

Legacy

Fall 2010

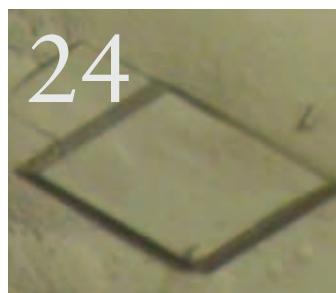
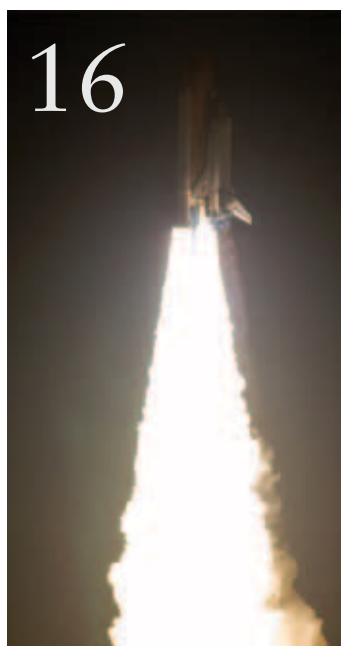


**BOLDLY
GOING**



(on the cover) This issue's cover illustrates a successful Noble Foundation experiment on the Space Shuttle Discovery. In reality, plant seeds were germinated in specially-designed canister. Illustration by Scott McNeill using source images from NASA and Noble Foundation photographer Broderick Stearns.

(above) Members of the Noble Foundation's research support staff cut sorghum at the Red River Farm in Love County, Okla., one of seven research and demonstration farms operated by the institution. The Noble Foundation operates more than 12,000 acres of farmland for use by agricultural researchers. (photo: Broderick Stearns)



Cover Story

16 Boldly Going

Noble Foundation scientist Elison Blancaflor earned the chance to launch an experiment into space aboard NASA's Discovery Space Shuttle. The findings could change agriculture and future space travel.

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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 insight into the outstanding scientists and agricultural consultants who pursue the vision of Lloyd Noble, the founder of the Noble Foundation, to benefit mankind.

Reprints

Reprint 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 mailing address, please e-mail jacalaway@noble.org.

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The Samuel Roberts Noble Foundation, Inc.
ISSN: 1939-5035

The Final Frontier

Outer space has fascinated me since I first laid eyes on America's original cosmic icon, Buck Rogers. As a youth, I spent many afternoons reimagining Buck's exploits with me in the lead role (complete with makeshift ray guns I forged from household utensils). My many misadventures as Buck served as the launch pad to my lifelong appreciation for the infinite region beyond Earth.

Years later as a newlywed living in Norman, my wife and I watched on a 7-inch, black-and-white television as Neil Armstrong took humanity's first steps on the moon. Despite my best application of tinfoil to the antenna (recommended to boost reception), the picture was ravaged with static. However, through the hazy images of that one giant leap, I clearly remember thinking mankind's potential was limitless.

This spring, I again found myself captivated by the wonders of outer space. Noble Foundation Associate Professor Elison Blancaflor was one of three plant scientists nationwide who earned an opportunity to rocket his research into the heavens as part of NASA's spring shuttle mission (see story, page 16). Blancaflor's research hopes to influence the development of agriculturally significant crops grown on Earth as well as to design plants better adapted to extreme environmental conditions for the purpose of deep space exploration.

The experiment serves as a career milestone for Blancaflor and his research team. The event also provides perspective for the Noble Foundation's own development.

Lloyd Noble established this organization in 1945 with the purpose of benefiting mankind by assisting regional agricultural producers and land stewards. Today, the Noble Foundation stands as a regional leader in agriculture consultation and research, and one of the most prominent plant science research institutions in the world.

The next 40 years certainly will be the most challenging decades agricultural producers have faced in history. With the dramatic increase in global population, farmers and ranchers will be asked to grow more food with fewer resources. This daunting task will require an industry-wide revolution. Agricultural researchers, plant scientists and producers worldwide must



photo: Broderick Stearns

look beyond our traditional methods and take bold steps to provide sustainable solutions to future problems. Solutions like sending plants into space.

Some may question the practicality of the project, but the knowledge generated from these pursuits is invaluable. Case in point, NASA's Apollo, Gemini and Mercury missions led to the development of the technology that became the computer. Likewise, plants will play a key role in future space exploration. They also can teach us about ourselves.

While the Noble Foundation remains focused on the Southern Great Plains and similar climates, projects like this are the next logical step in our organizational progression. We will continue to reach beyond what we believe is possible today and seek the necessary innovation to meet tomorrow's challenges – which from this end of history seem overwhelming. But so did space travel more than 50 years ago.

As our founder once said, "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."

Our ability to imagine, pursue and achieve the impossible remains a limitless resource. I know because we have gone from Buck Rogers to plants in space.

Sincerely,

Michael A. Cawley
President and Chief Executive Officer



photo: Nailia Schwarz

Mystery of the four-leaf clover solved by scientists

Turns out, the lucky four-leaf clover – a universal symbol of good fortune – is not the result of an ancient mystical force, just a special group of genes.

Research conducted by scientists at The Samuel Roberts Noble Foundation and the University of Georgia at Athens (UGA) has discovered genes responsible for causing this natural phenomenon, helping answer centuries-old questions about inheritance of multiple leaves in white clover.

While multiple genes dictate leaf color and shape, the study discovered a “repressor” gene specifically responsible for limiting the production of clover leaves. When the gene does not function, which can occur naturally, white clover plants develop four or more leaves.

“The four-leaf clover is a variation observed in nature for centuries,” said Joe Bouton, Ph.D., senior professor and plant breeder in the Forage Improvement Division. “There has been speculation about the role of inherited genes and the number of genes that cause this variation,

but it has been virtually impossible to track. Until now.”

The scientific team, which included UGA researchers Rebecca Tashiro and Wayne Parrott, and Noble Foundation scientists Yuanhong Han, Maria Monteros and Bouton used traditional breeding as well as advanced technologies like molecular markers to find the gene. Molecular markers serve as road signs on a plant’s genome, identifying specific genes and allowing scientists to trace them through several generations of testing. “This makes the breeding process highly efficient and keeps the scientist from guessing if the genes of interest are present in a plant,” said Monteros, Ph.D., assistant professor and plant breeder. “We can check for the marker and know that the plant contains a specific, associated gene.”

The U.S. Department of Agriculture characterizes white clover as “the most important pasture legume.” Widely adapted to many geographies, white clover serves as a highly palatable, nutritious forage for all classes of livestock.

The Noble Foundation-UGA team

conducted the experiment over the course of several years, growing white clover populations in Oklahoma and Georgia. The populations were grown in both outdoor and indoor environments during the winter and the summer. The findings indicated that environmental conditions played a significant role in clovers developing multiple leaves.

Additionally, experience gained through this experiment can be applied to other legumes which play an important role in agriculture.

Legumes take nitrogen from the atmosphere and – using special bacteria in their roots – turn it into its own source of fertilizer, which can defer input costs for agricultural producers.

“Genes that help make four-leaf clovers are interesting traits to study,” Monteros said. “The results are easy to recognize. However, we’re applying the same technology to discover more complex traits, such as drought tolerance. Technologies such as molecular markers allow us to develop a better variety faster so it can get into the hands of farmers and agricultural producers.”

