DONALD DANFORTH
PLANT SCIENCE CENTER

the Leaflet

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GREENHOUSE EXPANSION FOR FUTURE INNOVATION

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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To 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

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Students at the Jackie Joyner-Kersee Center in East St. Louis participate in hands-on science. The Danforth Center recently announced a partnership with the JJK Center to empower young scientists in the region.

I'm a Jackie Joyner-Kersee FAN!

NEW DANFORTH CENTER PARTNERSHIP AIMS TO INSPIRE STUDENTS TO CAREERS IN SCIENCE

Track star Jackie Joyner-Kersee holds six Olympic medals and is one of ESPN's "50 Great Athletes of All Time," but she never forgot where she came from. Growing up poor in East St. Louis, Illinois, she vowed to make a difference in the lives of children like herself. In 1988, she founded the Jackie Joyner-Kersee Foundation to inspire youth to thrive in academics and athletics, and to enhance their communities through the Jackie Joyner-Kersee (JJK) Community Center in her hometown.

The Danforth Center recently announced a partnership with the JJK Center and the University of Illinois. The new **Jackie Joyner-Kersee Food, Agriculture, and Nutrition Innovation Center (JJK FAN – I Center)** will become part of the JJK Community Center. Its aim? To teach children vital information about nutrition and food production, while providing a pathway from kindergarten to adulthood of opportunities in urban agriculture, scientific research, and innovation/entrepreneurship. Through training, mentoring, and unique learning programs, the partnership will engage students in STEAM and agriculture, prepare them for college and careers, and help transform their community.

"When students learn to see themselves as scientists, a new future becomes possible. Through this partnership, we seek to inspire students to transform their lives, while simultaneously transforming their community from a food desert to a food oasis."

– Kristine Callis-Duehl, PhD
Sally and Derick Driemeyer
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News & Events

NEW BOARD DIRECTORS

Four new directors have been elected to the Danforth Center Board, bringing extensive business expertise. They are: Teddy Bekele, SVP and CTO of Land O' Lakes; Desiree S. Coleman *(pictured)*, First VP, Diversity Client Segments, Wells Fargo Advisors; Ruth E. Kim, General Counsel and SVP, Fleishman-Hillard; and Ann C. Marr, EVP, Global Human Resources, World Wide Technology. The four assumed their roles this January. Rolling off the board were David W. Kemper and Dr. Usha Barwale Zehr, both of whom had served since 2000.

MOSAIC AMBASSADOR COMPANY

The Danforth Center is pleased to have been selected by the St. Louis Mosaic Project as a Mosaic Ambassador company at the gold level. Mosaic Ambassador companies promote diversity and inclusion in the workplace to make our region more globally welcoming. "Our international colleagues contribute skills and ideas that strengthen our research and the global competitiveness of the region," says Stephanie Regagnon, Danforth Center executive director of innovation partnerships and a Mosaic steering committee member.

SEEDS OF CHANGE: LIVING MACHINES

On March 11, the Danforth Leadership Council presented the first-ever virtual Seeds of Change. This free annual event featured Dr. Susan Hockfield, neuroscientist, author, and first female president of MIT *(pictured lower right)*. She presented on her bestselling 2019 book *Living Machines: How Biology Will Build the Next Technology Revolution*. According to Dr. Hockfield, the current convergence of tech and biology is poised to transform the world as we know it – and she credited the Danforth Center with leading innovation in sustainable ag technology. Visit danforthcenter.org to read more and to see upcoming events.

• Desiree Coleman

• Mosaic Partnership

39 NORTH INNOVATION DISTRICT THRIVES

The St. Louis region is within 500 miles of more than fifty percent of all of America's farmland. It's home to world-class universities, multiple multinational ag-related corporations, and the highest percentage of plant science PhDs in the nation. That's why the 39 North innovation community has grown and thrived here. Like a Silicon Valley for plant science, 39 North is a 600-acre district in St. Louis County anchored by the Danforth Center and BRDG Park, Helix Incubator, the Yield Lab, and Bayer Crop Science. This month saw exciting developments.

Benson Hill, the "food tech" company co-founded by Danforth Center Principal Investigator **Todd Mockler, PhD**, has announced plans for a new research facility. The 47,000-square-foot "Crop Accelerator" will provide dedicated plant growth infrastructure and be located just north of Benson Hill's headquarters on the Danforth Center campus. Benson Hill is partnering with St. Louis-based venture capital firm Lagomaj Capital.

