data on root size, shape, density, and other traits captured by the mesocosm's sensors.

Plants whiz by on the conveyer belt in the automated high-throughput Phenotyping Facility. Facility Director Dr. Katie Murphy (left) consults with fellow Principal Investigator Dr. Nadia Shakoor on her experiment.

Part of the Phenotyping Facility, the **Bellwether Foundation Phenotyping Facility** seen above is supported by the Bellwether Foundation and by donors like you. To support plant science for the planet, visit **danforthcenter.org/give**.

Speeding Plant Science

PHENOTYPING FACILITY LEADS THE WAY IN CUTTING-EDGE TECHNOLOGIES FOR SUSTAINABLE CROP DEVELOPMENT

Innovative plant science requires cutting-edge technologies. At the Danforth Center, our core facilities equip scientists with state-of-the-art instrumentation and expertise to do groundbreaking research. The cores act as hubs of collaboration and problem-solving that accelerate discovery and innovation.

WATCH AND LEARN

An essential part of plant science is understanding how plants respond to their environment. One way scientists can measure this is by monitoring a plant's *phenotype*, or visually identifiable characteristics, such as leaf size and shape, root structure, growth rate in particular conditions, and more. This data is used to develop improved and sustainable crops that are better able to withstand conditions like drought and extreme temperatures.

"Phenotyping is all about measuring plant traits," says Principal Investigator **Katie Murphy, PhD**, the Danforth Center's new director of phenotyping. "What does this plant look like? How tall is it? How green is it? How deep do its roots grow?" Answering questions like these is essential in the effort to develop stronger and healthier plants to feed and fuel the world sustainably. However, until recently, phenotyping was a slow and labor-intensive process involving individual observation and documentation and took many human hours to collect and process data. With the advent of robotic, imaging, and other sensing technologies, phenotyping has been catapulted into the era of Big Data.

AWESOME AUTOMATION

When it debuted in 2013, the **Danforth Center Phenotyping Facility** was the first of its kind at an academic research institute anywhere in the US. At the heart of the Facility, the Bellwether Foundation Phenotyping Facility features high-throughput automation to allow scientists to gather an unprecedented amount of data about the plants they are studying. With multiple systems for automated plant imaging, watering, and weighing, this Facility can measure the traits for 1,140 plants per day. This information helps scientists identify the key traits that affect plant productivity and resilience to environmental stress, and associate those traits to plant genetics.

"Instead of manually watering plants every day, we use robotics and a controlled environment to allow the precise, automated weighing and watering of plants," Dr. Murphy says. "We then take photos of the plants using different types of cameras and analyze those images using machine learning. This is a lot faster than using a ruler every day to manually measure our plants!"

Today, the Phenotyping Facility is expanding, adding new instruments and new venues. Dr. Murphy and her team are taking their expertise into the field, where they are measuring plant traits above and below ground—taking images by air, among the plants, and under the soil, as roots are growing.

ABOUT THE NEW DIRECTOR

Named the Director of Phenotyping in 2023, Dr. Murphy approaches phenotyping from a biological perspective. "I want to know how we can use these tools to answer interesting questions. How do you design experiments for plants with interesting problems?" As a Principal Investigator, Dr. Murphy uses the Phenotyping Facility to study how corn (maize) responds to heat stress. In her new role, Dr. Murphy works with Danforth Center labs and nearby start-up companies to help them answer research questions. This includes designing high-throughput experiments, analyzing data, and combining her team's expertise with the client's to achieve things neither can do alone.

WHY IT MATTERS

The world's population is growing and the climate is changing. We must understand the inner workings of plants in order to grow more food with less fertilizer and less water. The Phenotyping Facility is critical to speeding the science, so that we can feed the world in the future.

Sorghum plants on the Phenotyping Facility's automated track, which moves 1,140 plants per day to various stations for weighing, watering, and imaging. The Danforth Center's Data Science team collaborates on algorithm and software development to analyze all the data.

"As global temperatures continue to rise, we must increase crop yields and crop durability in order to feed people. Our Phenotyping Facility helps accelerate that science."

