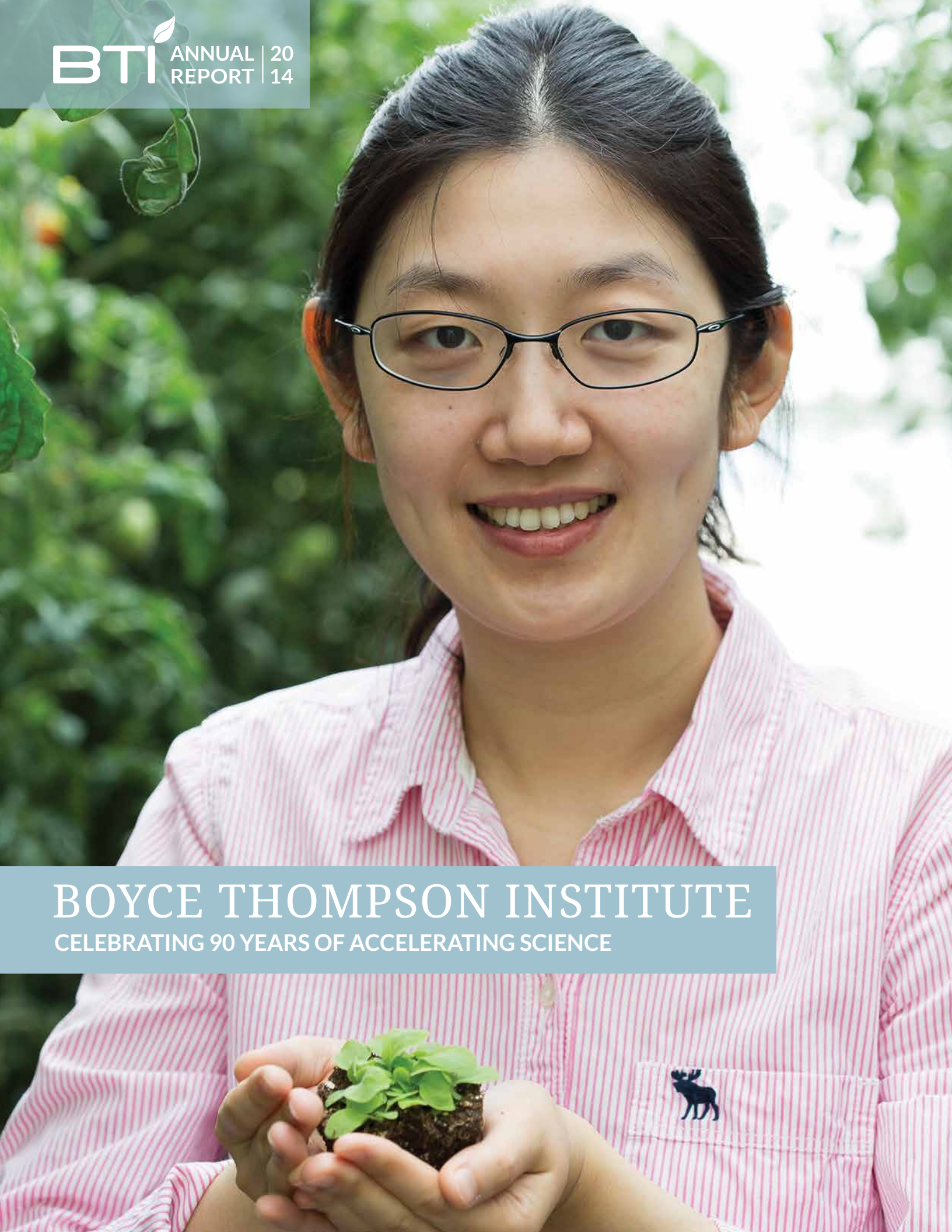
BTI ANNUAL REPORT 2014



BOYCE THOMPSON INSTITUTE

CELEBRATING 90 YEARS OF ACCELERATING SCIENCE

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PRESIDENT'S LETTER

In 2014, BTI celebrated 90 years of excellence in plant research. Alumni and friends of BTI gathered to commemorate the collective journey we have taken to advance plant science since the Institute's inception in 1924.

To mark BTI's 90th anniversary, Emeritus Professor Robert Kohut conceived of an original drama, called "Conversations with the Colonel", which gave us insights into the humanity of William Boyce Thompson, or "Will" as he was often called. Thompson was not completely the staunch, serious figure we see portrayed in his bronze likeness by the BTI entryway today. A child of the Virginia City gold rush, William was a wanderer and a philosopher, a risk-taker and a rogue. He was not only a shrewd man of business, but also a man of great intellectual curiosity—particularly about science. Thompson saw in the study of plants an opportunity for discovery—and the rewards he foresaw would be practical, substantial contributions to human welfare.