Noble Foundation earns top 5 ranking in two national surveys

In 2010, The Samuel Roberts Noble Foundation earned top 5 rankings in two of *The Scientist* magazine's annual "Best Places to Work" surveys.

In the spring, the Noble Foundation garnered the No. 2 ranking in the magazine's "Best Places to Work for Postdoctoral Fellows" (postdocs) survey, and this summer the organization ranked No. 5 in best places for academic faculty in the United States.

Internationally renowned for its plant science discoveries and agricultural programs, the Noble Foundation has participated in both surveys for the past three years, placing in the top 10 each year and outpacing more than 90 of the top research organizations in the United

States. The Noble Foundation ranked as the highest agricultural and plant science research institute in this year's survey and is one of the few organizations in the entire survey that conducts fundamental, translational and applied plant research.

"These surveys allow the Noble Foundation to benchmark our activities against the finest research organizations. We continue to distinguish ourselves as one of the top research institutions in this country and around the world," said Michael A. Cawley, president and chief executive officer of the Noble Foundation. "This survey reaffirms the Noble Foundation commitment to our research and our researchers."

As part of the "Best Places to Work for Postdocs" survey, the Noble Foundation earned top scores for training and

mentoring, quality of communication, networking opportunities, generously funding postdoc research programs and the quality of the infrastructure.

The "Best Places to Work in Academia" survey yielded similar comments about the support the Noble Foundation provides the more than 110 Ph.D. scientists from 29 different countries who perform plant science and agricultural research at the organization's facilities in Ardmore, Okla.

In both surveys, the Noble Foundation topped such recognized research organizations as the Mayo Clinic, the National Cancer Institute and the National Institutes of Health, as well as dozens of universities, including Yale University, Princeton University and the University of Texas M.D. Anderson Cancer Center.

Noble Foundation selects new Forage Improvement director

This summer, E. Charles Brummer, Ph.D., was selected as a new senior vice president and director of the Forage Improvement Division.

"Dr. Brummer is known throughout the United States and around the world as one of the very best in forage breeding and improvement," said Michael A. Cawley, president and chief executive officer of the Noble Foundation. "Beyond his wealth of experience and vast subject knowledge, Dr. Brummer's character and leadership make him the ideal steward of the Forage Improvement Division."

Brummer is only the second director of the Forage Improvement Division since its inception 13 years ago as one of the Noble Foundation's three operating divisions. "Having worked with the Noble Foundation throughout the past decade, I have a profound respect for this organization's significant contribution to agriculture and plant science research," Brummer said. "I am extremely motivated to continue the division's great success."

Brummer replaces Joe Bouton, Ph.D., who announced in January 2009 his wish to step down as director of the division. Bouton will remain on the faculty of the division as a senior professor and

continue his research program in forage breeding at the Noble Foundation.

Brummer earned a bachelor of science degree in agronomy from Penn State University and then master's and doctorate degrees in agronomy from the University of Georgia at Athens (UGA).

He spent the next 12 years teaching and conducting research at Iowa State University, progressing from assistant professor to professor.

Brummer most recently served as a professor of Forage and Biofuel Crop Breeding and Genetics at UGA and director of the UGA Institute of Plant Breeding, Genetics and Genomics.

Brummer, who officially joined the Noble Foundation in mid-August, will highlight the goals for the Forage Improvement Division's research programs in the upcoming Winter 2010 issue of *Legacy*.



photo: Courtesy of the University of Georgia



photo: Broderick Stearns

Basic AG program initiated for rural lifestyle producers

During 2010 the Noble Foundation implemented an educational program to benefit those new to production agriculture and land stewardship.

Known as Basic AG, the program focuses on providing practical, foundational knowledge that can be used in everyday operations. Each year, the Noble Foundation will host a series of Basic AG events that will offer new agricultural producers fundamental training – some of which will include hands-on experiences – designed to meet specific agriculture-related goals. Basic AG events will frequently incorporate speakers from state and federal agricultural organizations.

“Basic AG is less than a year old, and we are already seeing positive results,” said Billy Cook, Ph.D., director of the Agricultural Division. “I expect the program to continue to grow quickly. As more and more people move out of the city, seeking a rural lifestyle, they will need training on how to successfully use their natural resources, and we’ll be here to help provide that assistance.”

For more information on the Basic AG program or future events, visit www.noble.org/BasicAg.

Researchers garner more than \$1 million in grants

Three Noble Foundation researchers recently received a combined \$1 million in funding from the United States Department of Agriculture (USDA).

As part of the USDA’s National Institute for Food and Agriculture (NIFA) competitive granting process, Drs. Rick Dixon, Rick Nelson and Michael Udvardi received grants to advance research on key agricultural issues: tannins, virus movement and legume nitrogen fixation.

Dixon received \$336,000 for his work with tannins, chemical compounds within plants that help prevent pasture bloat and improve protein utilization in livestock. Dixon will focus on engineering alfalfa to produce tannins in the leaves, such that livestock can benefit from the bloat-protective properties of these compounds. Alfalfa does not naturally produce these health-benefiting compounds in the consumable portion of the plant.

Nelson’s \$399,000 grant will support research on how viruses move through plant cells to infect all parts of the host. Viruses do not have cells of their own so they require a host cell for replication and movement. This grant will allow Nelson to further research the interactions between viral and plant

(above) Tannins, which are not naturally produced in alfalfa foliage, hold potential benefit for livestock health and nutrition. The tannin precursors engineered into this alfalfa plant give the plant’s leaves a purple hue. Rick Dixon, D.Phil., has received a \$336,000 grant to further his laboratory’s tannin research.

proteins necessary for virus movement in model plants and how to prevent these interactions.

Udvardi’s grant for \$350,000 will support his efforts to identify and characterize transporters, key components in the process of nitrogen fixation.

Legumes, the family of plants that includes alfalfa, clover, beans and peas, are known for the significant role they play in agriculture and their high protein level, but they also have an innate ability to claim or “fix” nitrogen from the air. Their root system accommodates bacteria, called rhizobia, which convert atmospheric nitrogen to ammonia, creating a source of fertilizer and reducing production costs.

The transporters in question control the flow of nutrients and metabolites to and from the nitrogen-fixing rhizobia and could allow researchers to produce legumes that fix more nitrogen.

Feeding and Fueling the World

Using both conventional selection and advanced biotechnology, the forage breeding laboratory is developing tomorrow's forages

by Debra Levy Martinelli

When it comes to making better forage for food and fuel, Joe Bouton, Ph.D., has a lot of tools at his disposal. And he uses every one of them.

Bouton, who served as Forage Improvement Division director from 2004 until summer 2010, has returned full time to the laboratory and leads the forage breeding lab, one of seven research units within the division devoted to developing new cultivars for grasses, legumes and small grains for grazing and hay production.

At its core, the forage breeding lab translates basic plant science research into tangible plant varieties for use by farmers and ranchers in Oklahoma and Texas, as well as similar climatic regions around the world.

"What we do is build on Darwinian outcomes. We've taken the end products of natural selection and imposed additional, more specific selection for traits that we want," said Bouton, a plant breeder, geneticist and agronomist. "We're doing the same thing nature does, but we're going in a more specific direction to develop a group of true breeding plants more suited to a highly managed ecosystem like a farm or ranch."

