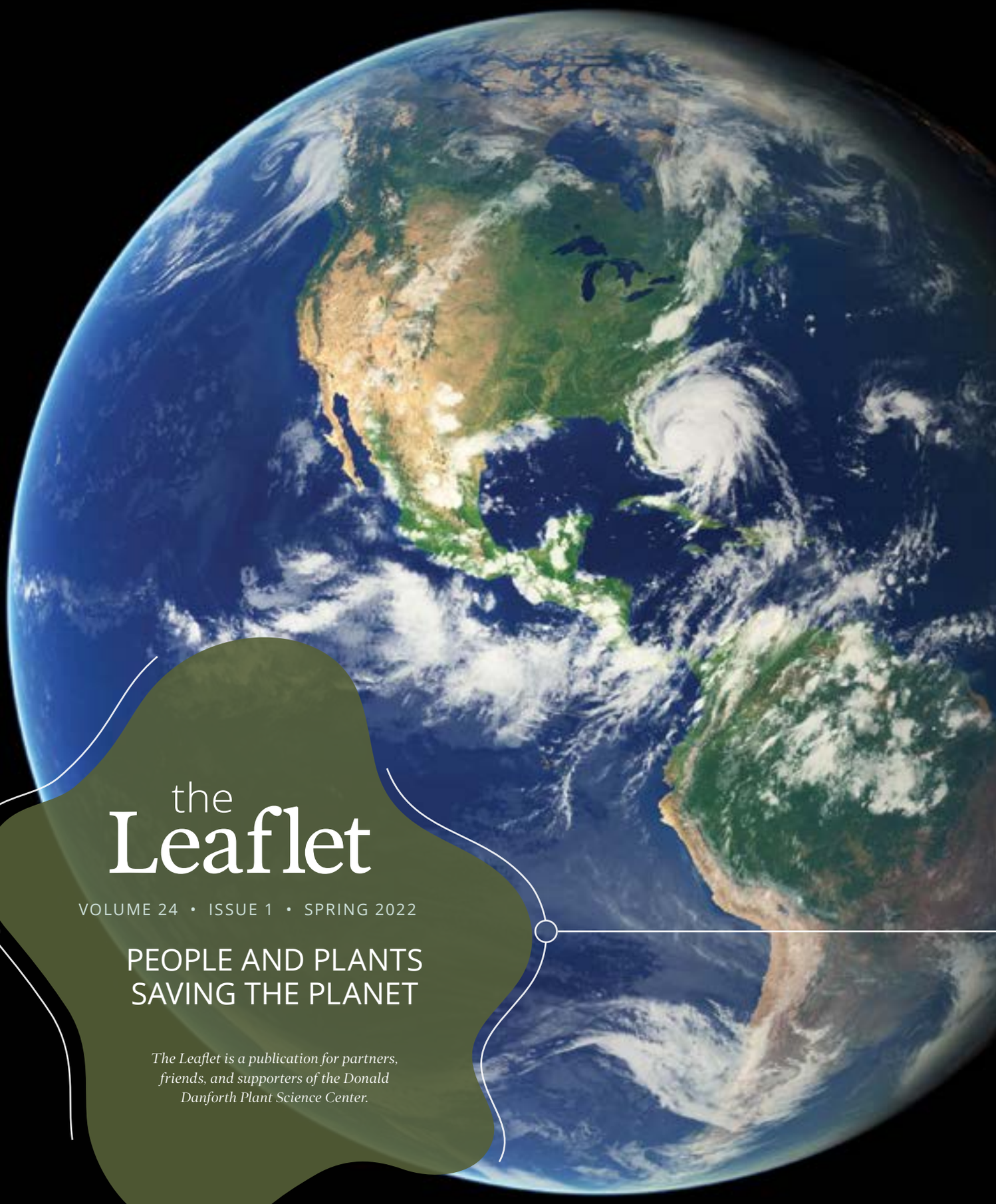
DONALD DANFORTH
PLANT SCIENCE CENTER



the Leaflet

VOLUME 24 • ISSUE 1 • SPRING 2022

PEOPLE AND PLANTS SAVING THE PLANET

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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Founder

William H. Danforth, MD

Leadership

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

Platinum Transparency 2022 Candid.

The Danforth Center holds the Platinum Seal of Transparency from Candid, representing the top 0.75% of the 1.8 million nonprofits profiled on the GuideStar.org website.

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Printed on paper from sustainably managed forests with 10% post-consumer content.

The Leaflet, spring 2022, vol. 24, issue 1

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photography: Adobe Stock (3, 5, 10, 15, 16, 21, 24, 28); Courtesy Sara Yang Bosco (4); Matthew Freebersyser (2); Devon Hill (4-5, 6, 9, 14 bottom, 17, 22); Bill Kezele (11 top); Courtesy KMOX (7); Elizabeth McNulty (7 bottom, 14); Allison Miller (8); NASA (cover, 3); Courtesy NASC (4); Bill Stutz (5, 8, 10 bottom, 14, 16 bottom, 18, 27); Monica Zawicki (6); USAID (11).

Heal the Planet

Climate change is the biggest challenge facing our generation. Mainstream scientists agree that greenhouse gas accumulation is causing the Earth's warming. Many people understand that power generation, manufacturing, and transportation play major roles. But many may not know that agriculture is also a major contributor to greenhouse gas accumulation. The most significant greenhouse gasses—carbon dioxide, methane, and nitrous oxide—are all emitted by various agricultural practices. **Farmers have a major role to play in combating climate change—and they need better tools and technology to help them, if we're going to feed the world sustainably.**

Science to address challenges at the nexus of agriculture and the environment has never been more important, and that's where the Danforth Center comes in. This issue of the *Leaflet* focuses on the ways Danforth Center scientists are tackling climate change: both in terms of mitigating its effects through sustainable agriculture, as well as adapting crops to survive in future conditions. In the words of our founder, Dr. Bill Danforth, "The special task for all of us who care about the future of humankind must be to work individually, and through the combined strength of our institutions, to help agriculture become more productive and sustainable, and to do so quickly."

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 and innovation expertise. They are: Patrick O. Brown, PhD, CEO and Founder of Impossible Foods; Sara Yang Bosco, Senior Vice President, Secretary and General Counsel for Emerson; and Sanjeev Krishnan, Chief Investment Officer of S2G Ventures. Board directors help ensure the Center operates lawfully, ethically, and productively, while serving as ambassadors for the Center's mission. They serve four-year terms. Rolling off the board were Brett Begemann and Chris Danforth, who had served since 2014 and 2011, respectively.

SEEDING THE FUTURE

The Danforth Center has signed a memo of understanding with the National Agricultural Seeds Council (NASC) in Nigeria to ensure farmers there receive the highest quality seeds with the best possible yields. The partnership will enhance the use of molecular diagnostics in seed certification and promote scientific exchange. Signers included Dr. Phillip Olusegun Ojo, NASC director general, and **Donald MacKenzie, PhD,** executive director of the Danforth Center's Institute for International Crop Improvement. "This agreement represents a key milestone and extension of our engagement with our partners in Nigeria," said MacKenzie.

40 UNDER 40

Congratulations to Danforth Center Vice President for Human Resources Anna Dibble, who was named one of the *St. Louis Business Journal's* "40 under 40." The honor recognizes young professionals in the St. Louis region who are having an impact across a wide array of industries. Anna leads people strategy for our community of nearly 400 scientists and staff. In her current role, Anna works to influence and foster collaboration and partnership among employees and leadership.