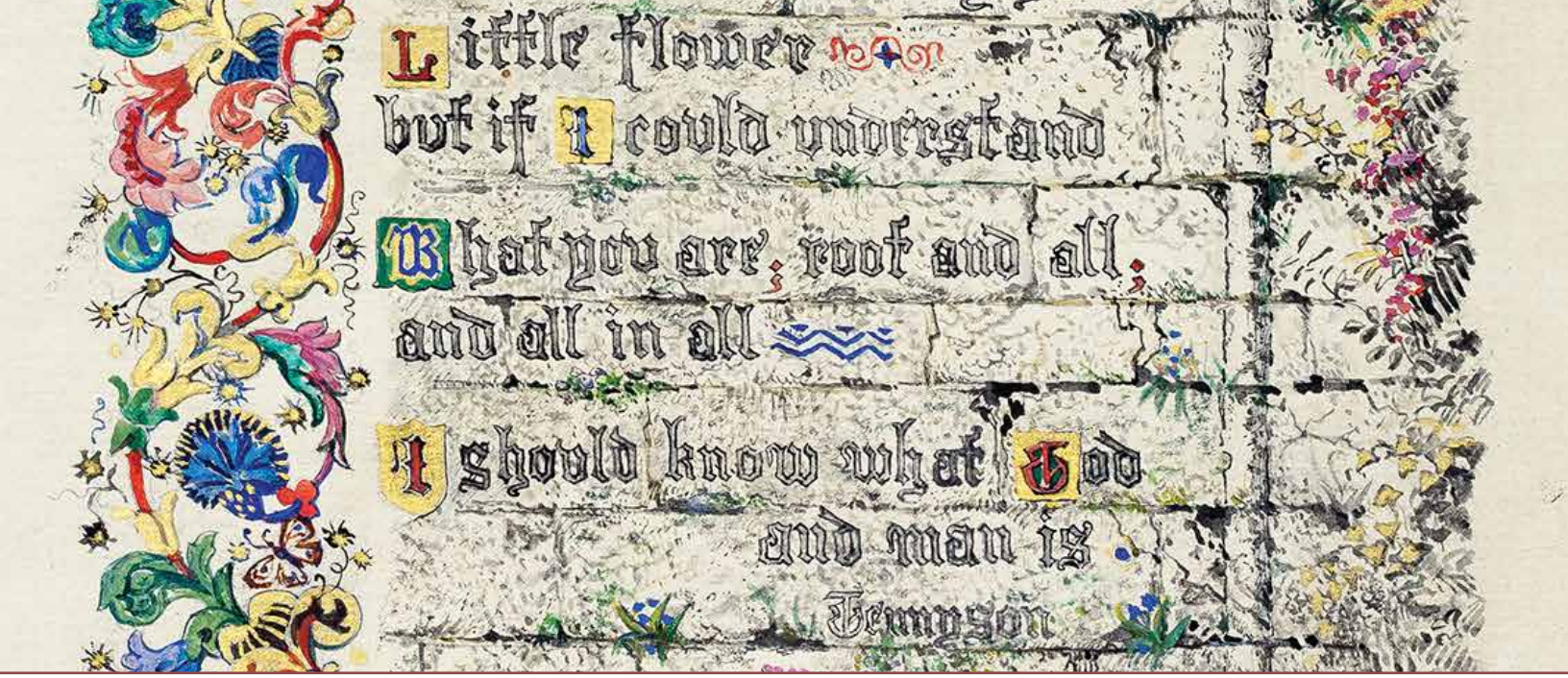
From its inception, BTI supported and insisted on plant science of the highest caliber. Thompson's fledgling enterprise attracted plant science leaders of the day: John Coulter of the University of Chicago as advisor to the project, and William Crocker as the Institute's first managing director. Other notable scientists from BTI's early days included Frank Denny, who studied chemicals that break potato tuber dormancy; Louis Kunkel, who showed that the disease aster yellows was transmitted by leaf hopper insects to more than 50 species of plants; and Francis Holmes, who made the significant finding that plant resistance to a virus was inherited from a single gene. As a signal of its rapid ascendance, only 15 months after its opening, BTI scientists presented no less than 11 papers at the annual meeting of the American Association for the Advancement of Science.

The BTI scientific pioneers initiated a tradition of meaningful discovery that continues to this day. In the pages that follow, we describe Lukas Mueller's yam and cassava databases that underpin enhanced breeding of those crops, and research from the Michelle Cilia laboratory on how bacteria and insects cause and transmit citrus greening disease. We also feature Daniel Klessig's forays into the plant immune system, which may one day reduce crop loss to plant pathogens, and how Frank Schroeder's discovery of small molecules in nematode worms may yield new therapies in humans.

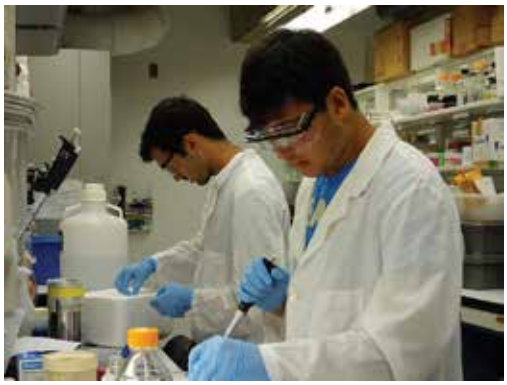
Education and mentoring are inseparable companions to scientific research. BTI's relocation from Yonkers, New York to the Cornell University campus in the mid-1970s represented a sea change in its educational environment. Well before this move, however, BTI scientists ventured outside their laboratories—for example, by teaching night courses on plant biochemistry to keep high school teachers abreast of changing concepts and research methods. Today, BTI builds on what began as the Emerson Summer Genetics Program in 2001, named after noted Cornell maize geneticist Rollins A. Emerson. Through a variety of mechanisms, BTI engages the next generation of researchers and their teachers. The goals are to build science awareness around us, to attract young people to the possibility of a scientific career, and to instill mentoring capacity in our faculty, postdoctoral fellows, and doctoral students. As a bonus, many of these interns make substantive contributions to research projects, culminating in a scientifically rich symposium at the end of the summer.

THE BTI SCIENTIFIC PIONEERS INITIATED A TRADITION OF MEANINGFUL DISCOVERY THAT CONTINUES TO THIS DAY

David Stern



Our history demonstrates BTI's role as a catalyst for excellence in collaboration. In the early days of BTI, collaboration among scientists for the purposes of plant research was itself a novelty. A New York Times review of William Crocker's 1948 book Growth of Plants: Twenty Years Research at Boyce Thompson Institute (1948) counted as noteworthy the diversity of expertise exhibited by the scientists Crocker assembled for BTI in 1924. Of course, BTI's later affiliation with Cornell University became a key partnership in creating opportunities for day-to-day interaction with colleagues from broad academic and scientific backgrounds.



BTI today forges collaborative relationships not only in the laboratory, but also to promote the interests of the broader plant science community. We have worked to align plant scientists to speak with one voice as we convey the importance of competitive, federally funded research grants to our elected officials. To that end, the National Plant Science Council has been established to realize the objectives outlined in the plant science community's 2013 Decadal Vision report. Also to that end, with our partners at the American Society of Plant Biologists we are forming the Coordinated Plant Science Research and Education Network. The initiative will serve as a clearing-house for the research, education and outreach activities and opportunities for its members and the wider plant science community. Expected outcomes include new collaborations among societies and scientists, new interdisciplinary research projects that will advance the frontiers of plant science, and innovative recruitment and training strategies for the next generation of scientists.

Ninety years after its founding, BTI thrives as a hub of discovery, mentoring and collaboration. Looking back, we think that "Will" would be proud. Looking forward, the sky is the limit.

Sincerely,

David Stern
President & CEO, Boyce Thompson Institute

CHAIRPERSON'S LETTER

The past year has been a time to look back with pride at nine decades of BTI accomplishments. It has also been a time to look forward to new challenges where we can have a long-lasting impact in areas of human health, environmental protection and agricultural sustainability. In our next 90 years, we will continue to make a difference in basic plant research and science education, with potentially transformative outcomes for our world.

BTI is an institution committed to basic research, though the significance and scope of these discoveries is often hidden until years or decades down the line. The 1966 Annual Report stated, "There is no sharp boundary between basic and applied research. The end objective differs but they are so interrelated each serves to extend and broaden the working base of true knowledge." That statement is still true today, as discoveries in basic research feed into real-world solutions to global problems in human health and agriculture.