Wheat is a good example of how this works. In nature's unmanaged ecosystem, primitive wheat seed was light and chaffy,

a far cry from today's plump kernels. It perpetuated itself by scattering its seed directly on the ground or clinging to animal fur to be deposited later. It also matured its seed at different times. "So wheat was selected and bred away from that natural ability," Bouton explained. "Now it has much larger kernels that all mature at a specific time, and therefore it became a crucial food crop."

The process of effecting change is completed through plant breeding, where the team uses the diversity of all the plants and tries to manipulate genes to select for specific and value-added traits. "We could just look at plants and select those that have the traits we want like specific flower color. But our approach is to narrow down the broad populations to specific ones that have all the main traits agricultural producers need and want," Bouton said. "By knowing something about the genes that underlie these traits, it is easier for us to make progress."

Bouton uses two analogies to explain the trait selection process. "Think of a funnel. At the broad end is all the germplasm of that species. What makes it through the narrow end and out the funnel are plants with the desired trait," he said. "It's also a lot like the way some baseball players make it to the major leagues. Millions of kids play the game

at any given time, but gradually that population is selected way down so that only the very best play professionally."

The methodologies used by Bouton's 10-member team range from conventional breeding techniques to biotechnology-based tools. When they are assessing plants for a unique trait, the team often looks to another Forage Improvement Division research unit, the molecular markers lab, to identify genetic markers to speed up the breeding process.

"Our approach is collaborative and fluid, so we also draw from the research of other units. We all have the same goal of producing plants that have certain traits. We just do different things to achieve this," Bouton said. "Biotechnologies are tools that can make everything more efficient."

Noble Foundation Associate Professor Malay Saha, Ph.D., who oversees the molecular markers lab, noted that in ►

(opposite) Joe Bouton, Ph.D., senior professor, examines switchgrass plants in a test plot with Brian Motes, senior research associate. Switchgrass, which holds potential as both a bioenergy crop and livestock forage, is a target species of the forage breeding laboratory. (photo: Broderick Stearns)



“We’ve taken the end products of natural selection and imposed additional, more specific selection for traits that we want.”

Joe Bouton, Ph.D., senior professor

conventional breeding, plants are selected by how they appear, but molecular markers enable selection based on the genes responsible for expressing specific traits. “This method results in greater confidence in trait selection,” he said. “And because the marker identification process requires only DNA from the plant, it also saves a lot of time. A conventional breeding trial can take from a year to a year and a half, whereas a molecular marker method takes as little as two to three months.”

One of the markers identified by Saha’s group is for digestibility in tall fescue, which is grown primarily for cattle grazing. “The ultimate goal is for the animals to gain the most weight in the shortest period of time. If the forage isn’t palatable and digestible, that won’t happen,” he explained. “By identifying the digestibility marker, we can help develop a more easily digestible fescue.”

Once a specific trait like digestibility has been identified and introduced into plant material, Bouton’s team employs a series of steps, some in collaboration with the Noble Foundation Agricultural Division, to determine whether the experimental material can successfully transition into an improved cultivar. Many of those functions are coordinated by Senior Research Associate Brian Motes, whom

Bouton depends on to run the laboratory’s day-to-day operations. “We take teamwork seriously,” Bouton said. “Brian is the straw that stirs the drink.”

That “drink” has many ingredients and covers significant territory, extending well beyond the Ardmore laboratory. Motes regularly travels to research stations from Haskell in northeastern Oklahoma to Overton, Texas, about 30 miles east of Tyler, to ensure the proper handling of trials for both conventional and regulated transgenic plants (those genetically engineered to include a trait transferred from a different species of plant). The trial material is sent even further away to several universities, including the University of Georgia, Texas A&M University and Mississippi State University, which generate additional research data.

“We like testing our material in different geographic locations, so the university collaborations are vital,” said Motes.

Motes also coordinates the unit’s plant variety protection trials (PVP) for cultivars close to commercial release. PVPs are particularly labor-intensive and lengthy. The data collected from PVP trials are part of a packet submitted to the USDA’s Plant Variety Protection Office for a Certificate of Protection. This certificate grants legal intellectual property rights to the breeder. “We collect data over

several years, focusing on the cultivars’ phenotypic (physical) traits. We then compare these traits to the traits of several common varieties that have been around for years,” Motes said. “This information allows us to distinguish our cultivar from other commercially available varieties.”

A major focus of the forage breeding lab’s work is domestication of switchgrass for both forage and bioenergy applications. Their efforts already have resulted in three varieties that have been adapted for use in the Southern Great Plains, upper Great Plains and Gulf Coast.

“As a bioenergy crop, switchgrass would be grown as a feedstock for conversion to fuel and for biopower, where it could be compressed and burned with coal to reduce emissions. The third avenue for domesticated switchgrass would be direct feeding to cattle,” Bouton said. “The beauty of switchgrass is that it can go any of those routes. That’s a decision that will be made by the farmer. All we can do is try to make our varieties as flexible as possible as quickly and thoroughly as possible.”

At the same time, Saha’s team is applying molecular breeding techniques by combining two methods: developing new populations of cultivars through cross-breeding evolution and molecular markers that identify desired traits.



Among the many reasons switchgrass is an appealing option for both forage and bioenergy are that it is a perennial, grows quickly and can be grown with minimum inputs of nutrients and water.

“If you plant switchgrass one time, it can give you a good yield for 10 to 20 years,” Saha said. “When senescence starts with the first frost, the plant mobilizes nutrients from the shoot to the root, where they are stored as start-up food for the next growing cycle in spring. It’s a smart plant.”

Saha’s group hopes to produce switchgrass plants that are ready to be made into biofuel. “The greater the plant yield, the more energy and forage that can be produced,” he added.

Additionally, Bouton’s team assists Principal Investigator Maria Monteros’ laboratory, that, like Saha, uses advanced technologies to breed new forage crops. Monteros, however, is focused on forage legumes, such as alfalfa and white clover.

The forage breeding lab helps integrate discoveries from Monteros’ program into tangible products by providing germplasm platforms that have been specifically selected and improved for grazing tolerance.

“We could not accomplish our goals without their invaluable support and expertise,” Monteros said. “I’m confident

Forage Breeding Laboratory Staff

Joe Bouton, Ph.D., principal investigator
 Hem Bhandari, Ph.D., research scientist
 Brian Motes, senior research associate
 Dusty Pittman, research associate
 Wes Scruggs, research associate
 Kelly Harris, research assistant
 Willy Inselman, research assistant
 Lynne Jacobs, research assistant
 Curtis Larson, research assistant
 David Kirkpatrick, research technician
 Cameron Williams, research technician

that the process we’ve developed for alfalfa and white clover can be applied to other species that are relevant to the Southern Great Plains.”