PLANT BREEDING BREAKTHROUGH

After four years of work, members of the laboratory of Danforth Center Principal Investigator **Keith Slotkin, PhD,** have uncovered new information that could make the entire field of plant improvement faster, easier, and more cost-efficient. Their remarkable findings, recently published in *Nature Plants*, shed new light on the causes of a major hurdle for researchers around the world—gene silencing. "We are at a crop research institute like the Danforth Center to make the plant improvement process easier for everyone," said Slotkin. Their technical achievement should enable researchers and breeders to avoid silencing of the trait from the outset.

MIDWEST CLIMATE COLLABORATIVE

The Danforth Center is a founding member of the Midwest Climate Collaborative. Launched in January, the Collaborative was born out of a series of virtual think tanks hosted by Washington University in St. Louis. Stakeholders include local and regional governments, universities, corporations, and nonprofits. "If the Midwest were its own country, it would be the fifth largest greenhouse gas emitter in the world," said Director Heather Navarro. "The Collaborative aims to facilitate and accelerate a coherent Midwestern response to the climate crisis."

HISTORIC ACHIEVEMENTS

Toni Kutchan, PhD, Oliver M. Langenberg Distinguished Investigator and vice president for research at the Danforth Center, was elected board president of the Academy of Science – St. Louis. Kutchan, a leading expert in medicines derived from plants, is the first woman to serve in the role. "The Academy is a major contributor to science literacy and STEM awareness in the region. I am honored to be entrusted with the role of president," said Kutchan.

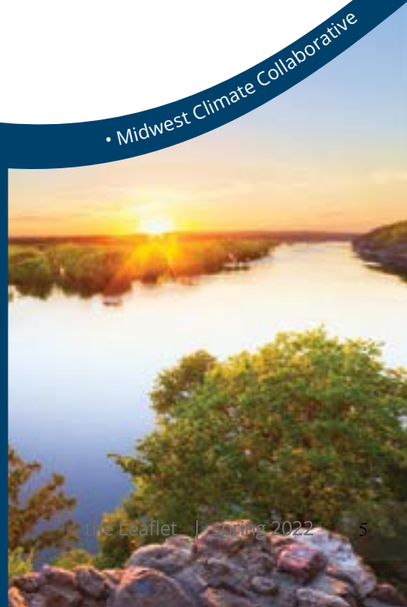
Elizabeth Kellogg, PhD, Robert E. King Distinguished Investigator at the Danforth Center, was given the 2021 Gray Award by the American Society Plant Taxonomists. The prestigious award recognizes a lifetime of achievements in plant systematics, in particular her "extensive contributions to the field of evolutionary developmental genetics." Kellogg, a leading expert on grasses, is also a member of the National Academy of Sciences.


• Sara Yang Bosco


• Nigerian Partnership


• Slotkin Lab


• Anna Dibble


• Midwest Climate Collaborative

WHD Fellow Kiona Elliott with cassava plants in the Danforth Center greenhouses.

Danforth Center Educator Darius Pikes and Olympian Jackie Joyner-Kersee receive a ceremonial check from Bank of America. The Neighborhood Builders program will support the Danforth Center's role in the JJK FAN Center in East St. Louis.

A Passion for Food Security

MEET THE 2022 WILLIAM H. DANFORTH FELLOW

Growing up in the metropolis of Fort Lauderdale, Florida, Kiona Elliott had little exposure to botany or agriculture. "Plants? Gardening? Nope. Nothing like that. I lived in the city, and nobody I knew was really interested."

However, during her sophomore year in high school, she was invited to participate in an independent research course and found her calling. Today, Kiona is a fifth-year PhD student in the Plant and Microbial Biosciences Program at Washington University in St. Louis. She is also the Danforth Center's 2022 William H. Danforth Plant Science Fellow.

Kiona works in the lab of Principal Investigator **Becky Bart, PhD,** and focuses on investigating the genetic mechanisms underlying cassava susceptibility to *Xanthomonas*-induced bacterial blight.

"My passion is in food security," said Kiona. "My goal is to take the research that I do and help provide enough food for the world's population. There are so many questions we can address, but they all lead back to producing abundant crops in a sustainable way.

Kiona is a first-generation college student who credits her mom with helping launch her studies: "When I became interested in plant science in high school, my mom drove me every week to the University of Florida Research and Education Center in Davie, 40 minutes from home. She'd wait in the car and do crossword puzzles while I was in the lab."

In addition to being a WHD Fellow, Kiona is a Gates Millennium Scholar, NSF Graduate Research Fellow, and NIH Initiative to Maximize Student Development Scholar.

"Kiona is a talented scientist and an amazing person," said Bart. "She sets a high bar among her peers in terms of her dedication to research, determination, and collaborative spirit.

The WHD Fellowship was endowed by Dr. P. Roy and Diana Vagelos to support outstanding PhD students whose research demonstrates great promise for advancing plant science.

"There are so many questions... but for me they all lead back to producing abundant crops in a sustainable way."

- Kiona Elliott, 2022 WHD Fellow

For Future Scientists

DANFORTH CENTER PARTNERSHIP WITH JJK FOUNDATION LANDS CORPORATE SUPPORT

Momentum is gathering behind a new initiative to transform students' lives and their community through the power of science. In early 2021, the Danforth Center joined forces with the Jackie Joyner-Kersee Foundation and the University of Illinois to start a new enterprise: the **Jackie Joyner-Kersee Food, Agriculture, Nutrition Innovation Center** (JJK FAN) in East St. Louis, Illinois. The goal? To help children learn to see themselves as scientists, while providing a pathway of opportunities in urban agriculture, research, and entrepreneurship.

The program seeks to inspire the next generation of scientists and science workers, contributing to a diverse and inclusive workforce that will meet the hiring needs of the St. Louis region's growing agtech and bioscience industries. And that's where local corporations see a sound investment.

BANK OF AMERICA NEIGHBORHOOD BUILDERS®

The Danforth Center has been named a 2021 Bank of America Neighborhood Builders® awardee. This highly competitive award provides the Center with a 2-year grant, as well as leadership training, to support equitable educational opportunities and workforce development at the JJK Fan Center. The Danforth Center is the only organization ever to be awarded this honor twice.

