A publication of The Samuel Roberts Noble Foundation

Legacy

Summer 2009

FINDING A WAY TO THRIVE

A young Kenyan boy smiles while looking after his family's stand in the Nairobi market. The boy is selling small dried minnows for people to eat.

Inside this Issue

Cover story

Finding A Way To Thrive

Noble Foundation researchers are capitalizing on genetic transformation to improve grasses and legumes. Noble scientist Zeng-Yu Wang is hoping to produce more drought-tolerant alfalfa by increasing the waxy coating on the leaves.

Features

Departments

On the Cover

The cover of the 2009 Summer issue of *Legacy* illustrates how genetic transformation may help grasses and legumes, such as this alfalfa plant, survive diseases and tolerate harsher environmental conditions, specifically drought.

Illustration by Doug McAbee and Broderick Stearns

Photograph by Maria Monteros

THE SAMUEL ROBERTS NOBLE FOUNDATION

Michael A. Cawley
President/CEO

J. Adam Calaway
Director of Public Relations
Editor/Writer

Scott McNeill
Director of Publications & Visual Media
Art Director

Doug McAbee
Graphic Designer

Broderick Stearns
Photographer

Jackie Kelley
Copy Editor

Writers
Laura Beil
Andrea Perry
Katie Reim
Baxter Stewart

Legacy is published by the Office of Public Relations and the Office of Publications and Visual Media at The Samuel Roberts Noble Foundation. Headquartered in Ardmore, Okla., the Noble Foundation is an independent, nonprofit institute conducting plant science research and agricultural programs to enhance agricultural productivity. *Legacy* offers detailed insight into the outstanding scientists and agricultural consultants, and their programs and research, which collectively serve to pursue the vision of Lloyd Noble, the founder of the Noble Foundation, to benefit mankind.

Reprints
Articles, photographs and illustrations appearing in *Legacy* may be reprinted with permission from the Noble Foundation. Rerun requests may be made by contacting J. Adam Calaway, Director of Public Relations, at 580.224.6209 or by e-mail at jacalaway@noble.org.

No-cost subscription/address change
Legacy is provided at no cost to the general public as a courtesy of the Noble Foundation. To receive a copy of the magazine or to change your current mailing address, please e-mail jacalaway@noble.org.

Questions and comments
Do you have a comment about *Legacy*? Send us your thoughts or queries. Please submit questions or comments to jacalaway@noble.org.

The Samuel Roberts
Noble Foundation
2510 Sam Noble Parkway
Ardmore, Okla. 73401
580.223.5810 (general information)
580.224.6209 (media)

ISSN: 1939-5035

Food for thought

A crisis looms at the doorstep of our world and most people are unaware that it even exists. This situation's potential global ramifications trump any other conceivable issue because it deals with one of our most fundamental needs – food.

Today, more than 6.8 billion people call this planet home, consuming almost the entirety of our annual food production. In the next 20 years, the world's population will balloon to 8.3 billion, which leaves us asking a simple question: How do we feed 1.5 billion additional mouths?

Many believe we've merely reached the tipping point between population and food production. The reality is that we've surpassed it. UNICEF recently reported that 25,000 children under the age of 5 years old die each day because of malnutrition. A generation is slipping through our hands because quality food is unavailable.

Norman Borlaug, a plant breeder, is the father of the Green Revolution – the agricultural renaissance of the mid-1960s that fused modern breeding and Western production methods. Borlaug saved millions of lives in India when his new varieties of dwarf wheat produced enough yield to feed a starving country. In a recent *Wall Street Journal* editorial, he explained that it has taken 10,000 years to attain our current production of roughly 6 billion gross tons of food per year. He calculated that in the next four decades the world's farmers will have to double production.

It's a daunting, seemingly impossible task compounded by equally striking challenges. The worldwide population explosion has led to urban sprawl, reducing usable land. That which is usable, however, is eroding at an alarming rate. The United States is losing soil 10 times faster than the natural replenishment rate, while China and India are losing soil three to four times faster than the U.S. Over the past 40 years, erosion has made 30 percent of the world's arable land unproductive. Add in shrinking water resources, pollution concerns and ever changing geopolitical policies, and we have a formula for a global crisis.

Today, we hear many commentators raising issues of "energy security," but in the near future it is not unimaginable to believe that "food security" will be our all-consuming priority.

To address current and rising challenges, we will need a myriad of solutions: fundamental research, implementation of this knowledge to produce new varieties of seeds and plants, production agriculturalists, workers on the ground who understand both localized and regional issues, and, importantly, a mechanism to widely deliver knowledge and tangible outcomes to and from the farms. In the U.S., we benefit from such a system. However, in the far reaches of the world, this whole-system approach is largely underdeveloped.

Borlaug understands what happens when these outcomes are achieved; he has seen it before. "Given the right tools," he wrote, "farmers have shown an uncanny ability to feed themselves and others, and to ignite the economic engine that will reverse the cycle of chronic poverty."

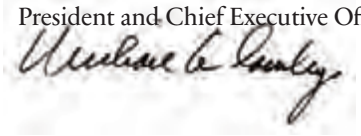
Agricultural research – specifically, plant science – will serve an increasing role in feeding our world. Scientists are using modern tools like molecular breeding and biotechnology to overcome environmental limitations such as drought and disease. The Noble Foundation and other international research institutions are creating and using these tools to render new innovations in the form of heartier and more productive crops. These new crops not only thrive under modern production methods, but we see that they can also add new life to past practices that may be found in countries that do not have access to fertilizer and other current technologies.

While the challenges before the world's researchers, agronomists, plant breeders and agricultural producers may seem overwhelming, I return to the words our founder, Lloyd Noble, wrote almost 60 years ago: "As I look around at the strides that have been made in our research laboratories, as I look at the things undreamed of a few years ago … the only degree to which we have reached the end of the road of opportunity is the degree to which we have exhausted the imaginative capacity of the human mind."

He was right. He has to be. Billions of lives depend on it.

Sincerely,

Michael A. Cawley
President and Chief Executive Officer



Summer Research Scholar makes amazing journey from Belarus to Noble

In 2002, an excited and anxious Mayya Glushankova arrived in New York City on a humid summer morning. Glushankova and her mother, Asya, had waited four long years to see her father, Valeriy, again. He immigrated to New York from Belarus four years before to pave a way for his family. He called Mayya twice a week and sent packages filled with candy. Now, at last, they would be a family again.

Seven years later, Glushankova stood at a laboratory bench in the Noble Foundation's Plant Biology Division building. She was 1,000 miles – literally and figuratively – from where she began her life in the United States. This summer, Glushankova joined a handful of select college students from around the country to serve as Noble Summer Research Scholars. Working side-by-side with a mentor scientist, each member of the group performs a research project specifically tailored to his or her interests and educational background.

Being a Research Scholar is the culmination of years of steadfast effort. As she reviewed her notes and talked about her daily duties at the Noble Foundation, Glushankova couldn't help but think about those first few years as an immigrant. When she first arrived in the United States, Glushankova could not even speak English.

Thrust into a completely foreign environment, Glushankova was forced to pick up the language quickly. She learned English within a year by observing friends and classmates. "When I finally learned, I was overjoyed to at last be able to fully express my thoughts to others," Glushankova said. "My school helped me to adapt to the new culture and traditions. I learned English and made friends."

In 2006, Glushankova graduated as valedictorian of her class and moved to New York University (NYU) to study chemistry and psychology. "I'm thankful to be in a country where hard work and motivation matter," Glushankova said. "I know that if I work hard enough I can be whatever I want to be."

Tragically, her father passed away the next year of cancer. Glushankova tried to overcome her pain and persevered to make the dean's honor roll her first year at NYU. "I think about the lost years with my father, but I know that he came here to help me and my future," Glushankova said. "He was the closest person I had in my life."

Over the next few years, Glushankova continued to excel in school, especially in her favorite subject, organic chemistry. She grew closer to her mom and leaned on her friends.

Last fall, Glushankova read about the Noble Summer Research Scholar Program on the Internet. "I typed in 'research internships' and it popped right up," she said. "It was an excellent opportunity to expand my understanding of chemistry and biology." Being no stranger to travel, the distance to Oklahoma did not bother Glushankova and she applied. Soon after, she was accepted as one of only five Research Scholars for 2009. The Research Scholars are selected from across the United States. This year's group included Jennifer Oswald from Princeton University, Craig Schluttenhofer from Purdue University, David Short of William and Mary, and Rhonda Walker of Western Kentucky University.

"We come from across the United States, but we have so much in common," Glushankova said. "The group instantly gelled. Our days are spent working with amazing people. Our nights and weekends are spent together, cooking and watching movies, exploring the region or just sitting poolside at our apartment talking about life. We've become like family."

Glushankova worked in the lab of Richard Dixon, D.Phil., a member of the National Academy of Sciences. Her ▶

Mayya Glushankova joined the Noble Foundation scientific staff as a Summer Research Scholar.

Photograph by Broderick Stearns

mentor was Yongzhen Pang, Ph.D. Glushankova's task was to isolate and identify proanthocyanidin compounds (PAs) from *Desmodium uncinatum*, a large perennial legume. The presence of PAs in the fruit, bark, leaves and seeds of many plants provides protection for the plant against predators. PAs in forage can also prevent pasture bloat in ruminant animals.

Glushankova hoped that this study would one day lead to the engineering of PAs into economically important crops such as alfalfa and white clover.

Glushankova said she valued the relationship she formed with her mentor. "She is passionate about her work," Glushankova said. "She is so patient and open with me. She makes sure I understand the work, and I know I can ask her about anything. She is truly dedicated to her projects and is an amazing person."

Her mentor feels the same. "She's an amazing young woman with a natural sensibility in the lab," Pang said. "I see her grasp difficult concepts quickly. She works hard. I know she's going to succeed in this field."

Glushankova concluded her stay by showcasing her research during a 20-minute presentation to the Noble Foundation's scientific staff. Her voice quivered just a bit as she talked about having to speak in front of so many people, but she said that Pang helped ease her fears.