In my nine years of service at BTI, I have enjoyed seeing world-class plant research unfold. But BTI is more than a hive of research activity. It is an incubator for future leaders in science. The environment is one of support, stimulation and collaboration, where young scientists—from high school, college and graduate programs—thrive and learn from BTI faculty, staff and their peers. Our goal is that every scientist who spends time at BTI remains a member of the BTI family, growing and strengthening the BTI network as they start their own labs or become future teachers and mentors.

BTI's researchers are not only leaders in academia, but they are the scientists sought by industry to address critical problems in our food supply or in applications to improve human health. Looking for comprehensive advice on setting our federal research agenda and spending levels, national policy and decision makers solicit our scientists' feedback and direction. In my future tenure, I look forward to seeing the scientific leaders that BTI will produce, and to witnessing the impact of current BTI research.

My background and experience in early stage start-up companies makes me acutely aware of the importance of research innovation in spurring economic growth. I accepted the Chair of the BTI Board of Directors to help foster the rich research environment at BTI, and to help discoveries find paths to real-world applications. My fellow board members come from many walks of life, from scientists to business people. They work for the government, non-profit institutions, large corporations and small companies, with expertise in finance, technology transfer, philanthropy, entrepreneurship and science. We come with a diversity of perspective, but with one thing in common: we are all very proud to be of service to BTI and recognize that it is an honor to have a role in the work that is done here.

To keep this pipeline of discovery, innovation and leadership flowing, BTI needs generous donations to fund cutting-edge equipment and facilities. My fellow board members and I are all committed to seeing BTI flourish for future generations. I'm proud to report that the entire board has made donations to BTI to contribute to its mission of excellence in plant research. I am certain that our support of BTI will spark new discoveries that will be the catalyst for innovative solutions for years to come.

In closing, I would to thank Professor Gregory Martin for his service as Acting President during the second half of 2014. His excellent leadership and diligent oversight were vital to the successful operation of BTI during David Stern's sabbatical.

Sincerely,

Laura A. Philips
Board Chairman, Boyce Thompson Institute

THE ENVIRONMENT IS ONE OF SUPPORT, STIMULATION AND COLLABORATION, WHERE YOUNG SCIENTISTS...THRIVE AND LEARN...

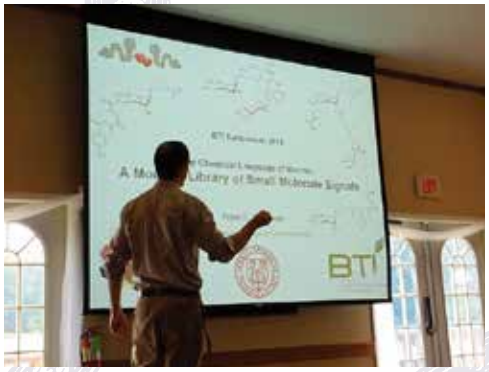
Laura Philips

BTI, A CATALYST FOR RESEARCH EXCELLENCE

EAT YOUR VEGETABLES AND TOSS YOUR VITAMINS, SUGGESTS RESEARCH ON AGING

Ongoing research in the laboratory of Associate Professor Frank Schroeder has identified compounds that control evolutionarily conserved aspect of lifespan and aging. Using the model organism C. elegans, a tiny roundworm, Schroeder characterizes novel small molecules called ascarosides, which the animals secrete at specific life stages. These largely unexplored compounds have great potential to increase our understanding of how to prolong life and may even yield novel antibiotics, treatments for chronic diseases and the means to protect crops from a variety of pathogens.

While previous studies in multiple organisms have found that strictly limiting calories can prolong life, Schroeder identified an ascaroside that can extend the lifespan of the worms, no diet required. His team also discovered another compound that shortens the life of egg-producing, hermaphrodite worms. "What we found is that the major pheromone produced by males strongly shortens lifespan of hermaphrodites—just smelling a guy shortens its lifespan," said Schroeder. Surprisingly, the chemical structures of the two compounds differ by just one double bond.



The mystery of how two such similar compounds could have opposite effects is still unexplained. But the pheromone that extends life appears to do so by inducing oxidative stress—the cell's response to oxygen byproducts. Oxidative stress has long been seen as a harmful imbalance of free radicals—an effect that could be stopped with antioxidants such as vitamin C— but scientists are beginning to question this idea.

"These findings confirm building evidence that oxidative stress is not a health risk, but rather a required component for a long and healthy life," said Schroeder. Many natural compounds in plants that are marketed as antioxidants may actually increase oxidative stress, instead of reducing it, which may be the source of their health effects. This line of research suggests that those in search of long life might want to view their morning vitamin with a little more skepticism.

HOW A SMALL GREEN FRUIT BECAME A BIG RED TOMATO

In 2014, BTI researchers peered back in time, into the history of tomato domestication. Associate Professor Zhangjun Fei and Professor Jim Giovannoni collaborated with an international group of researchers to discover how humans have shaped the tomato genome through breeding and migration. The study appears in the October 2014 issue of Nature Genetics.

The researchers sequenced the genomes of 360 varieties of wild and cultivated tomatoes. They aligned these genomes to the original "reference" genome of the Heinz 1706 tomato variety, whose genome was published in 2012 by Fei, Giovannoni and other BTI scientists as part of an international consortium. They then looked for genomic regions associated with desirable traits, such as larger size and productivity. They found that the increase in size likely occurred in two steps, creating modern fruits that are 100 times larger than ancestral varieties. They also found the causative variants responsible for pink tomatoes, which are a popular variety in China and Japan, and the genomic signature that led to the "processing tomato," which is a denser variety used for ketchup and sauce.

"This information can be used directly by breeders to design molecular markers than can shorten the breeding cycle," said Fei. "But it also provides knowledge for us to understand how the tomato has evolved from a tiny green, inedible fruit to a big, red, tasty tomato."

In that transition, breeders made improvements in taste and size, but tomatoes lost much of their genetic diversity. Today's varieties lack genes for resistance to certain diseases, as well as gene variants for tolerating drought, heat and salt.

Some breeders have attempted to remedy these vulnerabilities in cultivated tomatoes by crossing the modern tomato, Solanum lycopersicum, with a wild and hardy species from the Andes regions of South America called Solanum pennellii. These crosses have yielded tomatoes with better yield and tolerance to drought and salty soils.

Additionally, to make these breeding experiments easier, Fei and Giovannoni collaborated with a group of researchers to create a reference genome for S. pennellii. They pinpointed genes that are likely involved in stress tolerance and found that transposable elements—segments of DNA that can move around the genome—likely played a role in altering the genome to improve stress resistance. This work was published in the September issue of Nature Genetics.

Both data sets from the work are available through Associate Professor Lukas Mueller's SOL Genomics Network. This information could help tomato breeders to create better varieties that are more resistant to stress, while still retaining the shiny red tomato that consumers expect.