The St. Louis Economic Development Partnership has approved hiring R.V. Wagner, Inc., for the $4.2 million project to rebuild the busy Olive and Lindbergh boulevard interchange at the southern border of the 39 North innovation community. Construction should begin soon to transform the intersection into a "folded diamond" layout that better accommodates traffic from all directions, while providing more space for development.

TWO DANFORTH CENTER SCIENTISTS LAND EARLY CAREER AWARDS

Danforth Center Principal Investigator **Andrea Eveland, PhD**, has been announced as the recipient of the 2021 Marcus Rhoades Early Career Award the Maize Genetics Conference. Dr. Eveland was credited for her "amazing research mixing genomics, developmental biology, and advanced bioinformatics." The Eveland lab focuses on understanding the genetic and molecular basis for plant architecture, a major component of crop yield. With funding from the U.S. Department of Energy, Dr. Eveland is currently leading a multi-institutional project to deepen the understanding of sorghum, a leading bioenergy crop and maize relative.

Danforth Center Principal Investigator **Malia Gehan, PhD**, has been announced as the recipient of the North American Plant Phenotyping Early Career Award. This award recognizes a high-achieving individual who is making important contributions to plant phenotyping in areas of data analytics, engineering, modeling, physiology, plant breeding, plant sciences, remote sensing, or allied related disciplines. The Gehan lab focuses on improved temperature stress resistance in plants and improved measurement of plant phenotypes. Dr. Gehan has been a leader in organizing national and international phenotyping efforts and tools.

• 39 North Exchange

• Benson Hill

• Dr. Susan Hockfield

Rice is grown in more than 100 countries and is a staple for more than 3.5 billion people around the globe. Danforth Center scientists are working to combat a pernicious weed that reduces yields.

"This work has the potential to help farmers here in Missouri while also helping to feed millions of people around the globe."

- Chris Topp, PhD, Danforth Center Principal Investigator

Attack of the Feral Weed

DANFORTH CENTER SCIENTIST FIGHT BACK AGAINST RICE'S EVOLVING ENEMY

The world depends on rice: it is a staple food for more than half the Earth's population. Rice has been grown for thousands of years and in more than one hundred countries. And just about everywhere rice is grown, a thieving, cunning, lookalike weed runs amok, damaging harvests. It's known as "weedy rice."

Weedy rice is a plant that belongs to the same genus and species as cultivated rice, but it produces a much smaller harvest. Due to its striking resemblance to desirable rice, it's easy for this invader to flourish in fields undetected. Left unchecked, weedy rice steals water and precious nutrients from the rice crop, resulting in a dramatic loss of yield—by up to 80 percent. Estimated annual losses are more than $45 million in the U.S. alone, resulting in higher prices. When weedy rice outcompetes crop rice, farmers and consumers both lose.

But now, with backing from the National Science Foundation, Danforth Center Principal Investigator **Chris Topp, PhD,** is partnering with Kenneth M. Olsen, professor of biology at Washington University in St. Louis and others to help learn how weedy rice outcompetes crop rice—and how to defeat it.

THE HIDDEN HALF

Weedy rice is essentially domesticated rice that has gone feral, but how exactly does this happen? Researchers are hoping to find out, but one thing they know for certain is that a significant source of its abilities lies below ground, in the roots. Better understanding the "hidden half" of plants—the 50 percent below ground—is a major focus of the Topp lab. They have pioneered the use of X-ray 3D computerized tomography (CT) for nondestructive observation of root growth and development over time. The facility is unique in North America, and already the work is yielding results. Using this unique imaging to observe undamaged roots of growing weedy rice, they discovered a major aspect of its success: weedy rice had evolved "cheater traits" that allow it to take advantage of the soil to beat out rice crops for nutrients. The team is now expanding on this discovery. "By understanding how this invader competes for nutrients underground, we can learn how to better fight against it, save countless rice crops, and, as a result, improve farmers' bottom lines and contribute to feeding millions of people," said Topp.

POTENTIAL FOR GREATNESS

The research has significant application beyond just identifying the best methods to combat a pest. Several traits that weedy rice currently possesses could prove useful for improving the real rice crop someday. Besides the cheater traits, weedy rice is also resistant to the common fungal disease rice blast. Understanding the genetic basis for these traits could eventually help breed stronger, more productive crop rice varieties.

Rice harvest in the Missouri Bootheel. The state is the fourth largest rice producer in the country.