Glushankova is not entirely sure of her future plans beyond undergraduate school, but this summer at the Noble Foundation opened her eyes to some of the possibilities for those passionate about science.

"I've gained valuable experience and confidence in the laboratory," Glushankova said. "The Noble Foundation is a terrific place. The people are so friendly that I look forward to coming to work. They are ready to answer any questions and always encourage me in my efforts. They are fully committed to the projects, and I can see how much they enjoy doing them. I couldn't have asked for a better summer."

by Baxter Stewart

For more information on becoming a Noble Foundation Summer Research Scholar visit www.noble.org/SummerScholar

---

Collaboration initiated to improve alfalfa

The Samuel Roberts Noble Foundation and Forage Genetics International, LLC, a Land O'Lakes subsidiary, entered into a multi-year research collaboration focused on improving alfalfa for forage, silage and industrial uses.

As part of the collaboration, Forage Genetics International (FGI) provided a gift to advance the Noble Foundation's infrastructure, and research, education and outreach programs as well as additional funding for targeted research in alfalfa for the next decade. In return, FGI obtains an option to commercialize Foundation technologies in alfalfa.

As with all legumes, alfalfa plays a key role in cropping systems around the world. Legumes, such as soybean, clovers and peanuts, are high in protein and fix a significant amount of atmospheric nitrogen, making them an economical and environmentally important resource. According to the National Alfalfa and Forage Alliance, alfalfa contributes $7.5 billion to the United States economy.

"The Noble Foundation's basic research on engineering metabolic pathways has generated an exciting new opportunity to improve forage quality and expand the potential industrial uses of alfalfa," said Mark McCaslin, President of FGI. "The forage genomics and metabolomics programs at the Noble Foundation are cornerstones to understanding gene function and driving new trait discovery, and have the potential to greatly increase the value of alfalfa worldwide. In the next 10-20 years, we will be able to redesign alfalfa for optimum performance under various growing environments and for various end uses."

The Noble Foundation and Forage Genetics International are working together to improve alfalfa, a crop worth $7.5 billion to the United States economy.

Scientist fights against tomato disease

When Rao Uppalapati examines the tomato plants in his laboratory and finds spots surrounded by yellow haloes, he knows there is a full-scale war waging within.

Tomatoes, like all other plants, use hormones to regulate development and defend against pathogens. However, pathogens have their own tricks. When the bacterial pathogen *Pseudomonas syringae* infects a tomato plant, it produces a toxic compound called coronatine, which mimics a growth hormone (jasmonic acid) and hijacks the hormone's pathway. The newly conquered pathway is a molecular, four-lane highway for disease to invade the plant.

This is where Uppalapati comes in. As a research scientist with the Noble Foundation, Uppalapati seeks to understand coronatine and identify its molecular targets in an effort to improve tomato plant health.

"Anybody that has seen a tomato plant has at one time or another seen the yellowish spots," Uppalapati said. "That's because coronatine is a phytotoxin. It is literally killing the chlorophyll in that area of the plant. From our perspective, they look like little spots, but the tomato is fighting for its life."

Originally from India and a Ph.D. graduate from Nagasaki University in Japan, Uppalapati has researched the intricacies of coronatine for seven years since he was a postdoctoral fellow ("postdoc") at Oklahoma State University under Carol Bender, Ph.D. When he arrived at the Noble Foundation, he continued his work.

Uppalapati's research efforts were recently rewarded when he received a two-year, $82,000 grant from the Oklahoma Center for the Advancement of Science and Technology (OCAST). Uppalapati's grant was one of seven OCAST grants awarded as part of the third round of research to receive support under the Oklahoma Plant Science Research program, which began in 2007.

Spots with yellow haloes like these can indicate that a plant is fighting for its life.

Uppalapati said receiving the grant exemplified yet another advantage of working at the Noble Foundation.

"At many other research institutions, only a laboratory's lead scientists are allowed to apply for grants," Uppalapati said. "At the Noble Foundation, not only can research scientists apply, but our lead scientists help us, providing mentorship and assistance through the grantmaking processes. I am very thankful for the tremendous amount of support from my colleagues at the Noble Foundation and for this important grant."

So are the tomatoes.

Noble Foundation ranks No. 4 in national survey

For the second consecutive year, the Noble Foundation has placed in the top 10 of *The Scientist* magazine's annual Best Places to Work for Postdoctoral Fellows (postdocs) survey.

The Noble Foundation, which is internationally known for its plant science research and agricultural programs, ranked No. 4 out of more than 85 institutions nationwide, moving up four spots from the No. 8 ranking the organization received in 2008. The Noble Foundation also ranked as the highest plant science research institute on the list.

"The Noble Foundation continues to distinguish itself as one of the top plant science and agricultural research institutions in this country and around the world," said Michael A. Cawley, President and Chief Executive Officer of the Noble Foundation. "This national survey reaffirms the Noble Foundation commitment to our research and to our researchers. We have outstanding postdocs from around the world, and we strive to provide them the means to succeed during and after their time here."

The Noble Foundation received high scores for training and mentoring; generously funding postdoc research programs; and the quality of the infrastructure.

The Noble Foundation topped such recognized research organizations as the Mayo Clinic, the National Institutes of Health, the National Cancer Institute, M.D. Anderson Cancer Center, St. Jude's Children's Research Hospital and the Boyce Thompson Institute for Plant Research, as well as dozens of universities, including the University of Texas Southwestern Medical Center and Duke University.

Billy Cook discusses forage management during a recent demonstration field day.

Photographs by Broderick Stearns

Looking Toward the Future

by Katie Reim

Cook assumes reins of leadership

For Billy Cook, the deeply instilled values of a solid work ethic, honesty and accountability can be traced back to growing up in West Texas on his grandfather's ranch near the small town of Imperial.

While his formal education came years later, Cook says his real schooling came from working cattle through blistering summer days and drought conditions on the plains of Texas. There, Cook learned one of the hardest and most valuable lessons about being a successful rancher – oftentimes you have to make the best out of limited resources. It was an experience that continues to serve him well as he assumes a new position at the Noble Foundation.

Cook, Ph.D., became the Senior Vice President and Director of the Agricultural Division this spring, taking over for Wadell Altom, who retired after 43 years of service.

"My upbringing helps me relate to producers and communicate with them on a personal level," Cook said. "Working at the Noble Foundation, our focus is on helping agricultural producers achieve their goals through direct consultation, education and research. When you've been in the producer's shoes trying to make ends meet, you know how difficult it can be to reach those goals, so you understand the importance of providing them with the best ▶

possible guidance and information."

Cook left his grandfather's ranch and attended Sul Ross State University in Alpine, Texas, where he received his bachelor of science in animal health management. He then transferred to Texas A&M University, where he earned a master of science in beef cattle production and a doctor of philosophy in beef cattle production and meat science, while assisting with the daily operations and management of a registered cattle operation.

After graduation, Cook served as general manager of the Beef Development and Research Center of Texas where more than 1,400 bulls were performance tested during the initial year of operation. Cook's time with the research center was valuable experience. He worked with hundreds of purebred cattle producers and thousands of commercial producers, which reinforced his desire to use his education and training to assist producers.

Cook had long been aware of the Noble Foundation's work to support agricultural producers. The Agricultural Division's consultation program – which provides regional farmers and ranchers with access to no-cost consultants who can address the complete spectrum of agricultural issues – aligned perfectly with his career goals. "I wanted to work directly with producers in a setting closer than what was possible with a university or state extension office," Cook said. "The Noble Foundation provided an opportunity to work one-on-one with producers. It was a unique opportunity that appealed to me."

Cook joined the Noble Foundation as a livestock consultant in 1999. For five years, he worked with area farmers and ranchers, learning about their specific needs and confirming that the lessons of his youth were universal.

"Being a farmer or rancher requires a tremendous amount of sacrifice – no matter where you are," Cook said. "It was a real privilege to help producers find new ways of maximizing their resources in a way that made a meaningful difference to their lives and their families."

Cook was content to stay a consultant until an opportunity arose to move into management and build the division's new research team. The group would conduct research to support the consultants and would also collaborate with the Noble Foundation's two scientific divisions to move plant science research from the laboratory to the field.

"The interaction with the producers was the best part of this job, no doubt," Cook said. "However, the opportunity to build a research program from the ground up and then utilize that research to benefit producers – that was a home run waiting to be hit."

As manager of the program, Cook helped shape and manage a multidisciplinary team of agricultural researchers, as well as provided oversight to the Noble Foundation's research farms – 12,000 acres of living laboratory. The research team receives continual feedback from the consultants about agricultural issues important to area farmers and ranchers. "The consultants identify the questions that the producers need answered," Cook said. "Our research team gives them the ability to answer those questions. The research team starts with the questions and then designs multidisciplinary, applied research projects that approach these issues from both production and economic standpoints."

The research team is involved in various types of research from investigating the effects of specific tillage methods on stocker cattle gain to determining the feasibility of using switchgrass in a dual purpose stocker cattle and bioenergy system.

Five years passed, and opportunity again came to Cook.

"We've come so far in six decades, helping thousands of farmers and ranchers achieve success while fulfilling the vision of Lloyd Noble to secure the land for future generations."

Billy Cook, Ph.D., Director of the Agricultural Division

Billy Cook, center, works with the Agricultural Division's nonresident fellows, (from left) Jimmy Kinder, Mary Sue Butler Clyne and Bill Turner, to craft a strategic plan.

When Altom announced his retirement, Cook became the obvious choice to succeed him, combining experience in both consultation and research, and possessing a proven track record of leadership.

"Dr. Cook's experience with each of the key functions within the Agricultural Division, along with his skills, knowledge and leadership, made him the only choice for the position," said Michael A. Cawley, President and Chief Executive Officer. "I speak for the Board of Trustees when I say the division and all the farmers and ranchers we serve are in good hands."

As division director, Cook is hoping to revisit the lessons of his youth – helping agricultural producers do more with available resources.