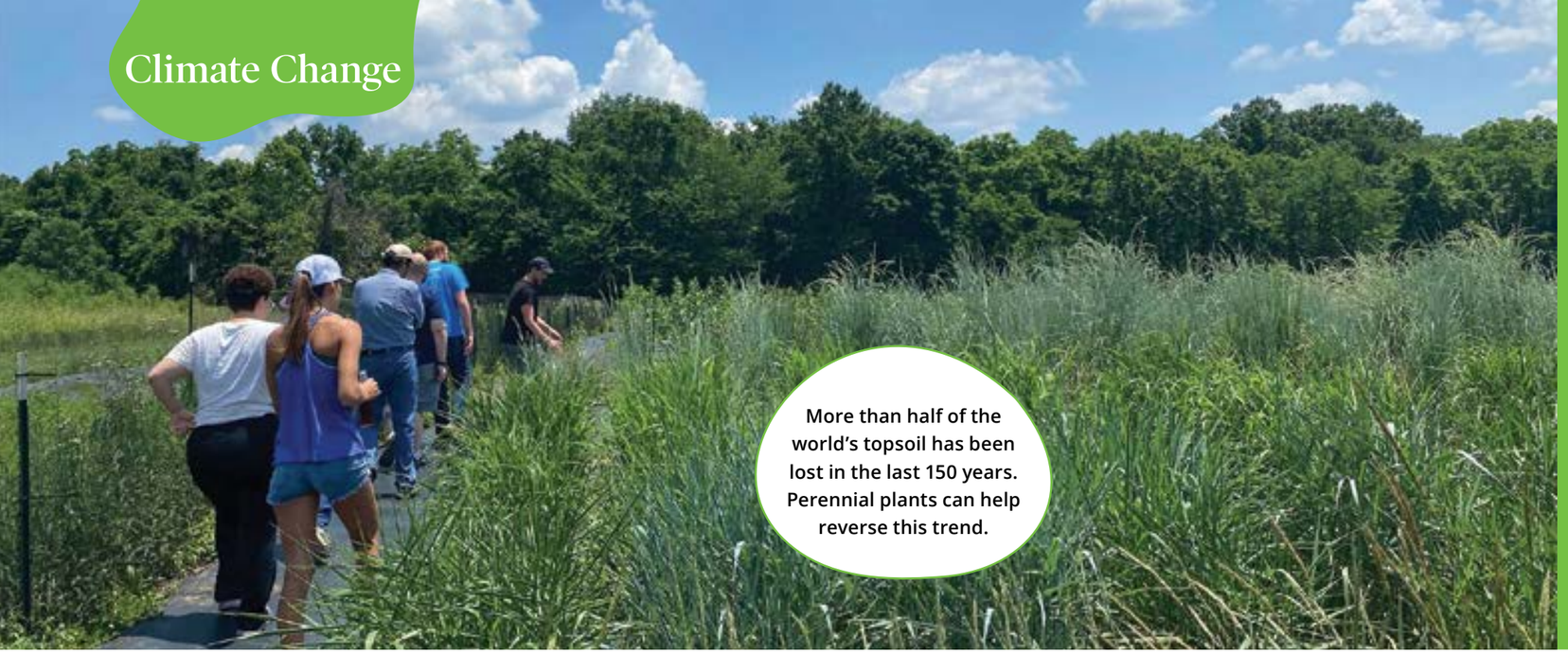
Danforth Center programs are supported by generous corporations, foundations, and individuals. Learn more about how you can help at ***danforthcenter.org***.

BOEING STEAM+AG CURRICULUM

The Danforth Center has received a grant from Boeing to support an afterschool curriculum at the JJK FAN Center for K-12 featuring STEAM+AG. Students will learn about genetics, molecular biology, plant pathology, food and agricultural science, and image analytics. There will be professional development for staff as well.

"We are grateful to Bank of America and Boeing for their investment in the future scientists of our region," said **Kris Callis-Duehl, PhD,** the Sally and Derick Driemeyer director of education research and outreach at the Danforth Center. "With your support, we are creating an education and workforce development pipeline that provides opportunities for students to develop marketable skills while learning about the importance of food and improving their own communities' access to nutrition."

Taylor Harris, a graduate student at the Danforth Center, talks about her work to students at the JJK Center.



More than half of the world's topsoil has been lost in the last 150 years. Perennial plants can help reverse this trend.

New Roots Partners

Danforth Center
Chicago Botanic Garden
Missouri Botanical Garden
Saint Louis Science Center
Saint Louis University
The Land Institute
University of Kansas
University of Missouri
University of Vermont

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New Roots is funded by the National Science Foundation with additional support from donors like you. To support plant science for the planet, visit ***danforthcenter.org/give***.

Putting Down New Roots

A NEW INSTITUTE BASED AT THE DANFORTH CENTER AIMS TO UNLOCK THE SECRETS OF PERENNIAL PLANTS AND THEIR WILD COMMUNITIES

As Danforth Center Principal Investigator **Allison Miller, PhD**, tells it, the story starts with the North American prairie. This breathtaking, expansive ecosystem stretches from Montana to Texas, and from Colorado to Indiana. What about it, she wondered, had helped the prairie sustain itself for thousands of years? And what could it teach us about healing our planet?

These questions are at the heart of the **New Roots for Restoration Biology Integration Institute** at the Danforth Center. With National Science Foundation funding, this collaboration involves nine organizations and more than 40 scientists and educators. It is led by Dr. Miller, who, in addition to her role at the Danforth Center, is also a professor of biology at Saint Louis University. The goal of the five-year research project is nothing short of harnessing nature to restore wild lands and to create the sustainable agriculture of the future.

PRAIRIE POWER

The prairie offers a valuable model for human-mediated ecosystems of the future. Prairies feature long-lived (or perennial) plants growing in diverse communities. Their deep, long-lived roots tolerate drought, foster healthy soil, and prevent erosion. They also sequester carbon.

Members of the Miller lab at one of their field sites. Allison Miller, PhD, is leading the New Roots for Restoration Biology Integration Institute, a collaboration to deploy knowledge about natural ecosystems to restore degraded landscapes.

"It's time to apply what we can learn from natural systems to move toward climate resiliency."

- Allison Miller, PhD
Danforth Center
Principal Investigator

Plants are unusual in that half their bodies exist above ground, in air, while the other half lives below ground, in soil. Scientists believe part of the answer to advancing restoration lies underground, in how root traits influence plant interactions with each other—and with the soil.

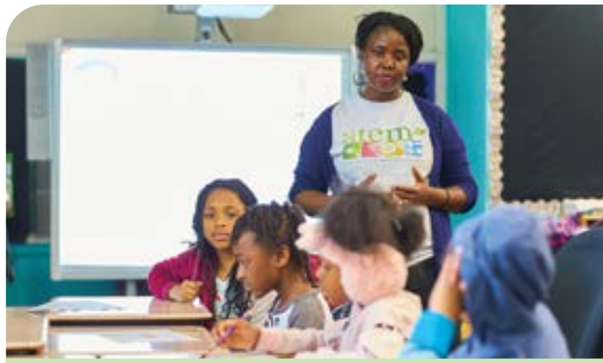
UNIQUE INFRASTRUCTURE

New Roots pulls together scientists from a startling breadth of disciplines to tackle these parallel and relational studies and deploys the Danforth Center's full cutting-edge infrastructure. To automate data capture of the above-ground part of plants, the Institute will use the Danforth Center's state-of-the-art Bellwether Plant Phenotyper. To understand below-ground plant traits, they will use the Topp lab's X-ray CT scanning capabilities. To grasp the elemental uptake, they will use the Baxter lab's Ionomics pipeline. To make sense of the reams of Big Data generated, New Roots will rely on Data Science Facility's computational power incorporating artificial intelligence (AI) and machine learning.

"New Roots will revolutionize our understanding by applying cutting-edge technologies used primarily in annual grain crops to wild plant species and perennial crop candidate species," said Miller. "I couldn't imagine leading this project anywhere but at the Danforth Center."

WHY IT MATTERS

Current agricultural methods are unsustainable: they require too much water, too much fertilizer. Urbanization of land and conversion to monoculture agriculture has impacted 75% of lands globally and has contributed to the loss of ~50% of the world's topsoil in the last 150 years. Central to the development of future food production systems are urgent questions of climate resilience, fossil fuel dependency, and the reversal of soil degradation. By mimicking natural ecosystems, scientists with the New Roots Institute are working to evolve an agriculture that both feeds us and restores the Earth.