Global Science, Local Impact

Danforth Center scientists are tackling other aspects of improved rice. Principal Investigator **Bing Yang, PhD**, is determined to eradicate the scourge of bacterial blight. Bacterial blight can reduce rice yields by up to 70 percent with the heaviest losses typically experienced by smallholder rice growers in low and middle-income countries. Recently, Yang's team at the University of Missouri – Columbia used CRISP-R technology to edit the gene that makes the plant vulnerable to the disease. Read more about this exciting development—and its classification as "conventional" for breeding purposes—on our blog at danforthcenter.org.

Rice research doesn't just impact smallholders internationally, it benefits local farmers as well. The **Missouri Bootheel,** with its natural flooding from the Mississippi River, makes Missouri the fourth largest rice-producing state in the U.S. Farmers like Chris Berry, a third-generation rice farmer in the Bootheel, like almost all rice farmers, has struggled with weedy rice. "It can get so bad to the point where it's not even profitable to grow rice on the soil it came from," he says. Making weedy rice easier to control would make a big difference in the lives of Missouri farmers—and farmers around the world.

Grapevines at the University of Missouri Southwest Research Farm in Mount Vernon, MO. Danforth Center Principal Investigator Allison Miller, PhD, is leading a multi-institutional project to better understand the effects of grafting.

Fruit of the Vine

HOW GRAPEVINE GRAFTING CAN HELP US RESPOND TO A CHANGING CLIMATE

Grafting is the joining of the root of one plant variety (the "rootstock") to the shoot of another (the "scion"). It's an ancient agricultural technique dating back several thousand years and is important in perennial agriculture for many reasons. Mature root stocks can help jumpstart juvenile shoots and help defend against pests and pathogens in the soil. Desirable characteristics like dwarf size, pest and disease resistance can all be imparted to the shoot thanks to the hardier root below. But the effects of grafting are still poorly understood.

Allison Miller, PhD, Danforth Center principal investigator and professor of biology at Saint Louis University. wants to understand grafting better. The work of the Miller lab is motivated by a fundamental challenge facing society: how can we feed a growing population in a changing climate in a sustainable way? One component of the solution likely involves perennial crops. And many perennial crops are grafted. Grapevines are one such grafted perennial crop.

"Grafting is used in more than 70 different woody perennial crops," says Miller. "In a changing climate, grafting takes on additional importance as a means of potentially mitigating impacts. Grafting makes it possible to select for features that optimize plant success both above- and below-ground."

THE PROJECT

Vitis is a genus of 79 woody vining plants we know as grapevines (though the diversity of *Vitis* rootstocks used in viniculture is very low). **Vitis Underground** is a multiyear, multi-institution project investigating the relationship between rootstock, scion,

"Perennial crops allow us to harness the power of plants to nourish humanity and heal the planet at the same time. With this study, we hope to speed the development of enhanced perennial crops with the characteristics needed to thrive in a changing climate."

- Allison Miller, PhD, Danforth Center Principal Investigator

This research is funded by the National Science Foundation Plant Genome Research Program, the Missouri Grape and Wine Institute, and donors to the Innovation Fund. Interested in supporting projects like this? ***Visit danforthcenter.org/give.***

and environment in grafted grapevines. Dr. Miller is the co-principal investigator, and she is joined by colleagues from the University of Missouri; Missouri State, Michigan State, and Ohio State universities; and the U.S. Department of Agriculture. The team's goal? To better understand the "transmissible effects" of rootstocks in grapevines. This understanding has important applications for sustainable crop management.

"Grafting was used initially in grapevines to deal with a soil pest and avoid it," says Miller. "But now we are not just looking at what the rootstock does below ground, but how it might be used to enhance the scion in other ways."

WHY IT MATTERS

Perennial crops offer many potential benefits to the environment, such as reduced tilling and increased season-over-season harvests. Perennials create deep root systems, which sequester carbon, reduce water needs, and help restore soil health. **They are food crops that also replenish the Earth.** As agriculture shifts to embrace more perennial crops, a better understanding of grafting will allow for perennial crop improvement and adaptability. The long-term goal is a kind of personalized medicine for perennials, providing custom rootstock-scion pairings to maximize vigor and harvest in particular climates.

Researchers from the Miller lab and collaborators from University of Missouri and Missouri State University after the harvest

Joel Swift, a PhD candidate in the Miller lab, is studying the interaction of rootstocks with the microbiota in wine grapes.