"There are many questions facing production agriculture in the next generation. How do we continue to feed a growing population? How do we ensure the survival of those individuals who choose production agriculture as a career? How do we help producers adapt to future changes, and what are those changes?" Cook said. "The Foundation is already in place to help address these needs. Now we want to further leverage our skills and resources during these challenging times to make certain there is a viable and prosperous future for agriculture."

Cook outlined four key objectives: provide stewardship and basic agricultural advice to the increasing number of landowners who are embracing a rural lifestyle; offer sound counsel on the many production and economic issues facing agricultural producers (higher production costs, complicated legislation and succession planning); continue to conduct quality, multidisciplinary applied research; and foster mutually beneficial relationships with strategic partners.

"We've come so far in six decades, helping thousands of farmers and ranchers achieve success while fulfilling the vision of Lloyd Noble to secure the land for future generations," Cook said. "But I know our greatest work still lies ahead of us."

Cook retains the spirit of the young boy who grew up working cattle on a West Texas ranch and learned to truly appreciate the agricultural lifestyle.

"Livestock and agriculture have played an important role in my life," he said. "Likewise, the agriculture industry plays a significant role in our society, one which will only become more vital in the future. That's why it is so important for me to fulfill my duties here at the Noble Foundation. Agriculture is not just my heritage, it's our collective heritage."

Genetic transformation may help grasses and legumes, such as this alfalfa plant, survive diseases and tolerate harsher environmental conditions, specifically drought.

Finding A Way To Thrive

Genetic transformation aids researchers' quest to build drought-tolerant grasses and legumes.

by Laura Beil

To most of us, grass is grass. We mow it in the summer or shoot a golf ball across it now and then, rarely giving a thought to the fact that more than one-quarter of the Earth's land is carpeted in hues of green. Some grasses thrive in cool weather, some across sunburned plains, some at altitudes few humans ever experience. Without grass, animals wouldn't survive, and neither would people who depend on them.

To scientists, grass is never just grass. Countless species of plants comprise what the rest of us refer to as grass, some of which – like clover – aren't really grass at all, but pod-bearing legumes. To researchers who study them, grasses and legumes are a diverse and dynamic cornerstone of life and agriculture. "Grasses and legumes can grow where crops cannot," said Zeng-Yu Wang, associate professor, who heads up genetic transformation research in the Noble Foundation's Forage Improvement Division.

Yet for all of their versatility, the world's most important plants still exist at the mercy of nature. A prolonged drought has withered pastures throughout much of the country, forcing many farmers and ranchers to feed livestock that ought to be grazing. Wang envisions a day when grasses keep growing in parched soils, with varieties of legumes such as alfalfa and white clover better equipped to draw nutrients and resist months of little rain. These plants don't exist now. That's why he is trying to make them.

His laboratory is Noble's epicenter for research into genetic transformation. In its simplest sense, genetic transformation is the science of altering a plant's genetic makeup. Humans have tinkered with the genetics of plants for centuries, which is one reason the impossibly plump, perfectly colored fruits and vegetables in the supermarket bear little resemblance to anything your ancestors ate. Traditionally, plant breeders turn up the volume on desirable qualities or winnow out less beneficial traits through selective crossing of certain plants. Wang's work tries to fast-forward the process. Instead of breeding whole plants, or even shoots of plants, Wang's laboratory inserts genetic instructions directly – in this case, codes that might enable a plant to absorb more phosphate from the soil or withstand long periods without rain.

The work is painstaking, complex and controversial. Yet for a man born and educated in China, challenge is something to embrace. "I thoroughly enjoy the work because of its tremendous potential benefits to food security and the environment," he said.

As a scientist, Wang knows to expect results in increments, not eureka moments. Each step of the work takes him from molecular genetics to plant breeding to tending seemingly endless generations of plants. He and his colleagues begin with the genetic instructions for the naturally occurring waxy layer on the outside of an alfalfa plant. Experiments suggest that thickening this almost invisible coating enables alfalfa to lose less internal moisture through evaporation and reduce its thirst for water in the same way car wax protects a paint job from the scorching sun. In a sense, the goal is to give the plant an ability to detail itself.

Which is where *Agrobacterium* comes in. *Agrobacterium* is a microorganism that uses plants for its own survival. When *Agrobacterium* needs food, the organism seeks to infect a host plant. Once infected, *Agrobacterium* has the ability to place its own genes among the plant's genes. In genetic transformation research, scientists use *Agrobacterium*'s unique gene transfer talent for their own ends. Researchers insert genes of interest into the *Agrobacterium* "vehicle" – genes that they want the plant to use. They then allow *Agrobacterium*'s natural mechanism to work.

"What we do is start putting our own genes in," Wang said. When it infects a plant, *Agrobacterium* will transfer whatever genetic cargo it contains – be it the organism's own genes or stowaways inserted by scientists.

But placing a gene into the plant's seed is, in many ways, the easy part. Insertion of the gene inside the plant's genetic machinery doesn't guarantee the gene will be expressed – meaning that it might sit silently buried in the seed. Or it might produce the changes in the wrong place. "You want this gene to be expressed in certain cells at certain times in the plant," Wang said. And there lies the biggest challenge.

In Wang's work, he wants the increase in wax to appear on the outside edge of the plant, not throughout. If the thickening occurs elsewhere, the plant might grow too slowly or have a poorer

"I think it's a critical technology that's going to be around for a while. It will be useful in increasing the production of crops, particularly as the population is growing."

Ed Kaleikau, National Program Leader in plant genetics at the United States Department of Agriculture's Cooperative State Research Education and Extension Service

Zeng-Yu Wang examines a piece of alfalfa. Wang is looking to improve grasses and legumes through genetic transformation.

Photograph by Broderick Stearns

nutritional value. Also, he said, "you only want the gene expressed in times of drought."

The same challenges appear in another line of experiments, this time with coaxing plants to absorb more phosphate. Phosphate is an essential nutrient for plants, but the majority of the mineral remains trapped in the dirt because the plant doesn't have a good mechanism to absorb it. Wang is experimenting with two genes that code for enzymes that allow phosphorus to more easily pass into the plant. He faces the same challenge of precision: he only wants the genes expressed in the plant's roots.

The targets of these experiments are alfalfa and white clover, both of which are important forage legumes for livestock. The work is partly funded by Forage Genetics International, a subsidiary of the Land O'Lakes corporation, known for producing other genetically engineered products.

In addition to the scientific realities, Wang also knows that genetic transformation is a rough terrain for public policy. One of his mentors was Ingo Potrykus, a professor at the Swiss Federal Institute of Technology in Zurich, who helped develop golden rice. Golden rice, which contains a gene that makes vitamin A, could help protect much of the developing world from blindness. At its introduction in 2000, the rice was hailed on the cover of *Time* magazine. Yet it has not yet been adopted in some of the world's highest rice-consuming, vitamin A-deficient countries because the idea of directly altering the genes of plants makes many consumers wary.

"There will be people against it, no matter what you do," Wang said. In the United States, genetically modified plants are widespread: 80 percent of corn, 86 percent of cotton and 92 percent of soybeans are genetically engineered.

"I think it's a critical technology that's going to be around for a while," said Ed Kaleikau, National Program Leader in plant genetics at the United States Department of Agriculture's Cooperative State Research Education and Extension Service. "It will be useful in increasing the production of crops, particularly as the population is growing."

Wang hopes what is true for food crops will one day apply to forage plants. People depend on grass and legumes, he points out, even if they never think about the stuff under their feet.

And if the research goes well, they won't have to.

Kelly Craven

Kelly Craven enjoys the road less traveled. Months after earning his bachelor's degree, Craven placed graduate school on hold and struck out on his own, shaking off the status quo for a little unfamiliar terrain. He bounced from the Bavarian Alps to the Mediterranean on a personal quest of discovery that honed his scientific aspirations and provided him confidence to blaze his own trail. Things haven't changed much in the last 15 years. Today, the 38-year-old Phoenix native is a mycologist, studying the phenomenal world of fungi and how they can maximize forage crops for the benefit of agricultural producers. It's certainly not a traditional course of research and that's just fine with Craven.

On his research:
My research involves using beneficial fungi to enhance agricultural food crops and bioenergy crops. I also look at what makes a fungus develop and grow, as well as how those fungi form harmful or beneficial relationships with plants.

On the impact of fungi on humans:
Fungi can help create larger, healthier plants by forming symbiotic relationships with them. They can also expand the range and types of lands that crops can be grown on. Learning how to get the most output from croplands and how to make use of low quality lands for agriculture is the key to feeding the world's growing population.

On his passion for fungi:
Fungi are amazing for their ability to produce a diverse array of compounds that humans use in medicine. Fungi are also the great recyclers. Without fungi, the land would literally pile up with plant material that could not be decayed and recycled. That's not all – fungi can extract their nutrition from almost every conceivable source and can colonize bare rock, jet fuel, leather, etc. To top it off, many of them are quite tasty and others make beer.

On trips, Dairy Queen and cooties:
We had a camper on my dad's truck, and we made a couple of cross-country trips when I was young. The camper came up over the cab of the truck, where my sister and I would spend hours looking out the window and talking. We tried to convince my dad to stop at every Dairy Queen we passed. That was a special time. Soon after the last trip, I discovered that "girls have cooties." My sister and I weren't such good friends after that. But let's face it, cooties are cooties.

On youthful life lessons:
My first job was bussing tables at a Tex-Mex restaurant in Mesa, Ariz. I was 14 and somehow got to hang out with the bartenders after work. It was a lot of fun, but it's probably why I did so poorly as a freshman in high school.

On ski lifts and Greek beaches:
After I earned my bachelor's degree at Arizona State University, I spent half a year working as a chair lift operator at a ski resort in the Bavarian Alps. I skied to work and sat in the sun all day. This was the most carefree time in my life. When the ski season ended, I hitchhiked to Prague and then flew to Greece for a month. Those were truly special days. I learned how to be self-sufficient and gained a deep admiration for other cultures. Lying there on the beaches in Greece was great at first. I lived solely off of Nescafe, noy-noy (goat's milk), tomatoes and bread. But I grew bored and realized I was missing mental stimulation. I recognized that I needed to pursue my scientific career. So, when I returned, I applied for graduate school.