Dr. Kaggwa, leader of New Roots Institute's DEI initiatives

New Opportunities

Restoration requires a diverse, nimble workforce that spans disciplines. One of the primary goals of the New Roots Institute is to bridge the urban-rural divide by reaching out to underrepresented groups. Students at the high school, undergraduate, graduate, and postdoctoral levels will receive scientific and leadership training. The program is designed as a career pipeline with many points of entry for trainees and ready mobility across participating institutions.

"We are committed to intentional efforts that re-envision the recruitment of trainees and the establishment of a nurturing training environment to attract scholars from racially minoritized groups that are historically underrepresented in STEM," said Ruth Kaggwa, PhD, Danforth Center education program manager and member of the New Roots executive committee.

Sorghum is nutritious and drought-tolerant, making it an ideal crop to be part of climate-resilient solutions.

Harnessing Plants for the Planet

DANFORTH CENTER PRINCIPAL INVESTIGATOR COLLABORATES WITH SALK TO BREED SUPER-SORGHUM

Plants can do amazing things. They provide us food, shelter, clothing, medicine, beauty, the very oxygen we breathe. They also sequester carbon when they "inhale" carbon dioxide out of the air and store it in roots or leafy matter, reducing greenhouse gas in the atmosphere.

That's why Danforth Center Principal Investigator **Nadia Shakoor, PhD**, is partnering with the Salk Institute's Harnessing Plants Initiative (HPI) to breed a better sorghum. The 5-year collaboration specifically seeks to identify and develop sorghum plants that can better capture and store atmospheric carbon.

"Up against climate change, plant science is uniquely qualified to help," said Shakoor. "And sorghum is an incredible plant that holds great promise as a carbon-sequestering crop."

ALREADY SUPER?

If you're looking for a crop superhero in the face of climate change, you'd be hard pressed to find better than sorghum. This ancient grain originated in northeast Africa thousands of years ago. As it spread, it adapted to become one of the most heat- and drought-tolerant of all grains.

The conversion of natural ecosystems to agriculture releases carbon from the soil into the atmosphere. What if we could grow food crops that also specialized in putting carbon back underground?

Today, sorghum is one of the top five cereal crops in the world and has a variety of uses—as a gluten-free grain for humans, sweet syrup, livestock feed, and biofuel. It is grown everywhere in primarily dryland acres with minimal inputs. In the US, the "sorghum belt" runs from South Dakota to South Texas, with the state of Kansas the number one producer. Globally, the US leads production, but sorghum is a very important food crop in Africa and Asia. More than 500 million people in 30 different countries rely on sorghum as a key part of their diet.

"Sorghum is an incredible plant that holds great promise as a carbon-sequestering crop."

- Nadia Shakoor, PhD, Danforth Center Principal Investigator

Dr. Shakoor's sorghum research is funded by Salk HPI with support from the Bezos Earth Fund and Sempra Energy. FieldDock has support from NSF and USDA-NIFA. Donor support of the Danforth Center Innovation Fund helps new ideas reach the stage of grant funding. Learn more at ***danforthcenter.org***.

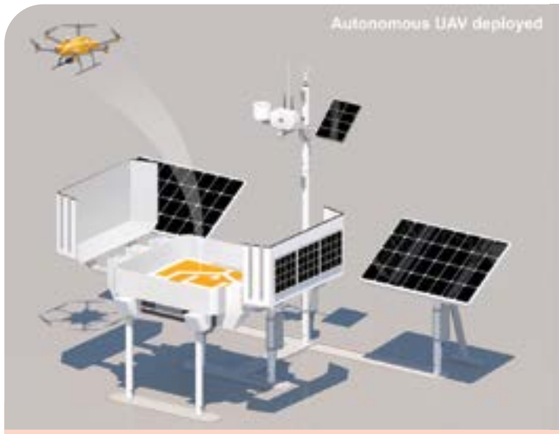
THE PLAN

Formerly the associate project director on the Danforth Center's Sorghum Genomics Toolbox (funded by Bill & Melinda Gates Foundation), Shakoor is an expert in sorghum genetics. Her lab has also sought to develop high-tech sensors to monitor plants' environments and growth in real time (see "FieldDock" at right). Using these data collection methods in the greenhouse and field, Shakoor's team will identify varieties of sorghum that have the traits needed for optimized carbon capture—such as large, deep root systems to store and move carbon into the surrounding soil. Shakoor's lab will then work with researchers at Salk to analyze the plants' genetics and identify promising candidates. They are working with National Sorghum Producers and Sorghum Checkoff Board to make sure that the outcomes are put into a breeding program.

THE PARTNERSHIP

"The Harnessing Plants Initiative is excited to partner with the Danforth Plant Science Center, which, like Salk, is a world leader in applying basic plant research to solve important problems such as climate change," said Todd Michael, PhD, research professor in Salk's Plant Molecular and Cellular Biology Laboratory and a member of the HPI team.

Sorghum farmers in Africa. Nigeria is the second largest producer of this ancient grain in the world. (Credit: USAID)