With the increase in world population and the decrease in usable land, plant breeding will play a paramount role in the success of the agriculture industry’s ability to feed the planet. “Using all the tools we have to create managed ecosystems is the only way we can produce enough food and energy for future generations,” Bouton said. “We must continue to seek ways to improve plants through all possible avenues and explore new possibilities so that we can meet the ever-growing demands on agriculture.” ●

(above) Research Scientist Hem Bhandari, Ph.D., examines switchgrass plants in the Noble Foundation greenhouse. The forage breeding laboratory is working to develop hardier varieties of the native prairie grass as a forage for livestock as well as a potential bioenergy crop. (photo: Broderick Stearns)



A Mission of Hope

With a little help from the Noble Foundation's Basic AG program, one military unit wages peace through agriculture

by J. Adam Calaway and Robyn Graves

In 1945, Lloyd Noble established The Samuel Roberts Noble Foundation to assist farmers and ranchers with land stewardship. Sixty-five years later, this mission is circling the globe.

For the past year, consultants from the Noble Foundation's Agricultural Division have provided fundamental training to members of the Oklahoma National Guard 2-45th Agribusiness Development Team (ADT). This team has been assigned to Afghanistan for an 11-month tour to support the region's farmers. By promoting agricultural education, the team hopes the Afghan people will establish an economic foundation from which to rebuild stability, said Lt. Col. Bruce Arnold.

While the team's training has taken them from Texas to New Mexico, their main educational resource has been the Noble Foundation's Basic AG program.

Basic AG is a series of educational events providing practical, foundational knowledge that can be applied to a farmer or rancher's day-to-day operations. Basic AG events offer straightforward

information and interactive experiences to give participants a better understanding of agriculture and new tools to achieve their production goals. The program was designed to benefit new agricultural producers in the Southern Great Plains, but, for the National Guard team, the information was directly applicable to their mission.

"When we found the Noble Foundation, we were shocked to learn about all the educational opportunities that the organization offered," said Master Sgt. Lorn McKinzie. "The Noble staff is helpful and knowledgeable in their various fields of expertise. We have attended seven events, and each has been well worth the drive. The hands-on experience and wide variety of information make the training extremely useful."

The team includes a dozen individuals from all walks of life. Specialist Mandy Kennedy, 27, enlisted in the Army just to participate in the Army's Agribusiness Development program. Kennedy grew up raising and showing horses on a small Wisconsin farm. Even though she has an agricultural background, she anticipates the many differences that await her. "I know I will come back with a greater appreciation for our resources," Kennedy said. "We certainly will not see the same

quality of livestock there as we do here."

In preparation for deployment, Kennedy has researched the area to which she will travel in hopes of better understanding the people and their culture. "They want to make an honest living," she said. "Hopefully, we can make a difference and help them reach their goals like the Noble Foundation does for agricultural producers in Oklahoma and Texas."

Arnold, one of two team members with overseas experience, will be returning to Afghanistan, but in a much different capacity than his first deployment. His previous excursion included training of the Afghan National Army and rebuilding infrastructure. In this, his first agricultural development endeavor, however, his knowledge will pay dividends.

Arnold is familiar with the Afghan people and their customs, he knows how to handle contract negotiations for supplies, and he is familiar with the rituals for entering the Afghanistan countryside. "From the outside, this deployment may look simple – even enjoyable," Arnold said. "But the challenges are immense, and they start the second we step foot off the plane."

Once in Afghanistan, the current team – in this case, another Oklahoma ►

(opposite) Kent Shankles, agricultural research operations coordinator, teaches livestock handling to a National Guardsman who will be deployed to Afghanistan. (photo: Broderick Stearns)

unit, the 1-45th Agribusiness Development Team – will brief them on the status of the program, upcoming needs and current intelligence so that the new unit can seamlessly continue the effort.

“We do not just go in and create new missions where we feel like it,” said Chief Warrant Officer Three Warren Higginbotham. “The Afghan people tell us what they need, and we try to help in every way possible. To be successful, we must implement the programs in ways that make them feel comfortable so that they will accept us and our help.”

When new missions are created or new areas are entered, the process is even more complicated. The language barrier must first be overcome. The team works with a translator to ensure that he understands their mission’s purpose and can translate it effectively to the oftentimes hesitant producers. The village elder must also be contacted and grant consent before the military team can enter the region. “We may be trying to help, but we in no way force that help on anyone who does not want it,” Arnold said. “We pride ourselves on being respectful and approachable.”

Conditions in Afghanistan are harsh. Perched at an elevation of 8,000 feet, the country is in dire need of energy sources. While the region is currently limited to use of generators and wood-burning stoves, the team hopes to introduce sustainable sources like solar and wind. While in Afghanistan, the National Guard team will live in “B Huts” – structures with tin roofs, wood sides and just enough air conditioning to keep the oppressive heat at a bearable level.

Energy limitations create additional challenges facing the agricultural producers, who still grow food without the benefit of modern equipment or technology. As an additional problem for the National Guardsmen, the Afghanistan growing seasons are short so the window for educating farmers on modern techniques is tight. The team will focus on the region’s primary agricultural products: fish, beekeeping and orchards, but also hopes to help modernize livestock management practices.

One Noble Foundation workshop the team attended taught basic livestock handling. “Afghan ranchers may not have nutritional supplements and access to hay as we do here in the United States, but general education and fundamental knowledge will certainly improve the quality of their livestock,” said Robert Wells, Ph.D., livestock consultant, who helped train the team.

Interacting with the soldiers hit close to home for Wells, whose wife served overseas in Iraq as a part of an Oklahoma National Guard unit.

“You have to admire those who are willing to volunteer to serve our country, especially in this capacity,” Wells said. “They are leaving their families and going over there to get their hands dirty right beside the Afghan farmers. They are traveling thousands of miles to help rebuild a country from the ground up.”

Higginbotham explained that agriculture is in ruins because the country has lost generations of farmers to war. By establishing sustainable agricultural practices, he hopes that the team can help reenergize the region while also eroding the attraction to radical regimes.

“If they can sustain themselves through agriculture and can build an economic base, they will not need the Taliban,” he said. “However, they can’t rebuild their country without the necessary support and education. In many ways, our team’s mission parallels the Noble Foundation’s consultation program. We help farmers and ranchers by providing information and support. They progress and grow, and soon they are finding success on their own. It’s a dynamic process.”

For Wells, providing training to the National Guard seems a fitting tribute to Lloyd Noble. “You look at the success the Noble Foundation has had in our region, and it is amazing to know that it all began with one man,” Wells said. “Now his legacy is being carried to the other side of the world to change the lives of those who desperately need it. I believe Lloyd Noble would have been extremely proud of this organization.” ●

Consultant assists Azerbaijani agriculture

In cooperation with several Oklahoma higher education institutions, Jon Biermacher, Ph.D., Noble Foundation research economist, traveled to Azerbaijan in late 2009 to help assess agriculture in that country.

Azerbaijan is located at the crossroads of Eastern Europe and Western Asia. It received its independence when the Soviet Union dissolved in 1991. Biermacher met with government officials in the capital city of Baku and toured Azerbaijan State Agricultural University in Ganja.

Biermacher’s trip was part of an exchange program between Oklahoma and Azerbaijan funded by the United States Agency for International Development (USAID). The program also allowed diplomats from Azerbaijan to tour Oklahoma processing plants, feed yards and research institutions.

Azerbaijan, in cooperation with the USAID, is working to build an animal feed analysis laboratory to evaluate the quality of their livestock feed. Research provided by this lab could eventually lead to healthier animals and improved nutrition throughout the country. Biermacher is working to determine the facility’s cost.