On hobbies both indoors and out:
I grew up playing pool with my father (often in places I probably shouldn't have been), and this was always kind of a special thing between us. Even as he got sick in his later years, we still enjoyed our time there. Today, I still play. I've been known to give some fellow scientists a lesson or two. I also love to be in nature. I really get a sense akin to a religious experience when I hike. Nature is my church.

On his lifelong love affair with music:
I love rock and roll. Pink Floyd, Led Zeppelin, KISS and the Rolling Stones provided the soundtrack to my life. One year my laboratory group dressed up as the Stones for Halloween. I was Keith Richards.

On being a scientist:
I think every scientist yearns for that thrill of discovery. To play a small part in pushing our knowledge forward is extremely satisfying to me.

On finding inspiration:
Art and music are very inspiring. I think individuality and walking your own path is inspiring. Arizona sunsets are definitely inspiring.

by J. Adam Calaway

Photograph by Broderick Stearns

A young African girl poses momentarily for a photo during a recent visit by a Noble researcher to Kenya. UNICEF reported that 25,000 children die each day of malnutrition, many in Africa.

Hope Is Alive

by J. Adam Calaway

In the years following the Dust Bowl, much of Oklahoma's agricultural land lay in ruin, ravaged by years of poor farming practices and drought. It was a time when agricultural producers – those who depended on the land for their livelihood – needed assistance in returning Oklahoma to a productive region.

Lloyd Noble established The Samuel Roberts Noble Foundation as a means to support agricultural producers recovering from the disaster. Early in his endeavor, he wrote: "What are we in the present generation going to do with this heritage? Are we going to encourage the terracing, conservation and upbuilding of our soil so it will support a growing, healthy and prosperous livestock and agrarian industry, or are we going to allow our soils to be depleted and our population shifted to other areas as we read about it in the newspapers?"

Today, the Noble Foundation finds itself in a unique position. The organization's experience in designing agricultural programs and conducting plant science research now holds the potential to play a key role on the global stage.

The Bill & Melinda Gates Foundation is bringing together researchers and scientists from around the world to find sustainable solutions for the formidable problems facing Africa. One Noble Foundation scientist traveled to Kenya this summer and witnessed firsthand the countless challenges facing Africa's agricultural producers. A continent is in peril, but hope is alive.

Photographs by Maria Monteros

The Swahili phrase "hakuna matata" roughly translates to "no worries."

In the United States, children of the mid-1990s remember it as a cartoon catchphrase in Disney's glossy, circle-of-life fairytale, *The Lion King*. In the stark reality of Sub-Saharan Africa, hakuna matata is a common expression spoken by everyday people, a few good-natured – albeit ironic – words of hope in a land plagued by problems.

Untangling the mesh of cultural, societal, economic and agricultural dilemmas facing Africa is not unlike a game of Jenga, where each issue tugs, supports or undermines stacks of interrelated problems, leaving no one problem easily fixed. Africa's continued population growth strains limited resources. Restricted access to medical treatment leads to outbreaks of treatable diseases like malaria. Lack of infrastructure and the steep cost of transportation stifle potential markets. All of which compound the challenges facing the continent's most vital industry – agriculture.

Three-fourths of the world's poorest people survive solely on the food they can grow and sell, both of which become complicated in Sub-Saharan Africa where there is a shortfall of usable land and available markets. Additionally, African farmers must overcome animal and plant diseases long since eradicated or controlled by Western producers. Clean water remains in short supply, and soil acidity makes large chunks of land too toxic to grow anything, much less food crops.

For generations, Americans have been reading about Africa's plight, never fully understanding the scope or interaction of the challenges facing the continent. However, the Bill & Melinda Gates Foundation, the world's largest philanthropic organization, is on a quest to bring sustainable solutions to Africa.

Building bridges

To date, the Gates Foundation has committed more than $1.3 billion to agricultural development efforts. The Gates Foundation seeks to mitigate or reverse many of the detrimental trends by being the touchstone for collaborative partnerships that will lead to profound change.

As part of this continuing effort, the Gates Foundation sponsored the U.S.-Africa Connection Workshop this June in Nairobi, Kenya. The workshop brought together 24 American scientists and 24 Kenyan scientists to build research relationships to approach the country's many agricultural challenges from new perspectives.

"This was an experiment for us," said Kathy Kahn, a program officer for the Gates Foundation, who develops initiatives

Noble Foundation scientist Maria Monteros, right, visited Kenyan farms during the U.S.-Africa Connection Workshop in June.

“Sometimes scientists can’t see how their individual research impacts the world; however, working in partnership with people on the ground in Africa, we hope they will see their discoveries change the lives of farming families in Africa.”

Kathy Kahn, program officer for the Bill & Melinda Gates Foundation

specifically aimed at impacting African farmers. “We wanted to provide these scientists an opportunity to see what issues were really facing the small farmers in Africa. We hoped it would be an opportunity to inspire them and let their creative talents loose, perhaps even change their lives. Sometimes scientists can’t see how their individual research impacts the world; however, working in partnership with people on the ground in Africa, we hope they will see their discoveries change the lives of farming families in Africa.”

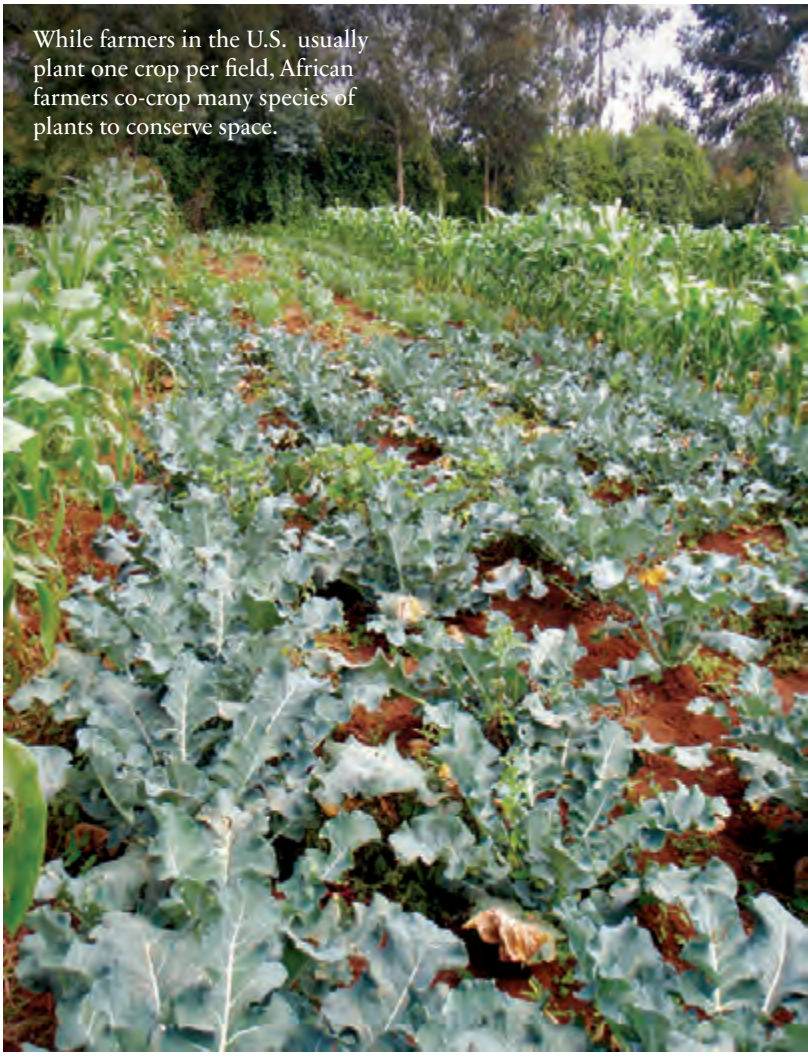
Maria Monteros, Ph.D., assistant professor at the Noble Foundation, earned a coveted spot with the United States delegation, joining colleagues from the United States Department of Agriculture, the Boyce Thompson Institute and select universities, such as Cornell University, the University of California-Davis and the University of Georgia. Scattered across the country, the researchers represented a broad spectrum of expertise from agriculture and livestock to genomics, virology and plant physiology.

Monteros’ research focuses on improving forage legumes, particularly alfalfa and clovers, for livestock systems. Her goal is to identify genetic solutions to overcome factors limiting legume productivity, including biotic (disease resistance) and abiotic (drought and soil toxicity) stress tolerance, while enhancing forage quality, yield and persistence. Her work holds great value for a country that must overcome both diseases and subpar environmental conditions.

Monteros’ experiences in Kenya, however, stirred more within her than just research possibilities.

Into Africa

Monteros’ weeklong journey began on Tuesday, June 16. Jet lag from the 24-hour-long trip from Ardmore to Africa quickly



While farmers in the U.S. usually plant one crop per field, African farmers co-crop many species of plants to conserve space.

vanished once she landed in Nairobi, Kenya's capital of 6 million people. The city's name is interpreted as "the place of cool waters." While the Southern Hemisphere was enjoying its cool season with tepid 50-degree evenings, the image of a relaxing tropic getaway evoked by the name was quickly replaced with the crush of humanity outside the airport doors.

Monteros was whisked away from the airport by a local driver named Simon, who provided an en route education on Nairobi's primary problem. Wheeling through the city's glut of traffic, he discussed the water issue: low rainfall and dusty springs have led to water rationing while more wells are dug. The lack of resources causes most structures to be built from "teba" wood, which, in turn, leads to deforestation and the creation of new desert-like conditions. The car ride to the hotel set the stage for the upcoming week.