BTI DEVELOPS TOOLS TO MAKE A BETTER TOMATO

Tomatoes are big business. In the U.S. alone, farmers sell about 2 billion dollars worth of this popular fruit. But the tomato is also an important model species—especially at BTI—which researchers use to study fruit ripening and nutrition. Last year, Assistant Professor Joyce Van Eck, along with colleagues from Cold Spring Harbor Laboratory in New York, and Sainsbury Laboratory in the United Kingdom successfully adapted a new genome editing technology for their studies of this important crop.

In a study that appeared in the November 2014 issue of Plant Physiology, Van Eck and her colleagues show that the technology called CRISPR/Cas9 can edit the tomato genome with relative ease and precision. This technology could potentially be used to create improved crop varieties. Scientists have used this gene editing tool in a variety of species, including bacteria, soybeans, mice and monkeys. However, to Van Eck's knowledge, this study is the first published use of the technology to create an engineered tomato plant.

The ease of use of the CRISPR/Cas9 system suggests that it may become the "technology of choice" to alter DNA for genetic studies. The tomato makes an excellent target for CRISPR/Cas9 editing because its genome has just two copies of each gene and because experiments can be planned using the high-quality tomato genome sequence.

The editing technique uses an enzyme called Cas9 that can snip through double-stranded DNA. The CRISPR contains a carefully designed guide RNA sequence that leads the Cas9 to the section of the genome to be edited. Enzymes within the cell then repair the cuts created by Cas9, often adding or removing bases, which can render the gene inactive. By deactivating specific genes, researchers can better understand which ones determine characteristics such as taste, productivity or insect resistance.

To test out the technique in tomatoes, Van Eck and colleagues decided to create mutations in a gene that create plants with an easily identifiable "wiry" appearance, called SlAGO7. The CRISPR/Cas9 system successfully created a variety of mutations that cause long, skinny plants. Though the SlAGO7 mutations cause limited fertility, the researchers showed that the plants passed on the mutations to their progeny, indicating that they had created a new variety.

For Van Eck, the research is the first step of an NSF-funded project to identify genes that could increase yield in tomatoes and other crops in the future.

BIG DATA ACCELERATES CROP BREEDING

Research in the laboratory of Associate Professor Lukas Mueller has the potential to be a catalyst to improve quality of life for struggling farmers.

The Mueller laboratory creates databases of genetic information from crops and links them to specific characteristics from multiple varieties. The additional software that they create enables researchers to implement a new breeding method referred to as "genomic selection."

The technique uses bioinformatics methods to create digital predictions of the results of new plant crosses before testing them in the field. It can predict how a new plant breed will look and taste—otherwise known as its phenotype—based only on information about the plant's genes.

"The really interesting question is how genes are related to phenotypes," said Mueller. "If you have enough data, you can predict phenotypes from genotypes."

Using Mueller's genomic selection tools, plant breeders can more quickly create improved crop varieties that have the potential to provide better nutrition, and to be more productive and disease resistant. Genomic selection is routinely applied in the private sector.

The laboratory did not initially start out with the goal of creating a database for breeders. In 2012, they partnered with Cornell University on the NextGen Cassava project to create a database linking the genotypes and phenotypes of different cassava varieties—a tuber vegetable that is popular in Africa, Asia and South America. They then expanded the number of features on the site to complement the existing breeding software. Now, cassava breeders can run aspects of their breeding programs through Cassavabase.

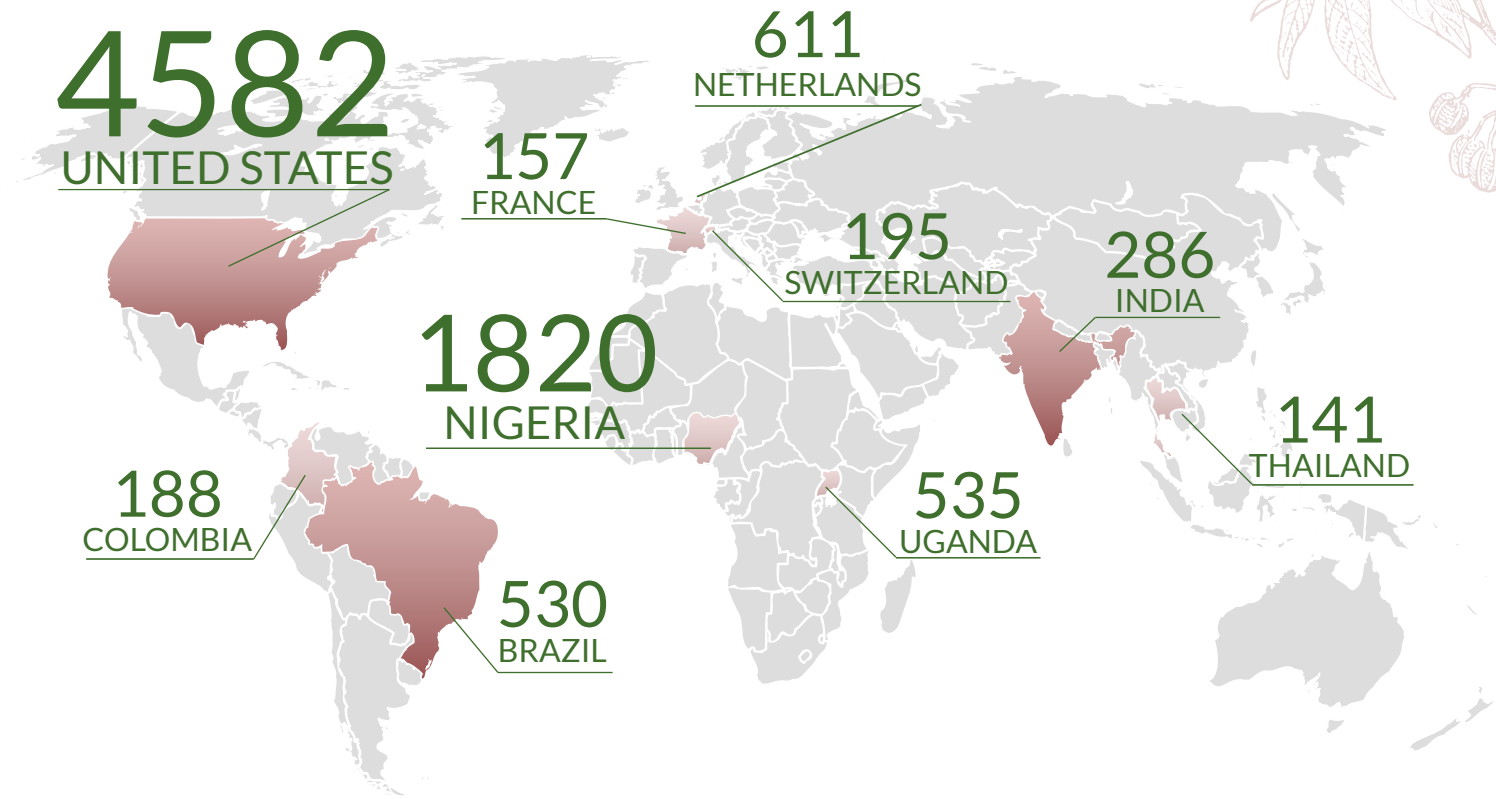
In 2014, the group added Yambase, a database for yam breeders. As a staple food, yams provide fiber, carbohydrates, and essential vitamins and minerals to people in West and Central Africa. But yam yields have diminished recently due to losses from pests and pathogens. Breeders and researchers hope to use genomic selection to create resistant yams that will produce better yields.