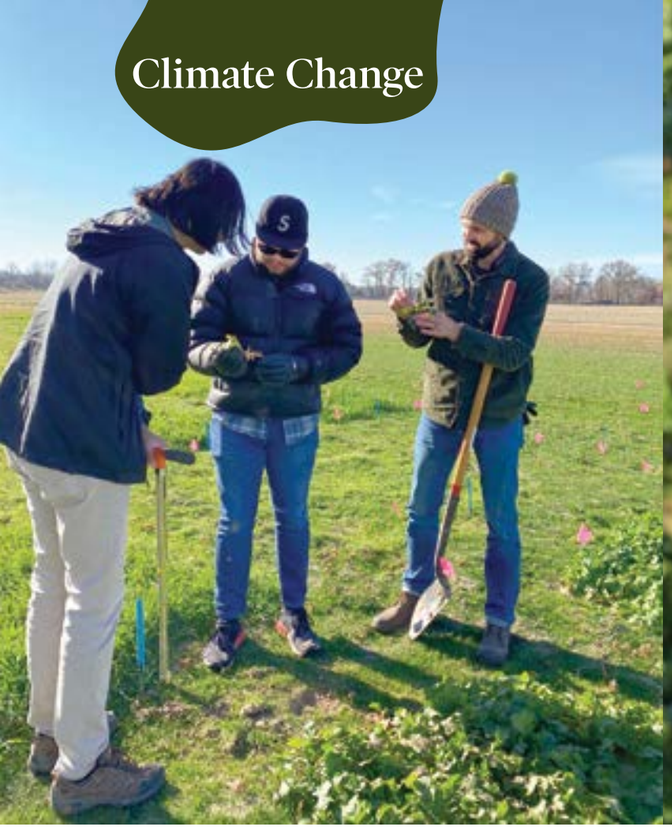


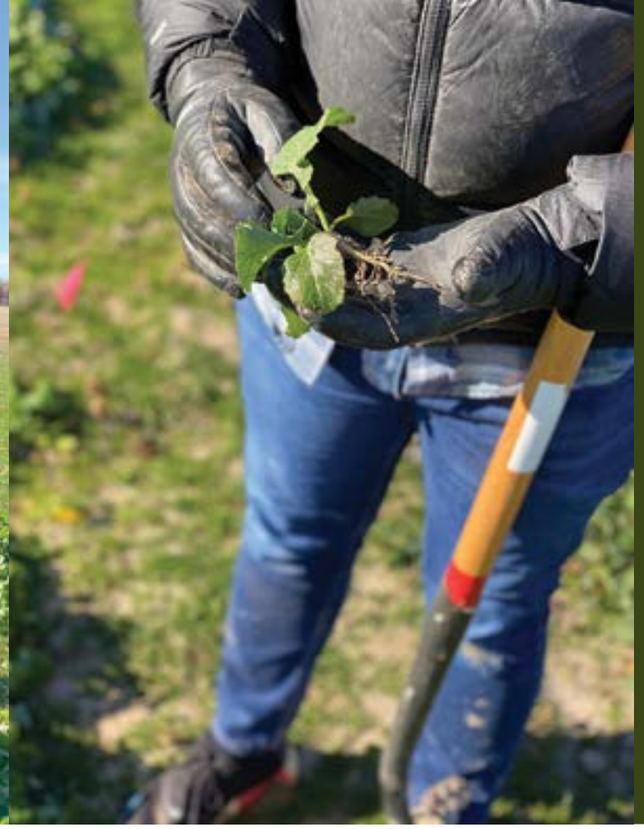
Farm of the Future: FieldDock

One of the tools at Dr. Shakoor's disposal in her sorghum research will likely be something she is developing in her lab: the FieldDock. In 2021, Shakoor received a USDA grant to develop an integrated smart farm system. The solar-powered technology will collect and analyze real-time data from the field to catch problems early, minimizing water and fertilizer use.

Shakoor is an entrepreneur. Her team first invented a field-deployable remote sensor in 2016. Called the PheNode, the device led her to found spinout startup Agrela Ecosystems. The FieldDock is the next generation: an all-in-one system that integrates a sensor base station with autonomous drone and "edge processing" of data right in the field. The project includes partners at Saint Louis University, University of Arizona, commercial farmers at Roth Farms, industry collaborators such as Microsoft, and local collaborators Integrated Systems Engineering, Inc. and Benson Hill, to build and test the FieldDock system.

Climate Change





Benefits of Cover Crops*

Capture of excess fertilizer (reduces pollution)

Improved water retention (reduces flooding)

Securing soil (reduces erosion)

Improved soil structure (less compaction)

Enhanced microbial activity (improves nutrient uptake)

Weed suppression

Soil carbon sequestration

And perhaps someday soon: revenue

**Not all benefits are available with just one cover crop. Success depends on selection for the local environment and for desired benefit. It's likely many farmers would benefit from a seed mixture.*

What's Old is New and Better

DANFORTH CENTER SCIENTISTS HELP IMPROVE COVER CROPS FOR SUSTAINABLE AGRICULTURE

Cover crops were once common. Farmers from the ancient Romans to the Native Americans to George Washington recognized the benefits of crop diversity to their soil health—and to their harvests. Modern agriculture replaced the practice with synthetic nitrogen fertilizer—the source, we now realize, of many unintended consequences. (See article "The (Ever)Green Revolution" on page 14.)

Today, in the face of erosion, pollution, and climate change, Danforth Center scientists like principal investigators **Chris Topp, PhD,** and **Dmitri A. Nusinow, PhD**, are working to improve cover crops for more rapid and widespread adoption. Said Topp: "Cover crops are an existing solution that's right in front of us. They are almost immediately actionable if we can just get past a few hurdles."

WHAT ARE COVER CROPS?

Simply put, cover crops are plants (often ryes, winter wheat, or legumes) grown between cycles of cash crops. Traditionally, they are not grown as crops

Danforth Center Principal Investigator Chris Topp, PhD, (at right in the photo above left) and Kong Wong, PhD, and Mitchell Sellers from his lab check on plots of cover crop varieties being evaluated at the Danforth Center Field Research Site.

themselves, but for "ecosystems services"; that is, the benefits they have to the soil and to other crops. Cover crops offer a variety of benefits, such as increased soil moisture capacity, weed suppression, and enhanced nutrient uptake. They can also reduce loss of soil, prevent fertilizer runoff, reduce flooding, and store carbon underground.

Yet with all these benefits, according to the USDA, just over 5 percent of available US farmland utilized cover crops in 2017. Why? Establishing a cover crop requires investment in, at minimum, seed and time (and sometimes machinery). There is a learning curve fraught with concerns for most farmers. And most cover crops have not been improved to modern standards.

> "Cover crops are an existing solution that's right in front of us. They are almost immediately actionable if we can just get past a few hurdles."
>
> ***- Chris Topp, PhD***
> ***Danforth Center***
> ***Principal Investigator***

GETTING TO THE ROOT OF THE CHALLENGE

Improvement of ecosystem service performance is rarely considered as a breeding trait for crops due to the complexities and challenges of below-ground evaluation. However, the Topp lab's creative adaptation of equipment from geology, hydrology, and the aeronautics industry is revolutionizing our ability to study roots. These advances in root phenotyping and genetic tools are critical in accelerating ecosystem service improvement in cover crops.

Right now the Topp lab is analyzing 30 species and varieties of cover crops at the Danforth Center Field Research Site. They are studying the root system architecture and capabilities, and tracking carbon and nitrogen flow in the soil and plant using isotopes. The goal: improved varieties and an eventual menu of options for farmers in order to de-risk the process of cover crop adoption, while obtaining maximum impact.

HELPING A LEADING CANDIDATE THRIVE

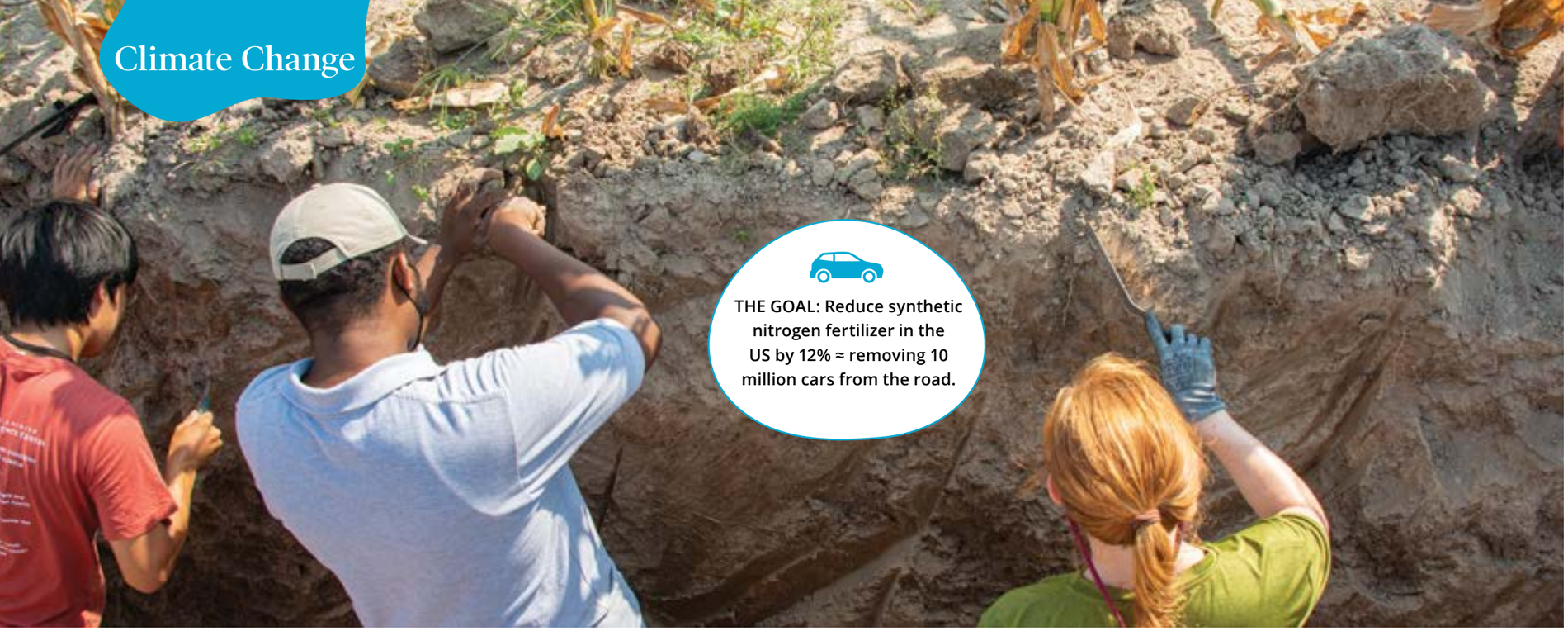
One especially strong cover crop candidate is pennycress (*Thalspi arvensi*). This common weed provides many ecological benefits: it protects soil from erosion, it draws down excess fertilizer, and, most exciting, in the hands of CoverCress, Inc., it is providing a third cash crop for farmers. (See "Spotlight" below.)