The first day of the workshop dawned, and Monteros traveled with the other participants outside of the city for a series of farm visits. The trip revealed a fundamental issue inhibiting Africa's renaissance – it's difficult to reach many destinations. Most highways are paved, but travelers who venture off those narrow corridors of blacktop are instantly plunged onto dirt roads consumed by potholes or worse.

Once on site, the division of farm land also provided insight into the cultural and agricultural challenges. The word "farm" carries a particular connotation for Americans – one of carefully cultivated, sprawling expanses of waving crops in neatly organized rows. In Kenya, quality land is at a premium, and the lack of water infrastructure prohibits irrigation; therefore, farms are small (1.5-15 acres), densely packed, highly efficient operations that operate by strict limitations. The vast majority of such acreages cannot sustain grazing operations so animals are fed in stalls or elsewhere. "It's not uncommon to see animals grazing on the side of the road or between the roads," Monteros said. "They're using whatever space they can find."

Gender also plays a significant role in African agriculture. Land ownership is generally reserved for men. As the family expands, an already restricted piece of property is divided to accommodate each new generation. "If a family starts with 10 acres and the

A Kenyan farmer uses donkeys to move his supply of water. One of the major issues impacting Africa's agricultural producers is the lack of infrastructure.

At the Nairobi market in Kenya, food items are measured and sold using various sizes of discarded oil cans.

parents have three sons, then the parents keep 2.5 acres and each son receives 2.5 acres," Monteros said. "If there are grandchildren, then their acreage is subdivided again."

The first farm the workshop group visited was a 5-acre spread run by a woman named Pauline. The group learned that many men seek higher paying jobs in the city, leaving the agricultural work to their wives.

The farms use every inch of space. In an area no bigger than four football fields, Pauline and her six children farm potatoes, beans, maize, vegetables and forages, while raising animals. Oftentimes the maize is co-cropped with a number of other species. There is little waste. All byproducts, such as cow manure, are put to use. The family even built rentable rooms to increase productivity of the space. And all of the work is completed without electricity.

"You're seeing the rise of empowered women's groups who share farming techniques and pitch in to buy items that they couldn't afford separately, like water to help them survive drought," Monteros said. "They have a sense of pride and they should. They are accomplishing a lot with limited resources."

Experiencing the problems

A visit to Mugumo Farm, a 25-acre spread (a behemoth by African standards) offered the visitors a glimpse into additional complexities of the region's farming as well as the potential of an expanded operation. More space equaled a wider variety of vegetables and the opportunity to take more produce to market. Still, space remained limited for livestock, meaning less protein for their diet.

"Until you're standing there, it's difficult to understand," said Monteros, affirming the intentions of the Gates Foundation for hosting this workshop. "For every positive, there is a problem. But everyone we met was hopeful and excited. They were proud of what they had accomplished, and they were confident they would be able to overcome the many hurdles."

The Mugumo Farm is more productive than most regional farms because of proximity to roads and higher soil quality. The majority of Kenya's farms, however, face a myriad of challenges, including a lack of access to water, power and infrastructure. They also face harsh environmental conditions, and their crops are more susceptible to diseases. Understandably, the tropical climate

of Kenya creates conditions that facilitate many crop diseases. Regional farmers lack capital and access to improved (hybrid) seed that can guard against diseases and increase yield, thus the need for additional research and the measured introduction of western technology into these agricultural production systems.

"In the United States, an acre of land using improved seed can easily produce 5 tons of a cereal variety," Monteros explained. "In Kenya, an acre produces less than a ton."

Still the most significant and fundamental issue facing Africa's farmers is the soil. Simply put: it's too acidic. Kenyan farmers can treat the topsoil, but the subsoil remains unfit. "If the soil is acidic, you're going to have real challenges," Monteros said. "But scientists, including myself, are examining ways to work around this type of obstacle."

The farm visits still fresh on their minds, the workshop moved to the Great Rift Valley Lodge, where the participants became the drivers of theorizing and focusing on solutions for the issues they had seen and experienced.

The team solution

Two days of roundtable discussions ensued, harnessing the assembled creativity and expertise. Before solutions were even conceived, the groups spent many hours further outlining the needs. The sessions brought to light the complexity of the individual challenges, forcing the scientists to think beyond their immediate frame of reference.

"When looking at Africa, you have to address the whole agricultural value chain from seed to sale," Kahn said. "They need better forages, new types of seeds and access to extension services and open markets. All this has to be completed with an understanding of the local, state and regional policies. If we have a new crop variety, but the regulations make it difficult to get to farmers, it affects the whole chain."

Oftentimes problems begot other problems. Monteros chaired a molecular breeding subgroup and discovered 18 separate issues that complicated the adoption of the science in Kenya. A key problem underlining all issues was training, a fairly universal problem that takes on a new twist in Africa.

"We think of training problems as finding individuals and then giving them the opportunity," Monteros said. "That's not quite the problem they have in Africa. We were told of a team of 19 Zambian scientists who were trained, but then all died of HIV-AIDS. These are the types of additional problems that complicate finding solutions in Africa."

The discussions were intense and complicated, but the atmosphere was collegial and productive. The workshop organizers wanted to empower the scientists, both domestic and international, while providing a forum to foster partnerships.

"Forty of the scientists completed a survey for us after the workshop, and 39 said they developed new partnerships. That is terrific," Kahn said. "It is a true measure of the workshop's value. We know that the benefit may not be seen right away, but they are bouncing around ideas to address the most pressing issues. In two years, we're going to see the fruits of our labor."

Monteros echoed Kahn's comments: "The Gates Foundation is looking for a long-term, complete spectrum solution and that takes time. Many good ideas will come from the workshop."

Monteros looks to partner with two Kenyan scientists in the near future. Her work with legumes, specifically geared toward coping with abiotic stresses, could play a key role in overcoming some of the challenges facing the regional farmers.

"There's so much to do in Africa," she said. "On the one hand, it's overwhelming, and on the other, it is invigorating because small improvements could provide major benefits."

The workshop concluded with visits to local research facilities, including the International Livestock Research Institute's Biosciences of Eastern and Central Africa (BecA) Hub. Private donors and investors have provided more than $10 million in funding for expansion of the facilities and training. "The BecA Hub showed me the country was actively seeking solutions," Monteros said. "They have an amazing level of dedication and pride, and I hope to be one of the many scientists who join them in their work."

With the formal workshop completed, the participants began winging back to their respective homes, carrying memories of a land and a people that will impact their research and lives.

"Your immediate reaction to Africa is simple: you want to quit your job to go over there and help. You want to sell everything you have and donate it all to them."

Maria Monteros, Ph.D., assistant professor

Monteros and two companions, Kahn and Greg Martin from Cornell University, decided they were not going to waste the final hours of their time in Kenya in the hotel. They decided to explore Nairobi on their final day. It would be the most remarkable part of Monteros' journey.

Her own experience

The real Nairobi lies outside the manicured and cozy tourist zones of the city. While focused on agriculture, the workshop had only exposed the trio to outlying areas through bus windows. Now they experienced the day-to-day reality from the ground level with no filter.

They walked on roads that weren't really roads, by open sewers and strips of makeshift housing that barely qualified as shanties. Monteros was no stranger to the realities of poverty, having seen slums in Brazil and similarly oppressed areas in her native Guatemala. Still, watching hundreds of people waiting to fill discarded, yellow oil jugs with water was heart-wrenching.

By the time they reached Nairobi's market, Monteros was emotionally spent. However, the market revealed even more about the need for agricultural research and the resiliency of the Kenyan people.

Mounds of well-worn clothes and broken shoes comprised acceptable wares. Tools and trinkets seemed outdated at best. And then there was the food – the cornerstone issue of the workshop. A large portion of the market was dedicated to food. Perishable produce, long past American standards of freshness, sold for human consumption. Food items were portioned, not by typical weights and measures, but through the use of three sizes of disposed oil cans. And then there was the fish section, which remains burned into Monteros' memory. She distinctly recalls the smell of fish baking in the sun and the sight of flies feasting on the mounds.

"It just gets to you," she said. "These people are living the hardest imaginable life, but they are still hopeful and happy. It brings such humility."

Another source of hope came when Monteros and Kahn traveled to a cultural center to learn about the local tribes. The tour culminated in a dance exhibition. Monteros and Kahn sat in the audience surrounded by a fortunate group of school children, all dressed in matching uniforms, on a field trip.

Monteros sat there half watching the performance, half watching the children. She viewed the scene with both promise and sorrow, realizing that a shockingly high percentage of these children would never reach adulthood, but knowing some of them could change their country.

"Your immediate reaction to Africa is simple: you want to quit your job to go over there and help. You want to sell everything you have and donate it all to them," Monteros said. "The challenges are so immense, but you realize that they do not need short-term solutions. You have to ask yourself, 'Realistically, what can I really do to help?' It is important that organizations, such as the Gates Foundation, are taking a long-term, systems approach. For this kind of effort, you have to understand that each of us is a piece of a much bigger puzzle. It is this coordinated effort that will find lasting solutions."

Until then, "hakuna matata" is just a saying.

Kenyan children often grow up in slums like these in Nairobi. Poverty is the ultimate outcome for a continent struggling to feed itself.

Where do you do your best thinking?

Location. Location. Location. The age-old business adage applies to more than just selecting prime real estate for commerce. Most researchers maintain a special retreat where they can escape and free their cluttered minds. It's a magic locale that unlocks solutions to long-held problems. It's a personal hideaway where grand thoughts are generated. It's a small slice of often overlooked acreage where thought collides with inspiration to be the impetus for discovery. While the outcome is the same, every location is as unique as the researcher who seeks it.

Malay Saha
Assistant Professor
Forage Improvement Division

"My backyard is my haven. I like to sit out there, especially on moonlit nights, staring up at the stars and thinking. The times I just lean back and let my mind wander are when I inevitably generate my best ideas. I think that man has always looked to the heavens for inspiration. It has something to do with realizing you're just a small part of an entire universe."