Although nearly 7,000 miles from home, Biermacher saw a land similar to Oklahoma. Azerbaijan is oil-rich and has an agricultural industry with a focus on wheat and alfalfa. “This is an opportunity for the Noble Foundation to continue its mission of enhancing agricultural productivity,” he said. “While our focus remains the Southern Great Plains, agricultural advances made by the Noble Foundation and our partners have application in similar climate zones around the world.”

Biermacher and Carol Jones, Ph.D., agricultural engineer at Oklahoma State University, returned to Azerbaijan in 2010 to conduct a detailed cost analysis for the laboratory.

by Baxter Stewart



(top, left) Deke Alkire, Ph.D., Noble Foundation livestock consultant, provides tips for proper cattle management. Members of the Oklahoma National Guard unit will use this knowledge as they assist farmers in Afghanistan. (photo: Broderick Stearns)

(top, right) Ryan Reuter, Ph.D., Noble Foundation assistant professor, discusses forage testing and cattle nutrition during an outdoors demonstration. As part of its Basic AG program, consultants provide foundational knowledge on a variety of agricultural topics. (photo: Broderick Stearns)

(bottom) Robert Wells, Ph.D., Noble Foundation livestock consultant, details the numerous roles of a beef producer during his PowerPoint presentation to the National Guard unit. (photo: Broderick Stearns)



One question changed Hugh Aljoe's life. While an undergraduate at Texas A&M, Aljoe dreamed of becoming a veterinarian. One day his advisor asked him, "Would you rather work with sick animals or healthy ones?" The question altered Aljoe's perspective, and he knew then he wanted to ranch. After completing his master's degree, he managed the Belvedere Land & Cattle Corporation in east Texas. The ranch became his training ground for the next 10 years. He grew the ranch from 145 head of cattle to more than 1,100. In 1995, Aljoe brought his expertise to the Noble Foundation as a pasture and range consultant. Today he coordinates the efforts of 19 consultants as consultation program manager, drawing wisdom from his ranch experiences and family.

On management philosophy:

As a manager, my role is to facilitate the success of others. I believe success comes from managing toward people's strengths and shoring up their weaknesses. Also I do not ask others to do things I would not do myself.

On the Agricultural Division:

To be successful in the Agricultural Division, I believe you need a desire to serve others. I am blessed to work with so many terrific people who share that desire. It is amazing to see what our presence means in the Southern Great Plains. There's no better feeling than to see others succeed and know that you played a part.

On growing up in Roscoe:

I grew up in the small town of Roscoe, Texas. We didn't have a whole lot, but I never felt like I missed out on anything. I learned that life isn't always fair, but it is good. It's what you make it.

On the origin of teamwork:

Before we discovered football, my two brothers, my cousin and I loved to play out at Grandma's house. There were old tractor tires and farm equipment,

barns and sheds, and a few mesquite trees to climb. That farm was our favorite playground. We invented a game called "hard ways" with the object being to make it all the way around the old farm without anyone touching the ground. If someone touched, we all lost. That is the root of my appreciation for teamwork.

On his personal interests:

Growing up, I spent a lot of time outdoors raising animals. That's been my passion. I also played all the sports I could, but what most people don't know is that I also played the drums in band. You wouldn't know it now, but I was pretty good. It gave me a real appreciation for music.

On the adage "an acorn never falls too far from the tree":

I've always been known as a fast driver, and I've had more than my fair share of speeding tickets. I couldn't really tell my sons not to drive fast because I'm not a good example. I just told them that if they got caught, they would pay the fine. In Texas, they let people take a defensive drivers class to remove a ticket from their driving record. On one particular occasion, both my sons and I were all

enrolled in the same class. The instructor saw that we were all related. He had an absolute field day with us.

On the importance of family:

My family is my life. I have two sons, Jeremy and Josh; two daughters, Jessica and Jordan; and a lovely wife Shelly. My favorite activities are those that I can do with them. Whether it was working on the ranch with my boys when they were growing up or building a tree house for my daughter, those are the best times.

On family wisdom:

Dad always told us boys, "When you work, you work till you are done" and "Never do things halfway." My grandfather's words are still well ingrained in my mind as well. He said, "Always look a man in the eye when you speak to him; when you shake hands, you shake 'em firm." He also said, "Real cowboys don't wear sandals." He died when I was 7 years old, and it was not until I was 44 that I bought a pair of sandals. They never felt right. They still seem to be a poor excuse for manly footwear. I should have known – granddads are always right.

by Baxter Stewart



Boldly Going

Noble Foundation researchers earn a rare opportunity to launch an experiment into space

by J. Adam Calaway

It is 6:21 a.m. on April 5, 2010. The official NASA countdown has hit zero, and the main engines and solid rocket boosters of the Space Shuttle Discovery have ignited a fiery plume under the craft. The initial thunderous blast emitted from Launch Pad 39A at Kennedy Space Center pulses through the assembled crowd more than three miles away where Elison Blancaflor stands with his research team, watching in silent amazement.

Clutching a video camera purchased specifically for this morning, Blancaflor gawks through the viewfinder as Discovery rocks slightly in its cradle before rising into the starless Florida morning like a manmade sun, the first step in its journey to the International Space Station.

For many, this trek into the stars will go unnoticed – dismissed as routine, even uneventful. For Blancaflor and his team, this launch – laced with a mixture of relief and pride – is the culmination of a stressful, blissful game of beat-the-clock that has consumed the past four months.

(photo illustration: Scott McNeill using images from NASA and Broderick Stearns, Noble Foundation)

Tucked away in Discovery's middeck are 14 petri dishes of plant seedlings that represent a once-in-a-lifetime experiment. If successful, the results could impact agriculture on Earth as well as provide answers for the next generation of sustained space exploration. If it fails, the disappointment will be a permanent sore spot in the collective consciousness of the Noble researchers.

Soon the realization sets in that it will be two weeks before they know the answer. But for now, it is 6:21 a.m., and all the exhaustion and fear has faded as Discovery burns a bright white streak against the black veil of morning. It is at this moment they know – despite the outcome – they have accomplished something great.

Defying gravity

The journey to Launch Pad 39A began with an e-mail. In September 2009, NASA officials peppered national researchers with correspondence calling for grant submissions as part of the Biological Research in Canisters (BRIC) program, which required rapid-turnaround, peer-reviewed experiments. In addition to funding, NASA promised awardees a rare chance to place an experiment in space.

The stars seemed to align for Blancaflor, who had received a NASA grant 10 years prior to conduct ground-based research on gravitropism – the impact of gravity on plant growth. The new grant's guidelines required the use of a specific model plant – *Arabidopsis thaliana* (a relative of the mustard family) – which happened to

be at the core of Blancaflor's research.

The experiment also held the potential to fulfill both NASA and the Noble Foundation's missions. Studying the gravitropism phenomenon would allow Noble scientists to understand how plants develop correct anchorage, acquire nutrients and water, and absorb light for photosynthesis – all of which impact agricultural crops.

“The best place to study gravitropism is where gravity is absent, and there's only one place to do that.”