A banana database called Musabase also joined Mueller's lineup in 2014. The starchy cooking banana, or Matoke, is staple food in Uganda, where people eat it like mashed potatoes. Bananas offer an interesting challenge because the crop has three sets of chromosomes and is propagated vegetatively. To produce banana seeds, farmers must cross one parent with two sets of chromosomes to another with four. These characteristics will require additional modifications to the databases' genetic tools.

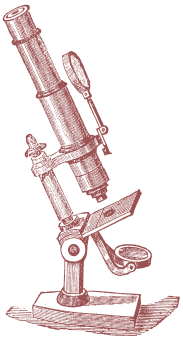
A sweet potato database is also in the works, in collaboration with North Carolina State University and CGIAR, a global agricultural research coalition. Mueller also works with CGIAR's Roots, Tubers and Bananas program to make these databases accessible to more breeders.

Both the Yambase and Musabase projects exist as collaborations with the International Institute of Tropical Agriculture. All collaborations receive funding from the Bill and Melinda Gates Foundation.

A GLOBAL LOOK AT CASSAVABASE



CASSAVABASE CONTAINS



7 MILLION
PLANT OBSERVATIONS
(PHENOTYPIC DATA)

540 MILLION
GENETIC OBSERVATIONS
(GENOTYPIC DATA)

20,000
CASSAVA
VARIETIES

100,000
PLANTS IN
EXPERIMENTAL PLOTS.

DEVELOPING NEW TOOLS TO FIGHT CITRUS GREENING

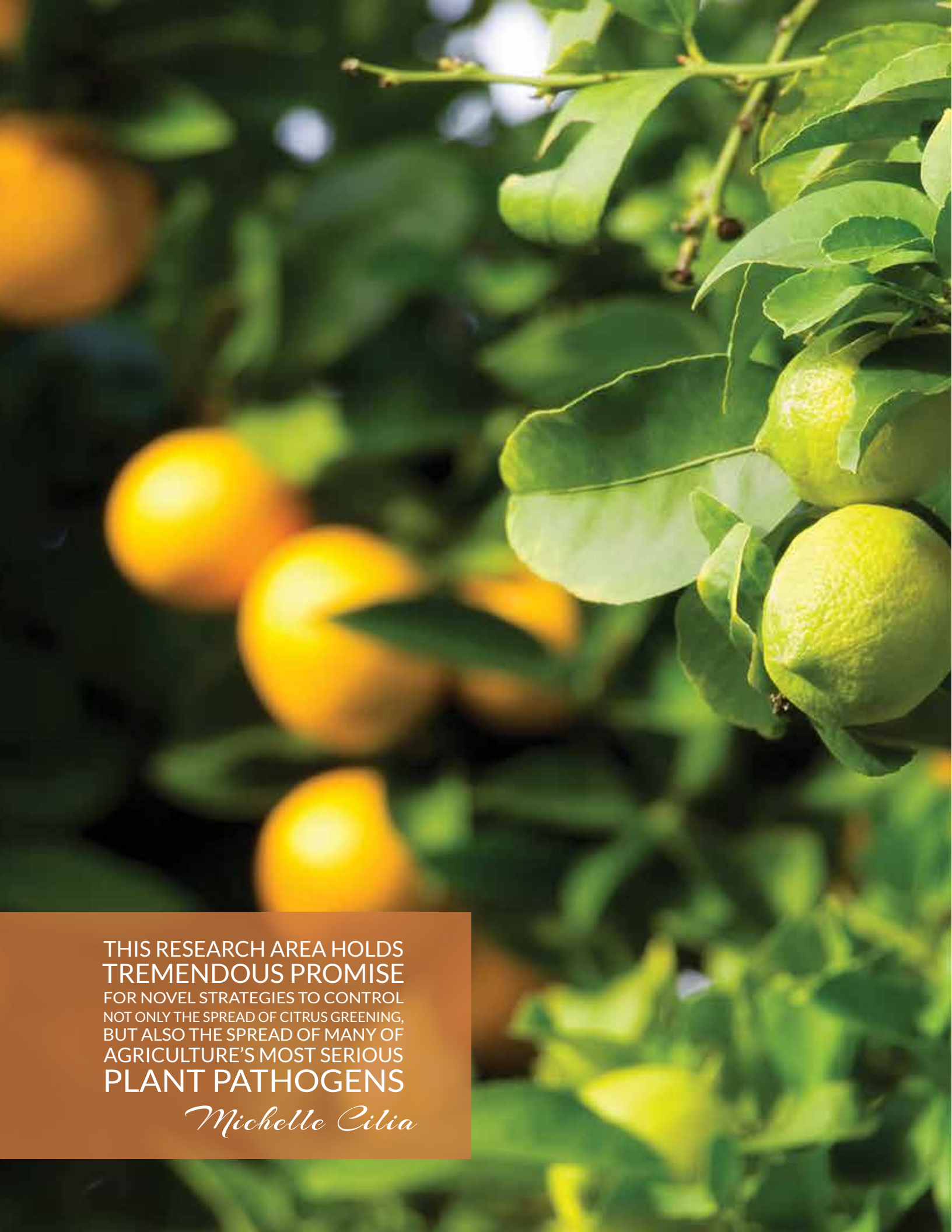
Several researchers at BTI devote their efforts to understanding insect-borne plant diseases that damage crops and can devastate harvests. Assistant Professor and USDA-ARS scientist Michelle Cilia focuses on the interactions between insects, plants and pathogens. She won the USDA-ARS 2014 Outstanding Early Career Scientist award for her work in cutting-edge biology of insect "vectors" that spread plant diseases. She studies a variety of diseases, including one that is making big headlines in California and Florida—citrus greening disease. Researchers think that the disease is caused by a species of bacteria spread by a tiny invasive insect called the Asian citrus psyllid. Infection by the bacteria causes the tree to yield small, green fruits, and is ultimately fatal.