John Blanton
Agricultural Research Programs Manager
Agricultural Division

"My most productive thinking would have to be when I am working with our horses or fixing up the barn. When I am in the barn, I am usually preparing the horses for a show or training, which involves considerable "busy work." There's something about the detail and repetition of that work that unlocks my mind. If I go down there with a problem, I'll usually come back with a solution."

Elison Blancaflor
Associate Professor
Plant Biology Division

"Believe it or not, my office is where I do my best thinking, but it has to be in the early morning when no one else has arrived in the building yet. During those first few hours of the day, I plug in my iPod and listen to mellow piano music like Jim Brickman. As a pianist, it helps me relax, and when I'm relaxed, my ideas really fly."

Julia Dyachok
Postdoctoral Fellow
Plant Biology Division

"I do my thinking at several places. Really, it's anywhere that distracts my brain from the problem I'm working on. A chat with a friend, a road trip, an exercise class – anything that allows me to recharge and reflect on a problem. But mostly, it is discussing things with colleagues at the lab. "

Photograph by Broderick Stearns

Beyond the Virus

Yiming Bao discovers more than just research niche at Noble Foundation

If you want to know about viruses, just ask Yiming Bao. He's dedicated almost two decades to the study of one of nature's most feared and most misunderstood organisms.

Bao, who received his Ph.D. from the John Innes Centre in Norwich, UK, currently serves as a staff scientist at the National Center for Biotechnology Information (NCBI) which is part of the National Institutes of Health. He's a significant contributor to the NCBI resources for piecing together genetic material that make up the genome of a virus (a genome represents all the genetic material in a particular virus). In 1994, however, Bao was just beginning to find his research niche when he accepted a postdoctoral fellowship in Principal Investigator Rick Nelson's laboratory at the Noble Foundation. Bao said his decision to come to southern Oklahoma was simple. "The Noble Foundation has one of the best virology departments in the country," Bao said. "There was so much to learn and study. The opportunities here were and continue to be tremendous."

Beyond the scientific reputation, the Hangzhou, China native's initial impression was shaped by a small, but important service. For international researchers, working in the United States requires a visa. Navigating the tricky waters of securing the correct type of visa is often an exhausting and frustrating process. "At the time, there were several types of work visas available," Bao said. "The Noble Foundation's Human Resources Department made the process extremely easy, providing me

direction and seeing me through the entire process. They were thorough and helpful. You do not see that level of service everywhere."

The initial assistance was a small part of the overall Noble Foundation experience – one that helped shape Bao's career and life. Early on, Bao worked with Nelson in characterizing the genesis of particular symptoms of tobacco mosaic virus. "He was a meticulous and conscientious researcher," Nelson said. "He's extremely bright, and he quickly became a strong member of our laboratory. He produced or co-produced multiple publications in some of the best scientific journals dedicated to virological and plant biological research from his work here."

Bao also became the go-to guy for cellular biology. He laid the groundwork for the Noble Foundation's current cellular imaging facility and played an instrumental role in purchasing the institution's first confocal microscope. As part of his cell biology/imaging work, Bao introduced the Noble Foundation to the powerful research tool of green fluorescent protein (GFP), a useful, "labeling" protein derived from jellyfish.

In the past decade, GFP has emerged as a guiding light for biochemists, cell biologists and physiologists in both medical and agricultural research. The gene encoding GFP is fused with another gene under study. The luminescent green color produced by GFP when exposed to a black light or other ultraviolet light source serves to mark the position of its fusion partner. By highlighting the location of the protein being studied and the various structures it associates within living cells, researchers better understand this protein in a more realistic setting. For example, GFP is used to study the formation and location of growing cancer tumors in animal tissue and the movement of pathogenic bacteria through plant cells by linking it with genes suspected to be involved with tumor formation or pathogen movement. "One of the experiences that led me to where I am today is when we began using GFP to label proteins," Bao said. "The combination of GFP and confocal microscopy enables us to better understand many aspects of viruses."

Beyond the laboratory, Bao found southern Oklahoma's surrounding landscape offered endless outdoor opportunities. "When I was there, I loved to fish," he said. "The Noble Foundation has several ponds spread across the 12,000 acres of research and demonstration land they operate. The employees were able to use them for recreation. It was amazing just getting out there and enjoying nature."

After his fellowship concluded, Bao earned a permanent position as a senior research associate in the Foundation's other virology laboratory, under the leadership of Marilyn Roossinck, Ph.D. During this time, Bao dug deeper into the world of virus research.

Looking back at his Noble Foundation tenure, Bao valued the vast range of experiences he was afforded. "Most young scientists beginning their careers have limited opportunity to conduct their own research, or they are given a very narrow scope under which they do their research," Bao said. "At the Noble Foundation, I was involved in a wide variety of research that established a strong foundation for my career."

Additionally, Bao's tenure at the Noble Foundation afforded him the opportunity to attend networking conferences, as well as sharpen his presentation skills, both of which have paid dividends throughout his career.

"My current job requires me to interact with researchers and give presentations at conferences and workshops worldwide," he said. "One of the things I appreciated most about the Noble Foundation was the weekly divisional seminars which helped us learn how to effectively communicate our findings. This greatly improved the scientific presentation skills that I need now."

Bao left the Noble Foundation in 2001 to work with the NCBI Viral Genome Project in Maryland. The project is a collection of completed genome sequences of viruses and viroids, aiming to provide molecular standards for viral genomic research.

In essence, Bao identifies completed genome sequences of all viruses, selects one for each virus as a reference sequence, curates them and then puts them into a publicly accessible database.

Scientists studying a particular virus can use the reference sequences instead of sacrificing valuable time – measured in days or weeks – to sort through thousands of partially complete sequences that often do not adequately represent the consensus sequence for the virus. These sequences enable them to better understand the characteristics and functionality of their particular virus.

Researchers studying the influenza virus, for example, often use the Viral Genome Project database to assist in their work to trace and defend against the ever-evolving "flu bug." "This keeps the scientists in my area very busy because influenza mutates so often," Bao said. To date, the Viral Genome Project has produced more than 3,340 reference sequences for 2,270 different virus species.

"I'm proud of the work I'm doing," Bao said. "I know I wouldn't be here if it had not been for the opportunities, experiences and mentorship provided to me by the Noble Foundation."

"At the Noble Foundation, I was involved in a wide variety of research that established a strong foundation for my career."

Yiming Bao, Ph.D., researcher with the NCBI Viral Genome Project

The Real *CSI*

by J. Adam Calaway

Mass spectrometry laboratory investigates some of life's smallest elements

Mass spectrometry has managed to creep into the mainstream consciousness – albeit without most people realizing it's even there. Popular television shows like *CSI* have proliferated images of investigators collecting samples from crime scenes and then "analyzing them in the laboratory" to understand their chemical makeup. That's analytical chemistry and mass spectrometry. That's Lloyd Sumner's world – without the crime, of course.

Sumner, a chemist by training, leads the Noble Foundation's mass spectrometry laboratory. His nine-member team uses some of the scientific community's most advanced equipment to conduct mass spectrometry, which literally revolves around sorting and weighing individual atoms and molecules. It's a detailed and painstaking process conducted on a level so small it defies most people's imaginations.

"For example, a molecule of sucrose (table sugar), a common molecule found in plants, is about one nanometer in size, which is roughly one millionth the size of a grain of sand," Sumner explained. "A similar comparison to help put this into perspective would be 1 foot relative to 189 miles."

Plants make a variety of complex molecules known as natural compounds, many of which have yet to be characterized. The weight of a molecule seems insignificant, but in reality the weight can reveal the molecule's chemical identity. Once a scientist understands the chemical makeup of a compound, he can begin to search for the mechanisms and genes within the plant that produce it. "We're detectives," Sumner said. "We're literally figuring out the functions of genes in plant chemistry, which is not a trivial task. "

While many of the Noble Foundation's researchers study the genes directly, Sumner's group moves to the other end of the spectrum and works backwards by conducting large-scale ▶

Lloyd Sumner, Ph.D., leads the Noble Foundation's mass spectrometry laboratory.

Photographs by Broderick Stearns

"The sensitivity of a mass spectrometer is one part in a quadrillion which is similar to being able to differentiate one hair from all the hairs on all the cows in Oklahoma."

Lloyd Sumner, Ph.D., associate professor

biochemical analyses of proteins and metabolites.

"The cellular machinery can be envisioned as a construction site. DNA or the genetic code serves as the blueprint from which work orders are issued as messenger RNA," Sumner said. "Messenger RNA is used to build proteins, which serve as the construction workers of life. The proteins then build cells and tissues using metabolites, which are like bricks and mortar."

Primary metabolites serve as building blocks (amino acids) or as energy sources (sugars and fats). Secondary metabolites, the focus of Sumner's research, function as unique communication signals

David Huhman prepares samples to be analyzed.

during plant interactions with the environment. They also act as chemical warfare agents involved in plant defense since plants cannot run from their enemies.

To a greater extent, large-scale profiling of hundreds to thousands of metabolites, known as metabolomics, offers a definitive view of the "metabolic status" of an organism. "It's a high resolution biochemical fingerprint, or a snapshot, of a cell's biology," Sumner explained.

In essence, scientists study the metabolite and protein populations in a control plant and then compare their findings to a plant that has been purposely stressed, such as with drought or disease. They then focus in on the differences (increases or decreases) of particular metabolites. Understanding these chemical changes becomes the basis of identifying the metabolites, proteins and gene(s) that are responsible for such changes.

These changes can only be detected using specialized instrumentation. The nerve center of the facility is a series of bays that contain nine mass spectrometers, each with its own abilities and characteristics. These various mass spectrometers differ in both sensitivity and how they receive samples – as a solid, liquid or gas.

There are an estimated 10,000 unique metabolites in the plants being studied at the Noble Foundation. Using the various mass spectrometers, the group can detect more than 1,000 of these. "It's very much a divide and conquer situation," he said. "Each molecule has different requirements, and we match them to the appropriate instruments. The mass spectrometers are just fancy tackle boxes. As the technology improves, we'll get even better at catching more trophy fish."