Elison Blancaflor, Ph.D., associate professor

As for NASA, the project had implications for future space exploration. Plants are a key component for a regenerative life support system, providing a potential source of oxygen and food if humans ever embark on long-term space missions.

“Putting an experiment into space was a natural step for the research that has been going on in my laboratory for years,” Blancaflor said. “The best place to study gravitropism is where gravity is absent, and there's only one place to do that.”

NASA agreed. Blancaflor was one of three plant scientists nationwide to receive a two-year, \$142,000 grant that included an opportunity to rocket research into orbit.

Project Manager David Cox, who along with Chris Comstock, deputy project manager, oversaw the BRIC mission,

explained that Blancaflor's proposal stood out among the submissions. “He earned this flight. No luck was involved,” Cox said. “He put together a solid proposal that received the universal respect of the peer review panel.”

NASA announced the grant recipients at the end of January and scheduled a March 18 launch date. The timeline was tight, microscopic even, as space-bound

experiments usually take months to properly prepare.

But Blancaflor realized the program was focused on rapid response, and he had anticipated the quick turnaround. He began preparations before he was selected so when the award was announced, his team was already steps ahead. Still, they battled the clock for 10 weeks.

Racing to the Stars

On the surface, a BRIC experiment looks simple: *Arabidopsis* seedlings are grown, sterilized, loaded onto petri dishes and shot into space. The plants spend two weeks growing in space and then are returned to Earth for study. In reality, growing plants in space requires more than a green thumb. Hundreds of man- ▶

(opposite) The Space Shuttle Discovery launches into the early morning sky from the Kennedy Space Center. Aboard the shuttle is an experiment from Noble Foundation scientist Elison Blancaflor designed to study the impact of gravity on plant growth. (photo: Jin Nakashima, Noble Foundation)



hours are dedicated to learning, following and repeating NASA's stringent protocols. There can be no errors, no oversights; only perfected, thoroughly reviewed processes.

"If we mess something up in our laboratory here on Earth, we can always try again," Blancaflor said. "With this particular experiment, we only had one shot at getting everything correct."

In February, Jin Nakashima, Noble Foundation cellular imaging facility manager and Blancaflor's right-hand man, traveled to the Space Life Sciences Laboratories at the Kennedy Space Center for hardware familiarization to learn the workings of the canisters that would hold their seedlings. He also established and stocked the remote lab, and coordinated schedules with the two other research teams sharing the lab space. The Noble team would take the earliest shift each morning from 4 a.m. to 10 a.m., and 18-hour days would become the norm.

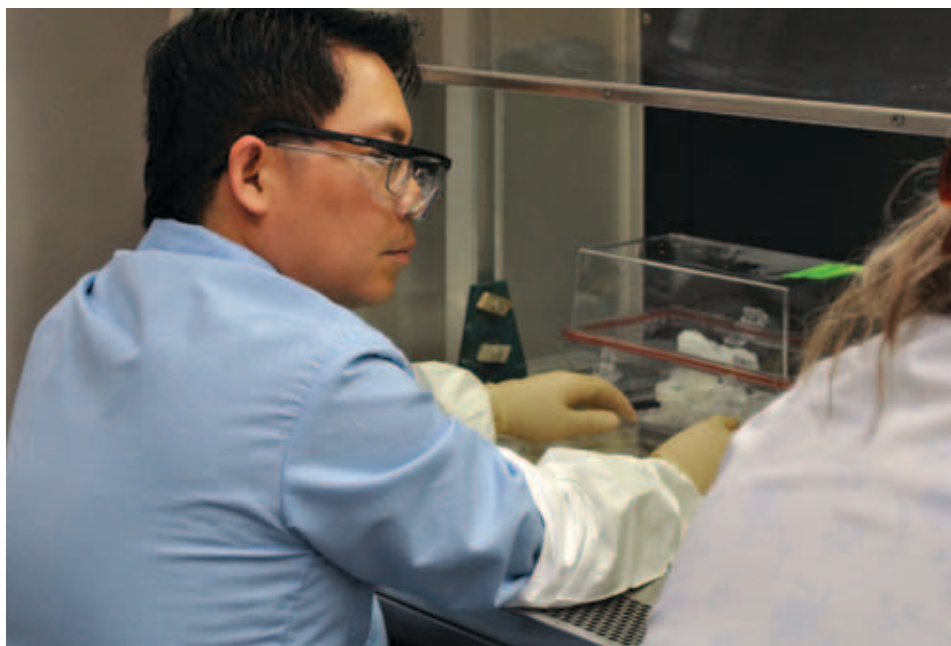
"Our preparation was the same there as it is here," Nakashima said. "But you are learning countless additional steps that generate consistent results."

Blancaflor, Nakashima, Yuhong Tang, Ph.D., the genomics microarray facility manager at the Noble Foundation, and Alan Sparks, the lab's research assistant, returned to Florida later that month and spent two weeks passing a gauntlet of science verification tests, as well as conducting a payload verification test (PVT) – dress rehearsals for the launch and arrival of the space shuttle.

During the PVT, the NASA team scrutinized each step of the Earth-bound procedures, nixing elements or practices that posed any risk to the astronauts.

"Safety is the No. 1 priority for NASA," said Blancaflor. "They talked about it in every meeting and every day. Some take space shuttle launches for granted; NASA does not."

The rigorous testing also examined the BRIC unit's ability to withstand the vibration it would experience during launch and ensured that the unit would not leak any chemicals that were used to treat the plants in space. Each test brought new challenges, but the group relished the experience. "We wanted to watch every



test, hear every explanation, learn everything," Sparks said. "How many times do you have this type of opportunity?"

While Noble's BRIC passed each trial, there were setbacks – one which could have derailed the entire experiment.

The Volkswagen Mission

The PVT serves as the linchpin to the entire preparation process. During the simulation, each team develops their samples and hands them off to NASA officials as though it was the morning of the launch. "There is no flight without a successful PVT," Cox explained.

Blancaflor, Nakashima and Sparks completed the flight PVT with near perfection. Though the plants were not going into space during the test, the teams were required to wait two weeks and return to Florida to simulate the landing.

Even though the petri dishes had been stored down the hall, the Noble researchers were eager to see the results. Following prescribed routine, a NASA technician examines the seedlings in each dish first, calling out various technical elements to be recorded, and then finishes the assessment by saying "good growth" or "poor growth."