To study this complex problem, Cilia's laboratory uses proteomics technology that allows them to identify and measure proteins within the cells of both citrus trees and psyllids. The technology allows them to study proteins that are key to the infection process. The researchers are developing a technique for early detection that identifies changes in the proteins generated by citrus trees after infection. Because the bacteria can spread through an entire grove before infected trees begin to show symptoms, early detection is imperative.

Cilia's laboratory also uses a tool called Protein Interaction Reporter technology, to find key proteins that the bacteria use to infect the psyllid. Developed by collaborators at the University of Washington, the technology yields detailed information on the interactions between the bacterial and insect proteins. If researchers in the Cilia lab can discover how to identify and block these proteins within the insect vector, then they could potentially stop the bacteria from infecting the trees.

"Our laboratory is uniquely poised to leverage state-of-the art technologies to identify and deliver targets for psyllid control to researchers developing in-grove solutions for citrus greening," said Cilia. "This research area holds tremendous promise for novel strategies to control not only the spread of citrus greening, but also the spread of many of agriculture's most serious plant pathogens."

Cilia's work sheds light on the evolutionary arms race that has long existed between insects and their pathogens. Her unpublished observations show that the citrus greening bacteria induce metabolic syndrome in the psyllids, which may alter their behavior and increase the spread of the bacteria. With a clearer understanding of how the bacteria use the psyllid to infect citrus trees, growers will have a better chance of defending their trees and protecting the citrus industry in the US and around the world.



THIS RESEARCH AREA HOLDS TREMENDOUS PROMISE FOR NOVEL STRATEGIES TO CONTROL NOT ONLY THE SPREAD OF CITRUS GREENING, BUT ALSO THE SPREAD OF MANY OF AGRICULTURE'S MOST SERIOUS PLANT PATHOGENS

Michelle Cilia

BTI, A CATALYST FOR NEW TECHNOLOGY

NEW TARGETS FOR ASPIRIN, INSPIRED BY PLANTS

Scientists rarely look to plants to better understand human diseases. But research in the laboratory of Professor Daniel Klessig has identified proteins—with equivalents in both plants and humans—that may play an important role in diseases as diverse as cancer, arthritis, stroke and Alzheimer's disease.

Since the Klessig laboratory's 1990 discovery that salicylic acid, or SA, is a major regulator of the plant immune system, Klessig and his team have been unraveling SA's mechanisms of action in plants. Most people are familiar with SA in a slightly altered form, acetylsalicylic acid, commonly called aspirin. Inside the body, aspirin rapidly breaks down into SA, which then acts to treat a variety of conditions including fever, pain, inflammation and cardiovascular problems. By identifying the proteins that interact with SA, researchers can identify targets that SA or aspirin act upon to treat certain diseases.

Researchers in Klessig's laboratory recently developed high-throughput methods to screen plant cells for targets that interact with SA. "Interestingly, many of those have counterparts in animal systems, some of which are believed to be involved not only in normal physiological processes but also pathological processes in humans," said Klessig.

When his team conducted similar screens to identify proteins that interact with SA in human cells, they found one target believed to play a role in diseases such atherosclerosis, sepsis, rheumatoid arthritis, stroke and cancers associated with inflammation. A second target is a key suspect in neurodegenerative diseases, such as in Alzheimer's, Parkinson's and Huntington's, while a third is a major player in energy metabolism and thus could be involved in obesity and diabetes. The Institute has filed a patent application on the process of using these screening methods for new drug discovery.

Klessig believes that the effects of low-dose aspirin usage in reducing disease risk can be attributed in part to its interaction with some of these targets. Furthermore, the screens revealed many additional candidate SA-binding proteins that have yet to be characterized.

In collaboration with Associate Professor Frank Schroeder, Klessig has identified a natural derivative of SA from an herb used extensively in Chinese traditional medicine and a synthetic derivative, both of which are 50 to 100 times more potent than SA and aspirin at altering the activities of these new targets, "thereby providing proof of principle that better derivatives of SA can be obtained which hopefully would provide more effective treatments for a variety of major diseases afflicting mankind," said Klessig.

BTI'S TECHNOLOGY TRANSFER OFFICE IS THE CATALYST THAT MOVES BASIC RESEARCH FROM THE LABORATORY TO THE PRIVATE SECTOR AND NONPROFITS.

Thus, BTI discoveries can fuel solutions to real-world problems in human health, agriculture and the environment, in accordance with its mission. Director of Technology Transfer Paul Debbie connects scientists with industry and foundations to ensure that BTI research has greater societal impact. The effort has broad participation across the Institute, with a majority of researchers filing disclosures for their intellectual property.

BTI's Technology Transfer Office is the catalyst that moves basic research from the laboratory to the private sector and nonprofits. Thus, BTI discoveries can fuel solutions to real-world problems in human health, agriculture and the environment, in accordance with its mission. Director of Technology Transfer Paul Debbie connects scientists with industry and foundations to ensure that BTI research has greater societal impact. The effort has broad participation across the Institute, with a majority of researchers filing disclosures for their intellectual property.

2014 HIGHLIGHTS

40 MATERIAL TRANSFER AGREEMENTS AND COLLABORATIONS WITH INDUSTRY, RESEARCH INSTITUTES AND ACADEMIC LABORATORIES.

7 INVENTION DISCLOSURES

29 PATENT APPLICATIONS, 10 U.S. AND 19 INTERNATIONAL APPLICATIONS

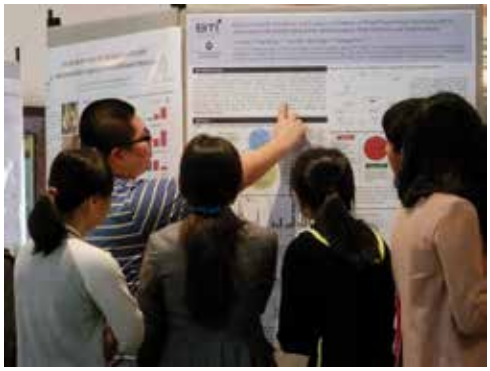
1 NEW PATENT ISSUED

FORMER BTI PRESIDENT RALPH HARDY FOUNDED THE TECHNOLOGY TRANSFER OFFICE

Today's thriving Technology Transfer Office began under the direction of BTI's fifth President, Ralph W.F. Hardy. Previously, Hardy had conducted research in biological nitrogen fixation at the Du Pont Company, from 1963 until 1984, ultimately rising through the ranks from Research Biochemist to Director of Life Sciences. He spent two years as president of Biotechnica International and then joined BTI in 1986. Hardy was the first leader of BTI to use the title President and CEO instead of Managing Director. He urged faculty to pursue research with practical goals, especially in regard to improving agriculture and the environment. He also encouraged the use of molecular biology and biotechnology in research programs wherever possible. Hardy foresaw that patents could be used to fund research and wanted BTI to become a world leader in the generation of new agricultural knowledge. He was instrumental in establishing a culture of aggressively protecting BTI's intellectual property and of careful management of the endowment. His nine-year tenure resulted in a strong portfolio of patents that helped to situate BTI more favorably in a competitive funding environment, and BTI continues to develop its intellectual property today.