For the scientists, the technology remains both the gateway and the barrier to delving deeper into metabolomics and proteomics (similarly, the large-scale analysis of proteins). For the layman, the technology's power seems almost incomprehensible. For instance, when discussing the sensitivity of the instruments, Sumner said, "The sensitivity of a mass spectrometer is one part in a quadrillion which is similar to being able to differentiate one hair from all the hairs on all the cows in Oklahoma."

While the advanced technology makes the job possible, it doesn't make it easy.

Television often highlights the equipment and the processes used during mass spectrometry. What's unfortunately misrepresented is the speed of the process. The results usually zip back to the TV detectives in minutes. That's not the case for real scientists.

David Huhman, analytical chemistry core facility coordinator, explained that samples can take three or more days just to prepare. Each sample will typically take an hour or two to analyze, meaning an experiment with several hundred samples can require days, weeks or months of continuous data acquisition. Working with plants doesn't help the timeline either. Eight to 12 weeks for growing the plant materials usually precedes the sampling process.

Raw data must then be processed by computers (at least a full

night) and analyzed by the staff, which might take days or weeks. "You must be meticulous in your preparation," he said. "If you make a mistake, you may not see it for two or three weeks. And if you do make one, it can cost you weeks of effort."

The work may be time consuming, but studying metabolites has brought about key findings that may impact agriculture in the future.

While studying the impact of plant stress on secondary metabolites, the Sumner team unearthed an unexpected compound identified as hispidol, which had not previously been linked to stress responses. "Because we were performing integrated RNA profiling, we could simultaneously identify two genes correlated with the biosynthesis of hispidol," Sumner said. "These discoveries can now be used to engineer plants to produce hispidol to fight against fungal pathogens and disease."

Another success for the laboratory revolves around cotton root rot, a disease that devastates more than 2,000 plant species throughout the southwestern United States. Wensheng Li, Ph.D., from the Sumner group, discovered that plants like alfalfa – an agriculturally and economically important legume – have a series of chemical responses that can defend the plant against fungal infection, but that these responses are not initiated soon enough to combat the attack.

The group is now trying to tweak the plant's response and engineer plants like alfalfa to initiate the secondary responses earlier to combat cotton root rot.

Sumner's group is seeking multiple viable solutions to protect crops like alfalfa from cotton root rot.

Working with his longtime mentor, Rick Dixon, Senior Vice President and Plant Biology Division Director at the Noble Foundation, the Sumner group sought to understand how white lupin is able to successfully combat cotton root rot. The researchers theorized that particular chemical compounds produced by lupin roots were responsible for its defense against the disease. Similiar chemicals are found in large quantities in the fruits of a local tree, the Osage orange.

The Sumner/Dixon groups were correct in their theory. They subsequently identified the chemical compound wighteone, present in both lupine and Osage orange, as a potent inhibitor of the growth of cotton root rot fungus. Wighteone possesses antimicrobial properties and seems directly linked to the Osage orange's hardiness. Although alfalfa does not naturally produce wighteone, it does produce highly similar compounds. The groups are now seeking the specific genes that would enable the one-step biosynthesis of wighteone in alfalfa.

"It's these discovery events that open new possibilities for metabolic engineering and the improvement of agriculture," Sumner said. "The challenges facing agriculture in future generations are going to be immense. We are utilizing highly sophisticated instrumentation to enable vital discoveries and enhance our understanding of plant biochemistry."

Individual samples are spotted onto a plate in preparation for scanning by a mass spectrometer.

Jake's Wish

Altom finalizes career after four decades with the Noble Foundation.

by J. Adam Calaway

The subject line on the e-mail simply read: Jake's wish.

Julie Altom clicked it open, read the first few lines and burst into tears. With Christmas a few weeks away, Altom expected the e-mail from her father, Wadell, to carry details about her nephew's holiday wish list. Instead, Wadell Altom sent his three adult children – oldest Tamara, Julie and her twin brother, John – an e-mail, announcing he was fulfilling his grandson's long-standing request. After 43 years of service to the Noble Foundation, Wadell was ready to retire.

"Jake had been asking his papa to retire for years so they could spend more time together," Julie Altom said. "I just remember sitting there with tears flowing down my cheeks, thinking what this meant, then I called my sister and we cried together."

While the decision marked a tectonic shift for the Altom family, it also sparked change at the Noble Foundation. Altom had been a mainstay in the Agricultural Division for four decades and capped his career as senior vice president and division director.

"I could have retired 10 years ago, but I was having too much fun," Altom said. "The Noble Foundation is a remarkable place to work – the mission, the people, the facilities are the best you'll find. I wanted to be a part of it for as long as I could. But last Christmas, my wife (Shelia) and I knew we were ready for the next chapter in our lives."

Agriculture has always played a significant role in Altom's story. Born near Comanche, Okla., Altom remembers driving (not just riding) a tractor by the time he was four years old on his parents' dairy farm. In high school, the ambitious FFA member rented his own land for crops, and, by college, his agricultural ambitions were firmly rooted. He graduated from Oklahoma State University with a bachelor's degree in agronomy and within a year became an assistant area agronomist with Texas A&M extension. Life settled into a pleasant rhythm. Early on, Altom, Shelia (whom he met in the second grade) and Tamara frequently returned to see family in southern Oklahoma.

"The route always took us through Ardmore," Altom said. "Every time we'd pass through, we'd say, 'This looks like a nice place to live.'" The opportunity to move to Ardmore came in the form of a letter from the Noble Foundation, advertising an open consultation position. Working in the Noble Foundation's consultation program appealed to Altom because of its direct link between consultants and producers.

Gary Simmons, then director of the division, hired the boyish Altom, remarking to another consultant after the interview that "He sure does look young." The consultant replied, "Time will take care of that."

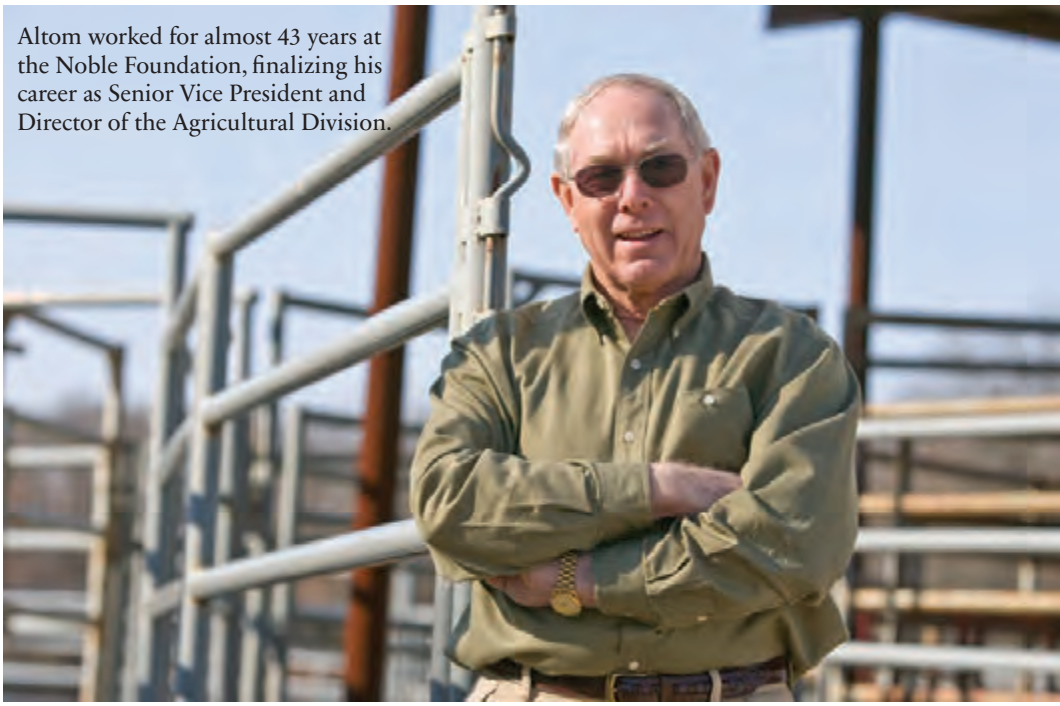
Altom's first day on the job was June 1, 1966. The eager young consultant walked in that first day expecting to stay five years. "Just another thing I'm glad I was wrong about," he said.

At the time, the Noble Foundation was home to 60 employees (one-sixth its current size) with only 12 in the Agricultural Division – the group now has

more than 80 employees. As part of a four-man consultation team, Altom relished the opportunity to apply his passion for and knowledge of agronomy for the benefit of regional landowners. "The people we consult with work hard and have the experience and knowledge to do well," he said. "Sometimes they need help fitting all the pieces together. We're here to help them do that. That's our goal."

The way the consultants accomplish this goal has radically changed during his career. Altom recalls writing letters by hand, making carbon paper copies, stopping at strangers' houses to access a telephone and mapping producers' land using an all-but-extinct planimeter.

"Technology has fueled tremendous growth. Tasks that took days can now be completed in a few hours or less," he said. "However, the Noble Foundation's mission remains the same – help the farmers and ranchers."



Altom worked for almost 43 years at the Noble Foundation, finalizing his career as Senior Vice President and Director of the Agricultural Division.

Photograph by Broderick Stearns

Altom served almost 40 years as a consultant and became a staple of the division's management team. In 2005, a new director was needed and Altom, the elder statesman, was a natural fit. "My philosophy has always been let people know what is expected and check in," he said. "If they are staying on the road, leave them alone and encourage them. If they start to get in the ditch, help them get out."

While he marvels at the continued legacy of the consultation program, Altom also points to the division's research work and its impact on agriculture. The Noble Foundation established two scientific groups – Plant Biology and Forage Improvement – and now the three divisions coordinate their research. The Agricultural Division specifically devotes more than 30 employees to applied agricultural research.

"When I began, you developed your own proposal, you served as technician, principal investigator, data collector and data processor," Altom said. "Today, we have the personnel and ability to conduct a wide variety of research that supports our consultation effort and assists the other Foundation scientists."