After only a few dishes, excitement had faded into dismay. By the end of the

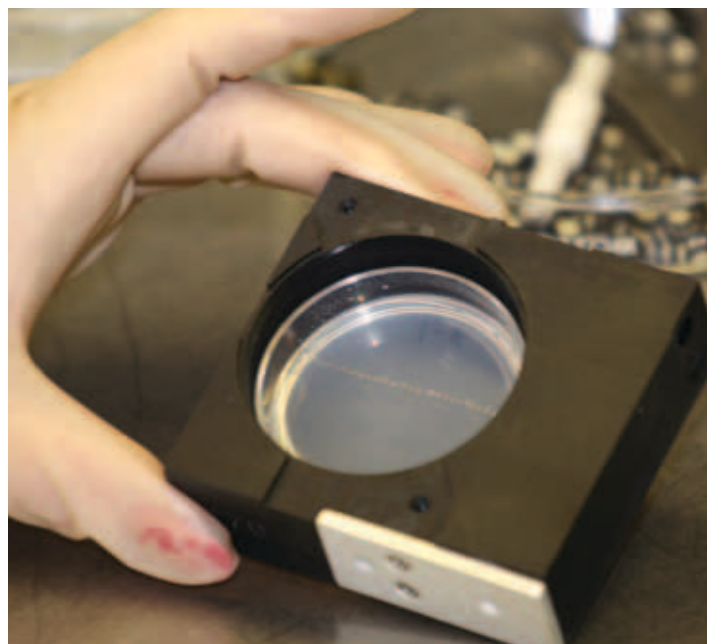
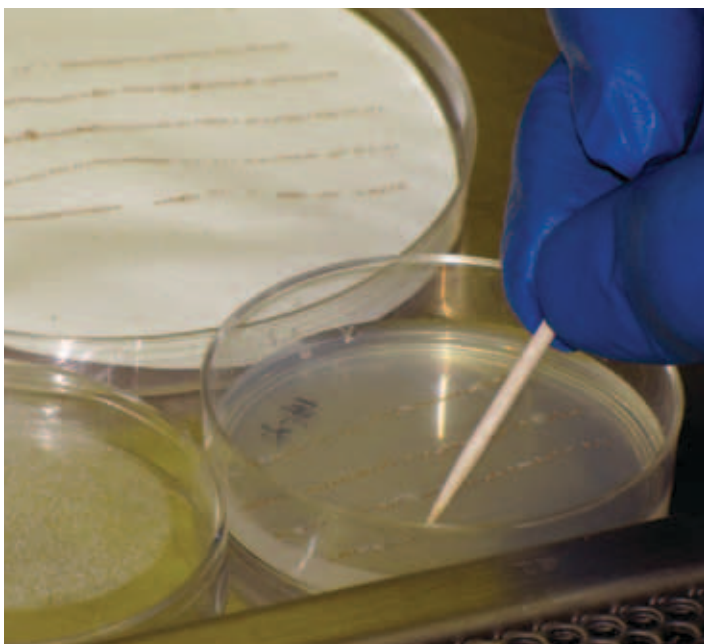
(above) Elisa Blancaflor observes the loading of petri dishes containing Arabidopsis seeds into a Petri Dish Fixation Unit. (photo: Todd Mortenson, NASA)

landing PVT, the technician had said "poor growth" more than 60 percent of the time. "It was a horrendous germination rate," Blancaflor said. "If they had been the actual seedlings returning from space, we would not have been able to get enough material to study."

Blancaflor had anticipated this moment a few months prior. The seeds his lab used for ground research were older, so before they even received the grant, he had Sparks harvest new seeds from fresh plants. Blancaflor theorized that in addition to the old seed, the higher concentration of the gel and not enough exposure to cold temperatures after planting may have contributed to the failure.

Additionally, the trip to Kennedy Space Center may have impacted the seed. Looking back, Blancaflor laughed at their mistake. "We checked the seed in our luggage, which went through the x-ray machine," he said. "That probably played some role in the low germination rate."

For the actual launch, the newly harvested seed was chauffeured the 1,250 miles from Ardmore, Okla., to Cape Canaveral, Fla., in the back of ►



(top, left) As part of NASA's Biological Research in Canisters (BRIC) program, Noble Foundation Associate Professor Elison Blancaflor and his team had to carefully prepare their experiment. In this photo, researchers planted seeds in medium that would secure them through the space flight. (photo: Jin Nakashima, Noble Foundation)

(top, right) Each of Blancaflor's 14 petri dishes was then placed into a Petri Dish Fixation Unit (PDFU). (photo: Jin Nakashima, Noble Foundation)

(bottom, left) The PDFUs were then loaded into a specially designed canister. Before returning to Earth, astronauts injected a compound into the canisters to preserve the plants' structures and genes, allowing researchers to compare the space seedlings with the control group at NASA. (photo: Todd Mortenson, NASA)

(bottom, right) The BRICs were loaded into a padded shelf which was then placed on the middeck of the Space Shuttle Discovery. (photo: Todd Mortenson, NASA)

Nakashima's Volkswagen GTI. "The PVT was extremely important because we learned from our mistakes," Blancaflor said. "Practice does make perfect."

Even before the PVT was finalized, word came that the launch date had pushed back to April 5. "Delays happen so easily; easier than the public thinks," Blancaflor said. "In every meeting, we discussed possible delays, delay scenarios and rumors of delays."

The team returned to Ardmore with the expectation that the postponement would allow some normalcy. Blancaflor kept the pressure on, however, testing and retesting every procedure, even conducting a PVT. Additionally, Sparks tested seed every day. NASA could attempt three launches in five days, meaning the team needed enough seed for five full sets of experiments.

By the time they returned to Florida in early April, they were tired, but ready.

The real deal

The day before Discovery's launch, Elison Blancaflor woke up about 2 a.m. While groggy, his mind raced with an ever-growing mental checklist. Nakashima, Sparks and Tang were anxious to begin the day as well.

The PVTs, while grueling, made the morning's work surprisingly simple. The team prepared the petri dishes seamlessly and handed them off to the NASA technician who loaded them into the canister and performed one last leak test. Once it was sealed, they could only wait for a launch that may or may not come.

They rested that afternoon, reassembled for an early dinner and attempted sleep once more, but with the anticipation of a launch, they returned to the lab at 2 a.m. There was also a chance the launch would be scrubbed, in which case they would need to begin the seed preparation process once more.

They brought pillows to rest, but ended up swigging down coffee and reliving the past four months. When no delay was issued, the team traveled with NASA officials to the Vehicle Assembly Building to view the launch. (Nakashima, who is also a member of the Japanese

media, shot photos from the press site.) Twenty minutes before launch, hundreds of people assembled around them in the dark, still wondering if there would be a launch. NASA can scrub a mission less than 10 minutes before liftoff. But the skies were clear and the crowd hopeful.

When the countdown boomed over loudspeakers, Blancaflor and Sparks held

their breath. At 6:21 a.m., Discovery rumbled into space with a grandeur and power Blancaflor can still barely explain. "It was like a giant ball of fire," he said. "We were three miles away, and the sound was so strong I felt like I was right next to it. Watching it on TV does not nearly capture the awesome force of a launch."

The engines and solid rocket boosters cracked like popcorn as they burned 11,000 pounds of propellant a second. The shuttle quickly gained speed, and, in less than a minute and a half, the stream of light disappeared. Still staring at the black sky, Blancaflor had a surprising emotional reaction: "It was a mix of feelings – relief that it is over, fear that everything will not work right and pride. There are so many shuttle flights, but when you have something on one, that's a part of you; it's just different, special."

The waiting game

If waiting for the actual launch was tough, waiting for the plants to return was excruciating. Blancaflor and company returned once again to the Noble Foundation and their daily routines, but the space shuttle, which orbited about 250 miles over their heads, was a constant source of conversation.

After 13 days in space, the astronauts

injected a special compound into the canisters to preserve the plants' structures and genes, allowing researchers to compare the space seedlings with the control group at NASA.

The process of injecting the fluid sounds as simple as squeezing a tube of toothpaste, but Cox explained that it involved more than a dozen meticulous

"We just wanted to open up the containers, grab the dishes and see if the seedlings grew in space."