The Danforth Center's Dr. Nusinow is an expert on plant circadian rhythms. He was tapped to help validate new technology of CoverCress, when they were named a Wells Fargo IN^2 company in 2019. Members of his lab are currently attempting to boost pennycress's heat tolerance and ability to compete when planted at densities needed for soil protection. Both features will be important in the face of climate change.

"The need to protect the soil, to protect the environment is very pressing," said Nusinow. "Farmers know it; they care. We're pulling together to improve human health and the environment."

SPOTLIGHT: CoverCress, Inc.

CoverCress Inc. is the developer of CoverCress™, a variety of pennycress that has been optimized to be both a cover crop and a cash crop used in biofuel and feed. The company was founded in 2013 and is based in the 39 North innovation district. In 2019, CoverCress was selected in the first agtech cohort of the Wells Fargo Innovation Incubator (IN^2), when they were paired with Danforth Center Principal Investigators Dilip Shah, PhD, and Dmitri A. Nusinow, PhD. Last year CoverCress secured $8M in B-series funding with Bunge leading the round. CoverCress Inc. was recently declared one of 10 "startups to watch" by the *St. Louis Business Journal*.



THE GOAL: Reduce synthetic nitrogen fertilizer in the US by 12% ≈ removing 10 million cars from the road.

Farmers have an important role to play in battling climate change. Currently, in the US alone, they apply 22M tons of synthetic nitrogen fertilizer each year. Improved crops that require fewer inputs would save farmers time and money—while benefiting the Earth.

The (Ever)Green Revolution

DANFORTH CENTER'S NEW CENTER OF EXCELLENCE AIMS TO PROVIDE ALTERNATIVES TO SYNTHETIC NITROGEN FERTILIZER

Nitrogen fertilizer was a game changer when first introduced. Its application to the shorter, sturdier bred plants of the "Green Revolution" in the mid-20th century helped produce the higher yields needed to feed a growing world population. But today, that fertilizer has created unintended consequences: it is polluting our air and water and contributing to climate change. We need a new revolution—an evergreen one—to feed the world sustainably.

The Danforth Center's new **Subterranean Influences on Nitrogen and Carbon (SINC) Center** is a center of excellence dedicated to developing technology that will reduce the amount of synthetic nitrogen fertilizer used in agriculture without sacrificing crop yield. It is a collaboration of four principal investigators and co-directors: **Becky Bart, PhD**; **Ivan Baxter, PhD**; **Doug Allen, PhD**; and **Chris Topp, PhD**.

SO WHAT'S THE PROBLEM?

Synthetic nitrogen fertilizer use is standard agricultural practice. However, it increases farmers' costs and is also destructive to the environment. Synthetic nitrogen requires large amounts of energy to produce. After application to fields, excess nitrogen runs off into waterways—where it has created "dead zones" in the Gulf of Mexico and elsewhere—and off-gasses as nitrous oxide that contributes to climate change. Nitrous oxide has nearly 300 times more heat-trapping potential than carbon dioxide. Fully 75 percent of nitrous oxide emissions are due to nitrogen fertilizer and other agricultural practices.

"Climate change is the biggest challenge facing our generation. The SINC Center is an opportunity to take science, apply it to a problem, and create real solutions."

- Becky Bart, PhD
Danforth Center
Principal Investigator
Director of SINC

HOW THE SINC CENTER WILL HELP

Nitrogen is abundant in Earth's atmosphere, making up 78 percent of the air we breathe, but in this form it's not available to plants. Beneficial microbes in the soil convert the nitrogen from the air into a form that plants can use. Other microbes in the soil promote nitrogen cycling, uptake of nutrients, and general plant health. But the mechanics of the symbiotic relationship between plants and microbes is poorly understood.

Members of the Topp Lab at the Danforth Center Field Research Site observe root performance. The SINC Center seeks to improve plants' nitrogen uptake and use efficiency to diminish the need for fertilizer.

The SINC Center aims to unlock the secrets of plant-microbe-environment interactions in order to improve plants' use of atmospheric nitrogen, thus diminishing the need for fertilizer. Using cutting-edge technologies and cross-disciplinary approaches, the SINC team will harness the power of plants and microbes to improve nitrogen uptake and use efficiency.

SINC Center scientists are using state-of-the-art technology at the Danforth Center to shed light on this complicated process. Research is ongoing at the Bellwether Foundation Plant Phenotyping Facility, Danforth Center Field Research Site, Plant Growth Facility, Proteomics and Mass Spectrometry Facility, and Advanced Bioimaging Laboratory. The Data Science team facilitates analysis of the large, complex datasets being generated. Through advanced modeling, scientists are seeking new nitrogen uptake and use efficiency traits, as well as novel symbiotic interactions with microbes.

"The SINC team brings exceptional scientific expertise to bear on a great challenge of our time," said Jim Carrington, PhD, president and CEO of the Danforth Center. **"Committing to lower the impact of agriculture on climate change is something we simply must do."**

The SINC Center was made possible with a founding gift from Phil and Sima Needleman (see donor profile p. 19) and with support from Bank of America. Learn more and watch the video at ***danforthcenter.org***.

The CATALST grant is part of the Commerce Department's "Build to Scale" program, which supports technology entrepreneurship.

Welcome, Elliott Kellner

Elliott Kellner, PhD, has joined the Danforth Center Innovation team as senior program manager overseeing the CATALST and IN^2 programs. Kellner has a doctorate in water resource science from Mizzou and worked most recently to support the USDA Natural Resources Conservation Service to mitigate the impacts of agriculture on water resources.