Meet Our Early Career Scientists: Joel Swift

Growing up in the rural small town of Marshall, Missouri, Joel Swift loved growing plants, especially Venus flytraps, but he never imagined that plant science could be a career. An independent research project doing plant tissue culturing at community college changed his mind. Swift went on to study plant biology at the University of Central Missouri and is today a PhD candidate at Saint Louis University and a graduate student in the Miller lab at the Danforth Center.

In 2017, Swift was awarded a National Science Foundation Graduate Research Fellowship, as well as a competitive grant from Missouri Grape and Wine Institute, to study the grapevine microbiota (the microorganisms living in and on particular parts of the vine). Swift conducted the research at the University of Missouri Southwest Research Farm, where Miller's Vitis Underground project is based, working with the Chambourcin varietal. Recently published in *Microorganisms*, the findings showed that the root-shoot combination creates a small, but measurable, impact on the grapevine's berry microbiota. Swift is expanding his research now to more varietals and rootstocks across the Central Valley of California.

Visit our blog at ***danforthcenter.org*** to read about cassava plant transformer Tira Jones of the Taylor lab.

Cassava provides daily calories for more than 700 million people in Africa. Cassava Plus, developed by an international team led by Danforth Center scientists, is now the first non-cereal crop to combine traits for disease resistance with enhanced nutrition in one plant.

Cassava Plus: First in the World

With a recent publication in *Plant Biotechnology Journal*, the Danforth Center's VIRCA Plus improved cassava has become the first ever non-cereal crop to "stack" multiple traits of disease resistance and biofortification. The cassava is enhanced with higher levels of the micronutrients iron and zinc to combat malnutrition. It also includes the traits of resistance to two major cassava diseases, cassava mosaic disease and cassava brown streak disease, to increase harvests.

Combining technologies was not easy. "Production of plants with both disease resistance and elevated mineral nutrition concentration was technically challenging," said **Narayanan Narayanan, PhD**, research manager in the Taylor lab at the Danforth Center. "We had to make sure the minerals were accumulated in the storage root, not the stem or leaves, and at the right level for both consumers and plant health."

It was important to confirm that the higher mineral levels were retained during food processing and cooking. Project collaborator Ihuoma Okwuonu, PhD, of the National Root Crops Research Institute in Nigeria, led the preparation of two common West African dishes: garri and fufu. These required a four-day

"Improved cassava has the potential to improve the lives of millions of people in West Africa."

– Nigel Taylor, PhD, Dorothy J. King Distinguished Investigator

This work was funded by Bill & Melinda Gates Foundation, USAID Feed the Future, and by donors like you. To learn more about supporting work like this, ***visit danforthcenter.org/get-involved.***

process involving chopping, soaking, fermenting, pressing, and roasting of the cassava root. They found that high levels of iron and zinc were retained through cooking and remained available for absorption in the gut following digestion.

The Danforth Center has a mission to improve the human condition through plant science, which includes feeding the hungry and improving human health. Field trials have been completed in Puerto Rico and are now underway in Nigeria under Dr. Okwuonu's oversight. The VIRCA Plus project is showing what is possible when cutting-edge technology is applied to orphan crops like cassava.

Building A Better Biofuel

Fast-growing and drought-resistant, sorghum is a leading biofuel candidate, but that can cause problems. "When we try to make an ideal bioenergy, we seek to increase the sugar and make the cell wall easier to break down," says Danforth Center Principal Investigator **Becky Bart, PhD**. "The cell wall is what keeps pathogens out. The sugar attracts pathogens, so bioenergy breeding is perfect for bacteria." Recently, Research Scientist Qi Wang, PhD, in the Bart lab, succeeded in building a host-pathogen model for the disease sorghum bacterial leaf streak. His results, which revealed a stronger defense response corresponding to a heightened bacterial virulence response (the "host-pathogen arms race"), were published in *PLoS Pathogens*. The research will help guide development of biofuels and aid in combating leaf streak in a changing climate.

Research scientist Qi Wang, PhD, and Principal Investigator Becky Bart, PhD. Wang recently published a host-pathogen model that may speed the progress of biofuels.

Time Will Tell: Plant Circadian Rhythms

Danforth Center Principal Investigator **Dmitri A. Nusinow, PhD**, wants to understand how plants know the time and season – and for that, he studies their circadian clock. Or perhaps it would be better to say "clocks." **Maria Sorkin**, a graduate student in the Nusinow lab and the 2018 Willam H. Danforth Fellow, has completed a scientific literature review that reveals a hierarchy of circadian clocks in plants—and that the shoot/apex clock is dominant. The article was published in *Trends in Plant Science*. "In humans, the stomach clock does one thing, the brain clock, another," explains Sorkin. "In plants, the vascular clock controls flowering. The leaf tissue controls cell elongation. And it turns out, all are ultimately controlled by the shoot." The finding has implications for grafting, where a shoot is attached to a different root.