- Dr. Katie Murphy, Principal Investigator and Director of Phenotyping

WHD Fellow Ketra Oketcho with a colleague in a cassava greenhouse at the Danforth Center.

The WHD Fellowship was endowed by Dr. P. Roy and Diana Vagelos to support outstanding PhD students in plant science. If you are interested in creating opportunities for bright, early career scientists, call 314.587.1234.

On a Mission to Improve Cassava

MEET THE 2023 WILLIAM H. DANFORTH FELLOW

Ever since she was a child in Uganda, **Ketra Oketcho** has been interested in the science behind the natural world. She would let a mosquito bite her to see how long it would take to feel the itch. When she noticed a papaya plant beginning to flower, she took a photo each day before school to monitor its development. Later, as a volunteer at the National Agriculture Research Organization in Uganda (NARO), she looked into a microscope for the first time and knew she was meant to do research.

When Ketra was hired at NARO, she gained experience doing plant transformation and field research in the VIRCA Plus project. She also met Danforth Center Principal Investigators **Nigel Taylor, PhD**, Dorothy J. King distinguished investigator, and **Becky Bart, PhD**, who encouraged her to continue to develop in her career.

Today, she is a second-year graduate student at the University of Missouri - St. Louis, conducting research to understand how the cassava mosaic virus replicates in cassava. She is also the 2023 William H. Danforth Plant Science Fellow.

"Being a part of creating a solution that is going to impact so many peoples' lives is a big deal."

- Ketra Oketcho, 2023 WHD Fellow

THE NEED FOR IMPROVED CASSAVA

Growing up in the village of Rubongi, Ketra experienced first-hand the impact that improved cassava could have on food security and human health. Cassava and millet are staples used to make bread. "People do not consider a meal complete unless that bread is present," explained Ketra. "If a disease wiped out cassava, the people in my village would starve."

Ketra is hopeful about the impact her work can have in her home country. "Being a part of creating a solution that is going to impact so many peoples' lives is a big deal. I feel grateful to be a part of the effort to find a solution for food security," she said.

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Danforth Center VP of Public and Government Affairs Karla Roeber leads a tour for Missouri state legislators. See p. 5 for details.

George Fonyo, 96, portrait taken prior to Lab Sponsor Luncheon 2022. often attends multiple events per day, a social schedule that would exhaust most younger people.

Connecting Silos

GEORGE FONYO IS HELPING SAVE THE WORLD, ONE CONNECTION AT A TIME

"I just have a wild imagination. I try to think of connections that people don't think of."

George Fonyo, 96, is trying to explain his success as one of the Danforth Center's most successful ambassadors. George has introduced dozens of friends to the Danforth Center, many of whom go on to become donors themselves. He has been one of the Center's most active supporters since the beginning.

"I was here the first night. There were only about 50 people in the new building. Bill Danforth was talking, explaining how he and [the Garden's] Peter Raven and [Monsanto's] Virginia Weldon were flying on a red-eye and sketched the vision for the Center out on a napkin at the airport!"

Born in the Chicago suburb of Evanston, George grew up in Clayton and attended Washington University in St. Louis. He spent most of his career in building products for the construction industry, most recently in aluminum curtain walls and flat panel cladding. He is gregarious by nature.

George has been a member of the Danforth Society since 2008 and has planned for the future of the Center by becoming a member of the WHD Legacy Society as well. He serves on the Danforth Center Friends Committee and speaks enthusiastically out in the community about the Danforth Center mission.

Beyond his wild imagination, George credits the mission of the Danforth Center for his zeal: "The Danforth Center mission appeals to me: critical solutions can all be done through plant science. If we're not successful here, there's just going to be a world of starvation. I won't be here, but I worry about it for my grandchildren!"

You can make a difference.
There are many ways to get involved at the Danforth Center. Visit **danforthcenter.org/get-involved** to learn more.

Fonyo with Dr. Bill Danforth (center) and supporters Jim Johnson (left) and Jim Knight (right) at a 2015 Danforth Center event.

Tributes

*The Danforth Center is grateful to donors who choose to honor or memorialize their friends, loved ones, and colleagues with a gift to the Center. Gifts listed here were received by December 31, 2022. To make a tribute, visit **danforthcenter.org/tribute**.*

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