BTI, A CATALYST FOR CAREER DEVELOPMENT

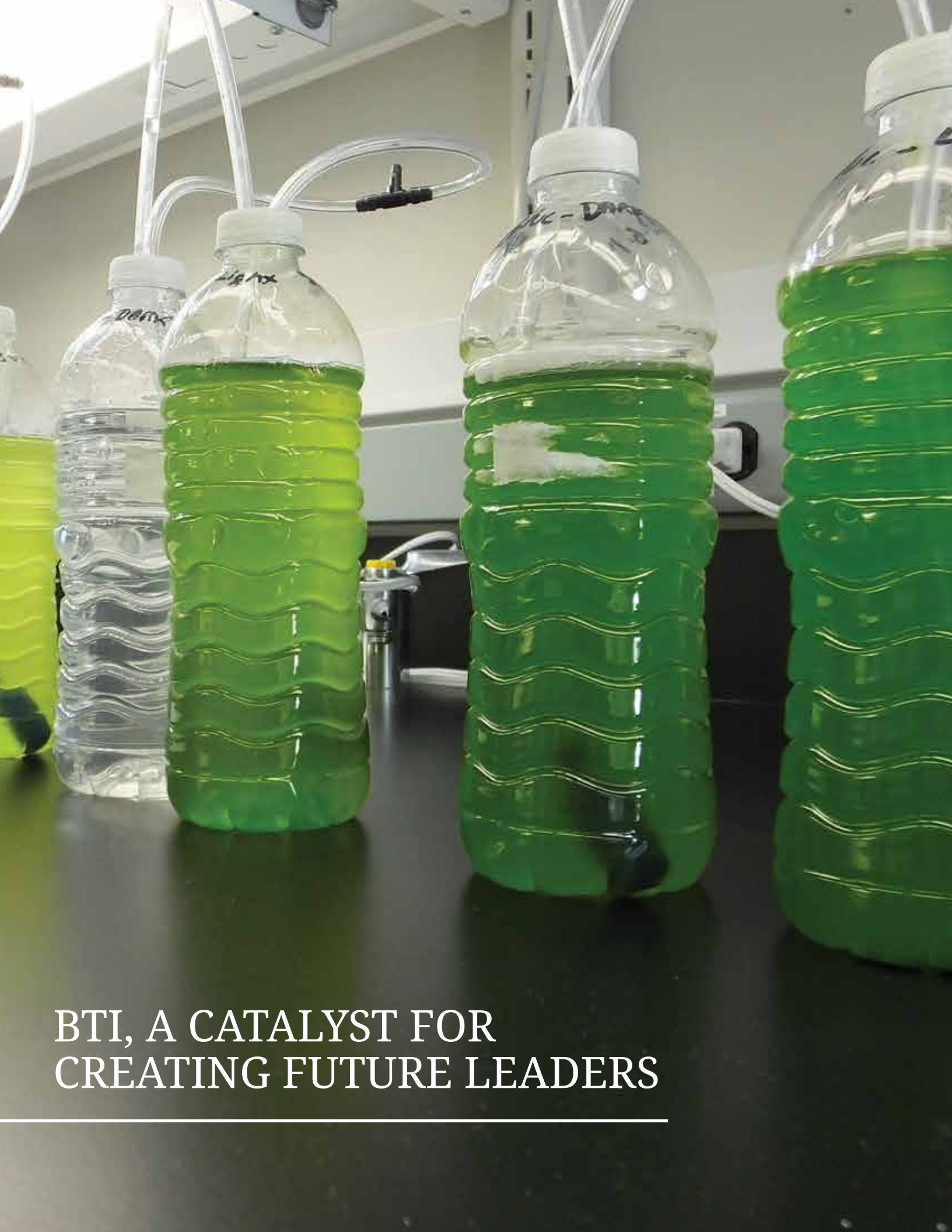
BTI supports its graduate and postgraduate students in sharpening their research, communication and networking skills, to gain an edge in in today's competitive job market. The Postgraduate Society seeks to promote professional development, foster a sense of community and to facilitate communication throughout BTI. The PGS, working with the former Vice President for Research Karen Kindle, held a variety of events in 2014, including seminars, informal chalk talks, and a fieldtrip. These activities give researchers an opportunity to talk about their work and to forge new connections within their field.



Members of PGS had the opportunity to visit the Monsanto Company at its Mystic, Connecticut location. Seventeen members spoke with head scientists and toured the transformation facility and greenhouses. They also participated in a panel discussion about working in industry.

SEMINARS AND CAREER DEVELOPMENT WORKSHOPS

- Richard Amasino, Professor of biochemistry at the University of Wisconsin-Madison, “Memories of winter: vernalization and the competence to flower."
- Sir David Baulcombe, Professor of plant science at the University of Cambridge, “When genomes meet: how RNA silencing and epigenetics can generate extraordinary phenotypes of hybrid plants.”
- Mathis Wackernagel, Executive Director, "The Global Footprint Network."
- Susannah Gal, Professor of biological sciences at Binghamton University, “Grant writing and the NSF process”.
- Bruce Lewenstein, Chair of the science and technology studies department at Cornell University, “Science public communication.”
- Richard Pattison, Assistant Editor of Nature Communications, "How to get published in Nature Communications: Demystifying the editorial process at Nature journals."
- Emma Granqvist, Publisher for plant sciences at Elsevier, “How to become a good reviewer.”



BTI, A CATALYST FOR CREATING FUTURE LEADERS

BTI Education and Outreach programs are nationally recognized for providing innovative learning, teaching and research opportunities in the plant sciences. Led by Director of Education and Outreach Tiffany Fleming, the program aims to raise public awareness of the importance of plant research and to mentor students and teachers in the newest advances in plant genomics. In 2014, BTI teacher education programs focused on sustainability, using topics such affordable biomass-based energy and improving the productivity and nutritional value of crops. With the growing involvement of BTI scientists, the Education and Outreach program continues to inspire a new generation of plant scientists and prepare them for pursuing innovative research.

The Bioenergy and Bioproducts Education Programs (BBEP) and Curriculum Development Projects in Plant Biology (CDP) introduced more than 250 science teachers to plant genomics and biomass-to-bioenergy research in 2014 through a series of summer institutes, conferences, and classroom visits, tours and workshops.