Mapping the Future

DANFORTH CENTER WINS NEW GRANT BLENDING AGTECH AND GEOSPATIAL

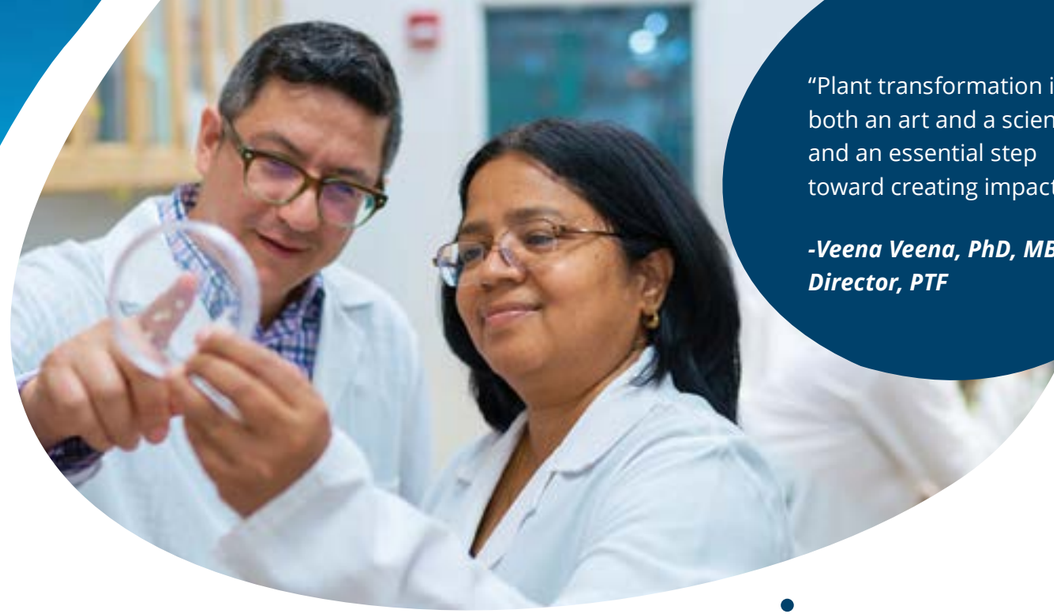
The Danforth Center has won a competitive grant from the US Department of Commerce Economic Development Administration. Part of the "Build to Scale" program, the grant supports a new "Center for AgTech and Applied Location Science and Technology" or CATALST.

The project aims to capitalize on the demand for new precision agriculture technologies by tapping into the St. Louis region's expertise in both agtech and geospatial science. The Danforth Center is partnering with BioSTL and T-REX to implement the CATALST strategic initiatives.

Funds will support proof-of-concept field research partnerships between Danforth Center scientists and early-stage companies to validate and de-risk their agriculture technology applications, such as remote imaging and sensing, smart devices, and predictive data analytics, powered by artificial intelligence and machine learning.

As part of the CATALST, the Danforth Center will also host a series of workshops on foundational and cutting-edge techniques in data science, bioinformatics, statistical analysis, data visualization, and other computational techniques. The goal is to provide location/data science crash courses for entrepreneurs in order to strengthen data analytic capacity in startups and fuel their growth in the region. The CATALST also provides for paid internships at early-stage startups, enabling a diverse cohort of early-career researchers.

"Intentionally pairing the region's emerging location science cluster with our globally recognized agtech cluster just makes sense," said Stephanie Regagnon, the Danforth Center's executive director of innovation partnerships. "The CATALST positions St. Louis in a leadership role for the Fourth Industrial Revolution."



"Plant transformation is both an art and a science—and an essential step toward creating impact."

-Veena Veena, PhD, MBA
Director, PTF

Dr. Veena Veena, director of the Plant Transformation Facility with Danforth Center Principal Investigator Dmitri Nusinow, PhD. Nusinow lab is one of dozens of clients, both internal and external, that utilize the Facility's cutting-edge equipment and expertise.

The Art of Transformation

HOW THE DANFORTH CENTER PLANT TRANSFORMATION FACILITY SPEEDS CROP IMPROVEMENT

"Plant transformation is a very delicate operation," said **Veena Veena, PhD and MBA**, director of the Danforth Center Plant Transformation Facility. "It's both an art and a science—and an essential step toward creating impact."

The Danforth Center Plant Transformation Facility (PTF) is where theory meets reality, where scientists do the actual gene editing to improve plants. Through this high-tech facility, scientists can make vital improvements in key characteristics like innate drought tolerance, disease resistance, nutritional content, yield, and more—at an accelerated pace.

The Plant Transformation Facility is supported by grants and through the generosity of donors to the Danforth Center Innovation Fund. To support these and other efforts to grow St. Louis as a world center for scientific research, visit ***danforthcenter.org/give***.

Veena once worked in corporate agriculture at Monsanto, but was inspired to take over leadership of the PTF in 2016. During her tenure, the PTF has grown to provide four full-service transformation pipelines: soybean, corn, sorghum, and *Setaria* (a model plant used widely in plant science research). The PTF provides full-service plant transformation and cell biology services, but also offers training, consulting, and access to state-of-the-art equipment for those in the plant science community who want to perform their own transformations.

GROWING THE ECOSYSTEM

The PTF is a valuable resource for both Center scientists and burgeoning startups in the 39 North innovation district. When Brazilian sugarcane company CTC Genomics chose BRDG Park on the Danforth Center campus as their North American research headquarters, they cited access to unique infrastructure as a decisive factor. Kultevat, a company that makes sustainable natural rubber, is a regular client and credits the PTF with allowing them to expand their technology and IP. "The level of assurance given is excellent," says Jillian Silva, PhD, Principal Scientist at Kultevat.

WHY IT MATTERS

The PTF works directly and in partnership to speed the innovation cycle from discovery to marketplace, accelerating sustainable agriculture solutions to feed the world and heal the planet. Through their expertise and state-of-the-art equipment, Danforth Center core facilities attract businesses from around the world and provide startups access to the latest technology, growing jobs and opportunities for our region.

Learn more about Dr. Bravo at ***danforthcenter.org***.

*In a Danforth Center greenhouse: Principal Investigator **Armando Bravo, PhD,** and Research Associate Melette DeVore.*

An Evolutionary Relationship

DANFORTH CENTER WELCOMES DR. ARMANDO BRAVO

This February, the Danforth Center welcomed **Armando Bravo, PhD,** as a new principal investigator. Dr. Bravo's work focuses on the relationship between plants and microbes. Prior to joining the Center, Bravo was a postdoctoral associate at the Boyce Thompson Institute in Ithaca, New York. He received his PhD in Plant Science at the University of Oxford in England and earned his BS in Biology at the National Autonomous University of Mexico.

A UNIQUE AND INTIMATE CONNECTION

Plants exist in an ecosystem both above and below ground. Underground, there is a symbiotic relationship between plants and microbes in the soil. Plants provide these organisms carbohydrates, and among other services, some of these microbes provide the plant necessary elements, like nitrogen and phosphorus, for growth. It is a unique and intimate connection, but poorly understood.

Dr. Bravo's lab seeks to understand the mechanisms underlying this mutually beneficial relationship—in particular, the relationship with arbuscular mycorrhizal fungi (AMF) that live in tight association with roots. Modern agriculture was not developed to be nitrogen efficient, depending as it does on synthetic nitrogen fertilizer. The work of Bravo's lab has potential to reduce that dependence, while also making crop plants more productive.

"The relationship between plants and mycorrhizal fungi has evolved over millions of years," said Bravo. "A better understanding of the diversity and evolution of the mechanisms that control this relationship could allow us to harness this system to enhance plants' nutrient uptake, reducing the need for fertilizer while still maintaining yield."

"The Danforth Center's state-of-the art facilities and community of first-class scientists are the perfect mix to push the boundaries of plant science."