Graduate student Maria Sorkin with Principal Investigator Dmitri A. Nusinow, PhD. Sorkin has identified a hierarchy of circadian clocks in plants.

The St. Louis Regional Chamber estimates that the Danforth Center campus has a $377M annual impact on the St. Louis regional economy.

The new cutting-edge Michael W. and Quirsis V. Riney Family Greenhouse facilities will provide much-needed space to researchers, speed progress, and attract more startups to our region.

Room to Grow

EXPANDED DANFORTH CENTER GREENHOUSES MEAN NEW DISCOVERIES AND NEW POSSIBILITIES

It's a good problem to have. Innovative plant science requires cutting-edge technologies. The Danforth Center's core facilities equip our scientists with state-of-the-art instrumentation and expertise to do ground-breaking research. This critical infrastructure serves as a hub of collaboration, attracting partners and new companies to the region. So what happens when it succeeds a little too well?

The Danforth Center's Plant Growth Facility has seen tremendous growth. This cutting-edge research complex provides users with access to a variety of controlled environments as well as expert horticultural services. It encompasses 54,000 square feet of greenhouses and 82 advanced climate control growth chambers - but it is no longer enough.

In recent years, skyrocketing demand for research-grade greenhouse space has meant the facilities were almost always full and the waiting list was growing. Besides the challenge of capacity, there was also the Danforth Center drive to innovate and keep pushing the boundaries of experimentation. It was time to expand.

FROM GROUNDBREAKING TO COMMISSIONING

In late 2019, construction began to expand the Greenhouse Range B, to increase total space available from 54,000 to nearly 66,000 square feet: more than 1.5 acres of greenhouses. Besides more space, this new facility adds additional cutting-edge features, increased efficiency, and tools to advance the work of Danforth Center scientists and other sustainable ag partners working to feed the world and heal the planet. Several new features are highlighted in the box opposite.

Opening a new greenhouse is called "commissioning," and it comes with a special set of punch-list items. First, the complicated computer control systems need to be tested—a process undertaken by the manufacturer,

"With a unique combination of advanced environmental controls, improved energy efficiency, and flexibility to accommodate a wide variety of research, these greenhouses will accelerate discovery for the Danforth Center and our partners."

– Kevin Reilly, Director, Danforth Center Plant Growth Facility

Argus Control Systems Ltd. “The technician said he was very impressed with the technological level of our greenhouses,” notes Danforth Center Greenhouse Manager **Sally Fabbri** “That’s high praise, given their expertise.”

Next, the horticulturists must test the facilities. Fabbri reports that she and her team have been growing plants sequentially for just this purpose. Every two weeks, they start more corn, sorghum, soy, and Setaria. “We will put those plants in the new greenhouse, so that we have plants at multiple developmental stages to validate the functions of the new facilities.” If all is well, it will be all systems “go” later this spring for the new Michael W. and Quirsis V. Riney Family Greenhouse.

Several new greenhouses feature 20-foot-tall ceilings equipped with adjustable lighting canopies. The expanded spaces allow scientists to grow crops to their natural height, while better controlling light and temperature.

WHY IT MATTERS

Danforth Center scientists conduct research at the nexus of food and the environment. Through this work, we help enhance the St. Louis region as a world center for plant science. Access to state-of-the-art facilities and expertise is critical to agtech and biotech startups, and the Danforth Center provides that access, helping ensure success at BRDG Park, Helix Center, and 39 North.

New Greenhouse Features	
20-FOOT CEILINGS	Current greenhouses range from 10-14 feet. Adding 20-foot capacity will allow researchers the ability to grow tall crops like maize and sorghum to their natural height.
MOTORIZED ADJUSTABLE-HEIGHT LIGHT CANOPIES	Part of the new 20-foot houses, the light canopies allow greater control of lighting to ensure more uniform conditions.
AUTOMATED BLACKOUT SYSTEM	Now able to block out sunlight entirely, several of these houses can better accommodate growth cycles of “short day” plants like rice, sorghum, and cotton.
BROAD-SPECTRUM, DIMMABLE LED LIGHTS	These high-efficiency lights will save money and energy, while mimicking sunlight better than previous LEDs.
IN-FLOOR HYDRONIC HEAT AND EVAPORATIVE COOLING	In research greenhouses, consistency is key. New HVAC systems will help ensure stable temperature and humidity, while conserving energy.