BTI educators visited pilot classrooms across New York state—from Rochester to Pulaski and Ithaca to Castleton-on-Hudson—to serve as scientific advisors and to assist with new curriculum development. Beyond New York state, seven universities partnered with BTI's Education team, using a five million dollar grant from the USDA, to implement the BBEP Program across the U.S.

YOU HEAR 'BIOFUEL' A LOT IN THE NEWS, I LIKE THE INTERDISCIPLINARY CONCEPT THAT INCORPORATES BIOLOGY WITH ENGINEERING, ENERGY PRODUCTION, AND TECHNOLOGY. YOU CAN COME UP WITH LAB EXPERIMENTS—**THIS IS TRULY HANDS-ON SCIENCE.**

Teacher & Workshop Attendee

WHY I GIVE, DAVID FERNANDEZ

At first glance, you would think that David Fernandez's philanthropic commitment to the Boyce Thompson Institution is due to his introduction to the Institute from late BTI faculty member Dr. Len Weinstein and Len's wife Silvia. The Weinsteins hired Fernandez and his company, Cayuga Landscape Co., to work on their new property in Cayuga Heights when BTI and its researchers moved to Ithaca in the 1970s. Len Weinstein had a unique vision for a modern landscape design that simultaneously created the atmosphere of a flourishing wild environment, and Fernandez happily worked with the family. With a landscape architecture degree from Cornell University and love for natural environments, Fernandez has a special knack for creating unique outdoor settings. He was even hired to plant the much-loved ginkgos on BTI's front lawn.

However, upon further conversation, you are introduced to an individual whose life is not only focused on the cultivation plants, but a life that is driven by acquiring new scientific knowledge, and of the plant sciences in particular—hence his commitment to Boyce Thompson Institute's research programs. Fernandez's career grew around helping plants survive, and so he is personally drawn to the vision of Will Thompson as someone who was devoted to discoveries in plant science. Moreover, Fernandez is drawn to basic research with its entrepreneurial spirit. As a regular reader of science news, Fernandez follows new scientific findings and has recently developed an interest in the study of the epigenome—the catalog of chemical modifications to DNA that can be related to lifetime activities, such as diet and exposure to pollutants.

Fernandez has been giving to BTI's annual fund since 1993. By making BTI a philanthropic priority, he likes that he can play a role by supporting research that is crucially important in today's world. Whether the work leads to understanding how plants thrive in fluctuating environments due to climate change or developing better agricultural methods to improve yield and human health, he is a part of that work.

BTI relies on the generosity of alumni and friends, like Fernandez, to support our innovative research and outreach programs. By supporting pioneering initiatives like our Research Innovation Fund, our vibrant Postgraduate Society or the transformative teacher and student research experiences, our community of donors ensures that BTI can continue to advance its leadership in plant science.

PHILANTHROPY

The Boyce Thompson Institute for Plant Research has enjoyed a long, rich history of philanthropy. It was Will Thompson, our founder, who invested a portion of his fortune to launch the Institute to honor his parents, William Thompson and Ann Boyce. From then on, the contributions of generous individuals have provided us with the edge we need to be champions for plant science. To those who appreciate the crucial role that basic research plays in solving l;larger global issues, we thank you. As federal funding sources become more competitive and limiting, your unrestricted donations allow BTI researchers to continue to explore discovery-driven research. Additionally, your donations support the training of our next generation of scientists and allow you take part in our passion for understanding the foundations of plant life. We take this opportunity to thank everyone who donated this past year. For information on making a donation, please contact our Development Office at (607) 254-2923.

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GIFT DESIGNATIONS

The Boyce Thompson Institute is unique from larger research institutions in that it is easy to see the journey of your gift, from donation to application. There is a wealth of opportunities for giving, including support for specific research projects or assistance for students to work alongside seasoned researchers. Gifts can also be an opportunity to honor or commemorate loved ones. To learn more about sponsorship or special gift designations, please contact our Development Office at (607) 254-2923.

IN SUPPORT OF ALUMNI LECTURES & RESEARCH PROGRAMS
Triad Foundation, Inc.

IN SUPPORT OF EDUCATION AND OUTREACH
Rose C. Mandl
Robert and Roberta Kohut
Dr. Ralph C. Zuzolo and Dr. Betty A. Fong

IN SUPPORT OF THE ANNUAL STUDENT SYMPOSIUM
Greg and Betsy Galvin

IN SUPPORT OF THE HIGH SCHOOL INTERNSHIP PROGRAM
Ithaca Garden Club
Carolyn W. Sampson

IN SUPPORT OF RESEARCH
Holly and Don Beermann
Polly Storrs Burchfield
Vanessa and John Wyatt Greenlee
Kathryn J. Mayo
Dr. Ralph C. Zuzolo and Dr. Betty A. Fong

IN MEMORY OF A. CARL LEOPOLD
Lynn Bradley Leopold

IN MEMORY OF LEN WEINSTEIN
David Fernandez, Cayuga Landscape Company
Robert and Roberta Kohut
Sylvia Weinstein

IN MEMORY OF RICHARD H. MANDL
Rose C. Mandl

IN HONOR OF DR. MARY E. CLUTTER
Machi and Greg Dilworth

FINANCIAL STATEMENTS

The Boyce Thompson Institute for Plant Research receives a substantial portion of its research funding through grants from the federal government, private foundations, corporations and individuals. The following section lists new research awards received in 2014.

NEW RESEARCH GRANTS AWARDED IN 2014 | *TOTAL $14,210,840*

GOVERNMENT

42%
National Science Foundation
$6,035,517

4%
United States Dept. of Agriculture
$627,100

6%
Dept. of Energy
$868, 412

23%
National Institutes of Health
$3,232,952

FOUNDATIONS

2%
Triad
$250,000

16%
Other Foundation Funding
$2,312,701

CORPORATIONS & OTHER SUPPORT

0%
Corporate Funding
$5,000

6%
Other Collaborations
$879, 158

INCOME SOURCES 2014 | *TOTAL $14,145,000*

$6,074,000	Federal Government	43%
$4,204,000	Institute Endowment	30%
$1,694,000	New York State	12%
$531,000	Foundations	4%
$1,293,000	Other Private Sources	9%
$349,000	Unrestricted Revenues	2%

EXPENSES 2014 | *TOTAL $14,145,000*

$9,734,108	Research Activities	69%
1,781,961	Administration	13%
1,220,931	Research Support	9%
648,000	Equipment and Facility	5%
287,000	Non-research	2%
473,000	Development and External Relations	3%

PIONEERING PLANT SCIENCE SINCE 1924

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