- Armando Bravo, PhD, New Danforth Center Principal Investigator

"We are thrilled that Armando Bravo has joined the Danforth Center," said President and CEO, Jim Carrington, PhD. "His work to understand mechanisms of plant-AMF interactions is fascinating science, and it will elevate the Center's contributions at the nexus of agriculture and the environment."

Sima and Phil Needleman (at right) receiving the White Coat Award from their friend Bill Danforth, founder of the Danforth Center.

A Better Place

THE NEEDLEMANS: A LIFE IN SCIENCE AND PHILANTHROPY

"It's no mystery. Don't we all want to leave the world a better place?"

Phil Needleman, PhD, is thinking about motivations —why he supports the causes that mean something to him and Sima, his wife of 63 years; also, why he got into science.

"If you're curious and want to learn and turn over new rocks, there's no better place than scientific research."

Needleman parlayed that curiosity into a career in pharmacology. After serving as chair of the department at Washington University in St. Louis, he moved to industry, where he would eventually oversee the research behind the anti-inflammatory drug Celebrex™. "To do medical research is a way to improve the human condition too, so that Danforth Center mission has always meant something to me."

A LONG FRIENDSHIP

In 1964, Phil had just started his postdoctoral fellowship at Washington University when he met a young cardiologist named Bill. "He and I used to park at Steinberg Ice Rink to avoid the med school parking fee." The colleagues became friends, having important discussions while walking up the hill to the Medical Center campus.

Years later, when Bill Danforth had set his vision for the Donald Danforth Plant Science Center in motion, Phil and Sima supported him without question, even when, one day, Bill called Phil and asked to meet for coffee. "I just said 'Bill, the answer is yes. You can tell me later what you've gotten me into.'" Needleman had committed to serve as interim president of the Center and to help identify and recruit Jim Carrington!

A LEGACY OF GIVING

Today, Phil is a long-serving member of the Danforth Center board, currently as vice chair. In addition to the Needleman's annual giving, Phil and Sima made a significant gift in honor of Bill Danforth's 90th birthday in 2016 and have recently made the founding gift for the SINC center of excellence (See "The (Ever)Green Revolution" on page 14).

"It knocks my socks off, the comprehensiveness of what Bill Danforth created. I hope that others feel as inspired by his legacy as I do."

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Tributes

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*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, 2021. To make a tribute, visit **danforthcenter.org/donate**.*

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From the Lake to the Lab: Tina Hissong

When the Danforth Center's new Development Officer Tina Hissong was growing up in Culver, Indiana, she discovered a passion for nature. "There's a large natural lake there, the centerpiece of the region. My first nonprofit job was working for the Lake Maxinkuckee Environmental Fund."

Today, after a 25-year career working for both environmental and biomedical/research organizations, Tina is uniting her passions: "I understand the value plants bring to our health and our lives."

Tina holds an MBA from Webster University and has three adult children. She looks forward to her work in planned and major giving at the Danforth Center: "I love uniting our donors' concerns for the future with science that shows real-world impact. There are many ways to leave a legacy—working to feed people and heal the planet seems an especially meaningful one."

If you have questions about including the Danforth Center in your estate plans, contact Tina at 314.587.1071 or email thissong@danforthcenter.org.

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PLANT SCIENCE CENTER

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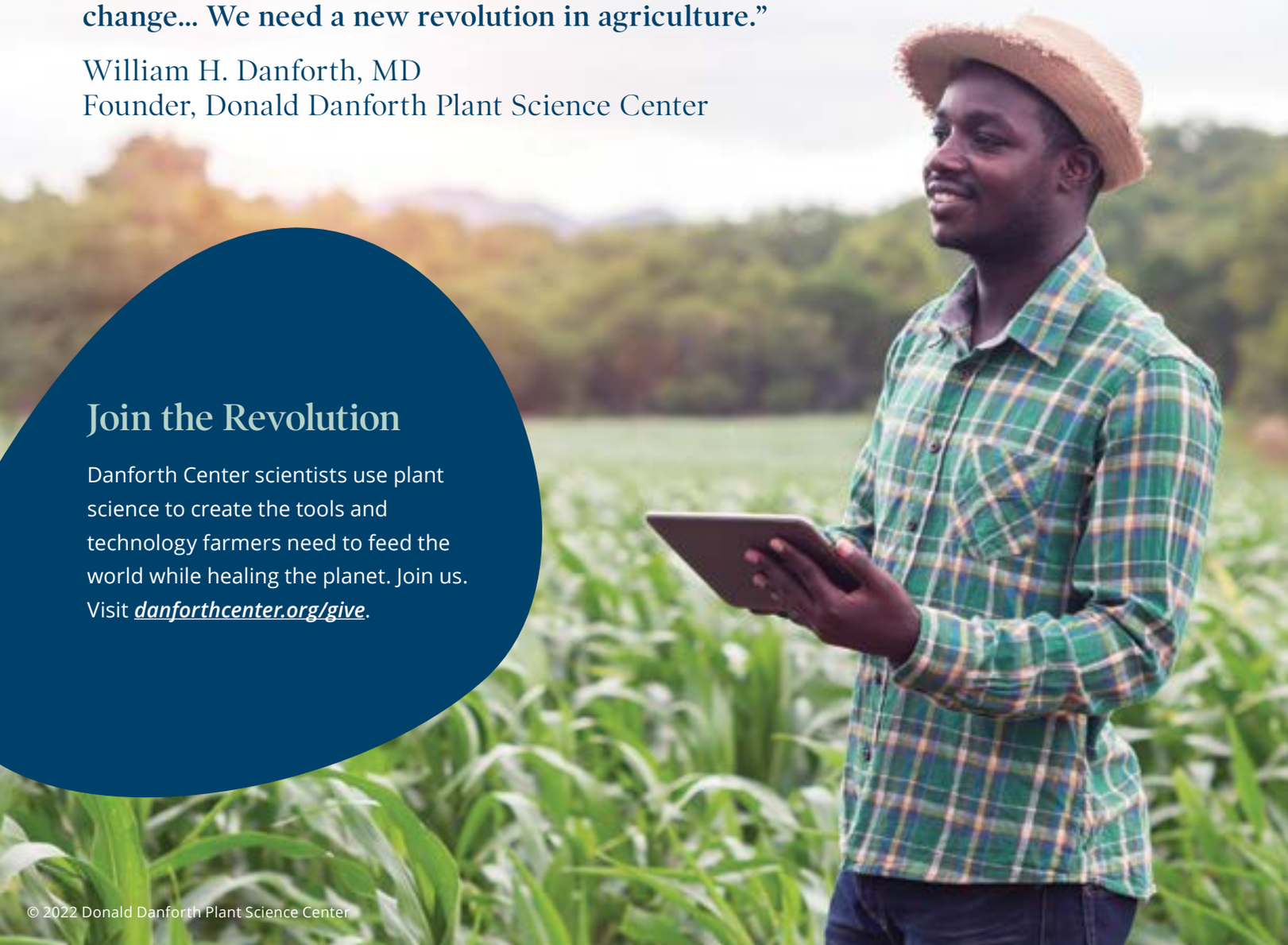
"The environment that sustains us and provides the abundance that we've enjoyed for so long, continues to change... We need a new revolution in agriculture."

William H. Danforth, MD
Founder, Donald Danforth Plant Science Center



Join the Revolution

Danforth Center scientists use plant science to create the tools and technology farmers need to feed the world while healing the planet. Join us. Visit ***danforthcenter.org/give***.