This project is supported by leadership donors Quirsis and Michael Riney, other contributors to the Innovation Fund, and the Missouri Development Finance Board. Tax credits are still available for qualified donors. Contact the Development team at 314.587.1234 or email development@danforthcenter.org for more details.

Tributes

TRIBUTES

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

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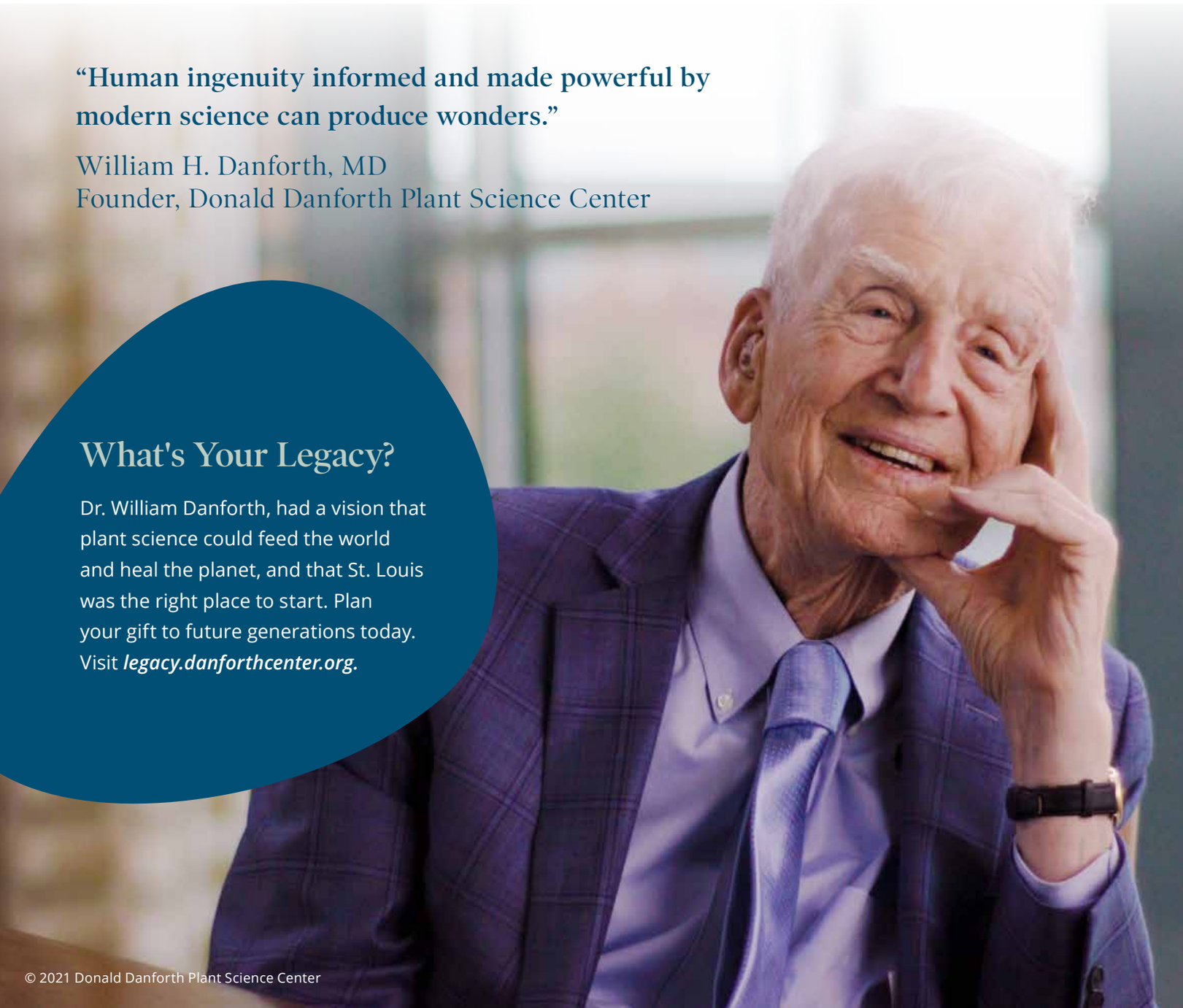

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