As he prepared to pass the reins of leadership to Billy Cook (see page 6), Altom said, "I would have done nothing different. This was the opportunity of a lifetime, and I've enjoyed every minute."

In the months preceding his retirement, Altom politely endured farewell receptions, tribute speeches and slideshows with embarrassing black-and-white photos. He never really used the "r" word, pointing instead to Shelia's growing honey-do list and their many travel plans.

At noon on March 31, his last day, Altom found a familiar chair in the cafeteria. Some days his lunch table was only partially filled, but as he ate his hamburger steak and fried okra, Altom was surrounded by his guys, all hoping to share one last moment with their boss, mentor and friend. Many looked at this moment as their last lunch together, but not Altom. "It's not the last anything," he said, flashing a grin. "I'll be back to eat with the guys as many times as possible."

Until then, he'll be out playing with Jake.

"He sure does look young." The consultant replied, "Time will take care of that."

Gary Simmons, former director of the Agricultural Division

I'm with Vera

J. Adam Calaway
Director of
Public Relations

Sure enough, the tire was flat.

Standing in my driveway, the rim of my wife's Toyota Camry resting peacefully on the concrete, I bemoaned the undoubted loss of part of my treasured weekend. I crouched down and spotted the culprit. The head of a silver screw poked out where the tread met the wall of the tire. I was amazed at how something so small had redirected my entire weekend. So I did what every man would have done after a long workweek – I ignored the problem for 24 hours.

On Sunday morning, I emerged with new resolve. I deftly replaced the flat with the spare, recalling my father's tire changing safety tips. As I lowered the car, basking in the glow of the morning sun and a job well done, a new problem emerged. The spare was not adjusting well to life outside the trunk. As the car's weight increased, the tire's roundness decreased. It was clear I only had minutes before the spare mimicked its predecessor.

I raced to my local supercenter where a greasy man took my key and told me the repairs would only take about 20 minutes. We both knew he was lying. I took my place on the plastic lawn furniture in the waiting room and my mood began to sour.

Forty-two minutes into my wait, Vera showed up. She wore a blue polka-dotted dress with sequined flowers. Her orthopedic shoes were scuffed and she walked with shuffled steps. She flashed me a bright smile as she made her way to the counter to inquire about the status of her car. "Twenty minutes," the lady said. Vera smiled. I frowned.

She took her place a few chairs down from me and folded her hands in her lap, content to wait. Her silver hair, weathered skin and gentle manner reminded me of my grandmother.

"Whatcha' in for?" I asked, mustering my best jailhouse accent. She recognized my lame attempt at a joke and with a light quiver in her voice she told me about how the tire light on her dashboard had come on that morning. "For a woman of almost 80, that's a big deal," she said with a hint of sarcasm. From that moment on, we talked like old friends. I told her about my tire, and she talked about missing the morning church service and her grandchildren in Houston.

Soon she asked me where I worked. When I told her the Noble Foundation, she said, "The Noble Foundation sure has done a lot for our community. We're blessed to have them here." A smile returned to my face. No matter where I go, people know the Noble Foundation for its generosity. Our founder, Lloyd Noble, established this organization with a simple edict – benefit mankind. We do that every day by helping farmers and ranchers through consultation, conducting plant science and agricultural research, and through grants to universities and other nonprofit organizations. I'm always proud of the Noble Foundation, but to receive Vera's stamp of approval, well, that was like a grandmother's gold star, and not much beats that.

Ironically, our paths had (sort of) crossed before. Vera recalled seeing an article in the newspaper about one of the Noble Foundation's agricultural consultants who was collecting old cell phones and sending them to a company that would then provide calling cards for soldiers in Iraq. "I clipped that little article out and sent it to a group of church ladies who were looking for a community project. They gathered up a bunch of phones, and I brought them down to your collection box." When I told her I had written the article, we both chuckled.

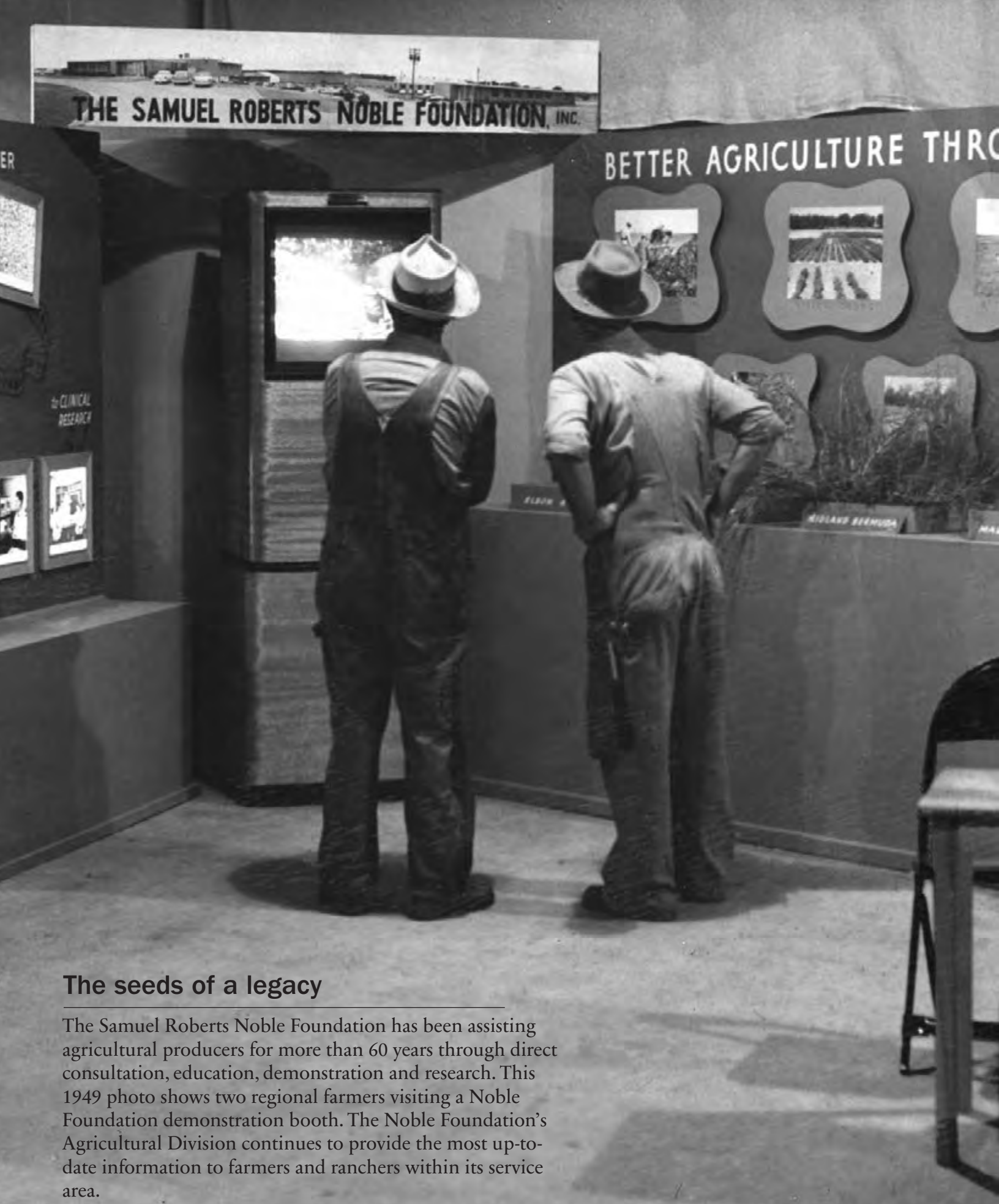
There were other commonalities as well. I worked for an organization founded by one of Oklahoma's most famous oilmen. Her husband had worked in the oil fields for more than 30 years, a second-generation roughneck who joined the workforce two years early because of the shortage of manpower from World War II. They had skipped across the Midwest following the ebb and flow of oil before finally retiring to Ardmore in 1977, a year before I was born. He golfed. She kept the home. They traveled to see their three children. Life was perfect. Her husband passed away about three years ago, leaving Vera to handle the flat tires of life, but that's OK. She was content where she was.

An hour into our conversation, a key dropped through a sliding window that separated the garage from the cash register. My car was ready. I shook Vera's hand and told her I hoped to see her again soon.

As I drove home, I thought about how one person can change a situation. Lloyd Noble saw a state in disarray after the Dust Bowl, and provided a sustainable solution through the Noble Foundation. His vision changed the lives of generations of agricultural producers in the southern Great Plains, and now, because of the Foundation's scientific research, his influence is circling the globe.

Then I thought about Vera and how she had sweetly and effortlessly changed my negative experience. It was clear to me that you can either be a catalyst of change, like Vera or Lloyd Noble, or you can be stuck by circumstances.

As for me, I'm with Vera.



The seeds of a legacy

The Samuel Roberts Noble Foundation has been assisting agricultural producers for more than 60 years through direct consultation, education, demonstration and research. This 1949 photo shows two regional farmers visiting a Noble Foundation demonstration booth. The Noble Foundation's Agricultural Division continues to provide the most up-to-date information to farmers and ranchers within its service area.

Parting Shot

Future scientists?

As part of the Noble Foundation's community outreach, more than 50 groups will tour the institution's Ardmore campus. Students from elementary to college, community leaders, agricultural producers, gardening enthusiasts, out-of-state dignitaries and international scientists will all visit, peering into the organization's rich history and seeing how researchers and agricultural consultants work together to benefit mankind.

To arrange a tour, please call Adam Calaway, Director of Public Relations, at (580)-224-6209.

THE SAMUEL ROBERTS NOBLE FOUNDATION

The Samuel Roberts Noble Foundation
2510 Sam Noble Parkway
Ardmore, Oklahoma 73401
Phone: 580.223.5810

Address Service Requested

Nonprofit Organization
U.S. POSTAGE
PAID
Oklahoma City, OK
Permit No. 926