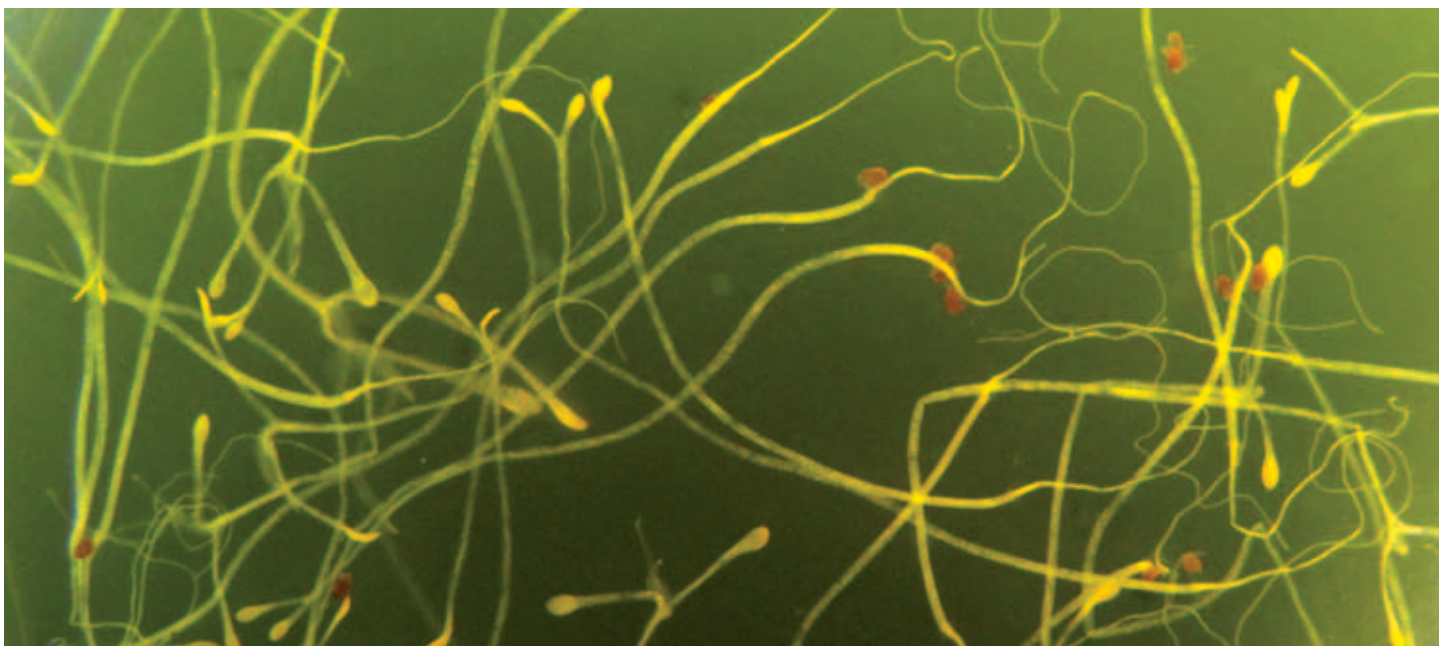
Elison Blancaflor, Ph.D., associate professor

steps, using specially designed equipment that provided triple containment to the potentially harmful fluid at all times.

"The lay person rarely knows of details involved in carrying out space flight experiments," Cox said. "It is very expensive to do research in space. We cannot afford to mess up, so we script the crew's every movement. They were trained on injecting the fluid into the BRIC units before we even awarded the grants."

Less than a day after the plants had been fixed, the first landing attempt had been scheduled and then scrapped due to excessive rain in Florida. The next day fog threatened to force Discovery to its alternate landing site in California; however, the haze cleared and at 9:08 a.m. on April 18, the space shuttle landed safely at the Kennedy Space Center. Five hours later, the petri dishes the team had packed away two weeks prior were brought in by NASA technicians. "I was like an expectant father waiting for the birth of my child. It was a mixture of anxiety and excitement," Blancaflor said. "I kept thinking: What if the seeds did not germinate? We just wanted to open up the canisters, grab the dishes and see if the seedlings grew in space."

Following the usual stringent protocol, however, the NASA tech disassembled the BRIC unit, examined the first dish,



detailed the technical aspects and then she said, “We have lots of growth here.”

Success. All 14 dishes housed thriving seedlings that had been successfully preserved in space. Over the next two days, seedlings from each petri dish were harvested, washed and photographed before being frozen in liquid nitrogen for transport back to Ardmore.

Discovery

Three months after the shuttle landed, Blancaflor sat in his office, a NASA coffee cup proudly displayed on the shelf behind him, as well as a photo of his team’s faces crudely Photoshopped onto the bodies of astronauts. “We’re just now getting back to a normal routine,” he said. “It was worth all the stress and worry, though. I would not trade the experience.”

Down the hall in the heart of the Noble Foundation’s cellular imaging facility, two experiments are making slow, but steady progress. Blancaflor and Nakashima are studying the structure of the cells to understand how microgravity impacted plant development. They initially hypothesized that the lack of gravity would cause the roots to grow in all directions. However, the roots grew in a particular pattern, a phenomenon that had never been observed before.

For her part, Tang is looking at the changes in gene expression, specifically did the lack of gravity cause certain genes to function at a higher or lower level? Her early findings have demonstrated a large number of genes are indeed affected by space flight.

Tang will spend the next several months cataloging the list of genes and their relationship to each other, and then correlating those genes to the growth and structure of the plant.

By using the information from space flight experiments, Blancaflor hopes to influence the development of agriculturally significant crops grown on Earth or the design of plants that are better adapted to extreme environmental conditions such as those found in space or severe drought. Months and maybe years of analysis lie ahead, but Blancaflor is undeterred.

“Science is performed by excavating a single layer of data at a time,” he said. “The knowledge we gain from studying plants in space will be important for what we do here on earth and as humankind seeks to colonize new worlds, but it will take time to sift through the data. Science is definitely not for those seeking instant gratification. Those moments of discovery only come along every so often.”

Like at 6:21 a.m. on April 5, 2010. ●

(above) These seedlings germinated and grew during the Space Shuttle Discovery’s spring mission to the International Space Station. The seedlings were a part of Noble Foundation Principal Investigator Elisa Blancaflor’s gravitropism experiment, which examined how gravity impacts the growth of plants. (photo: Jin Nakashima, Noble Foundation)

Crystallizing Moment

The Noble Foundation's x-ray crystallography laboratory works to uncover the hidden structures of plant proteins

by Laura Biel

Xiaoqiang Wang is probably one of the few plant structural biologists who started his career by looking at fish. In the late 1980s, Wang was a master's student at Wuhan University in central China, measuring the heat that radiates from a fertilized loach egg as it transforms into a striped – a swimming version of its former self. The particulars of loach embryology did not make an impression on him. Instead, he became fascinated with the chemicals that cued each step of the animal's development. Without the right enzymes appearing at the right time, he realized, the fish darting around in the tank would have remained a microscopic cluster of cells.

He wanted to know more about the most basic mechanics of life itself. He learned that the function of every enzyme in the plant and animal world depends on how it looks. Like paper airplanes, biological molecules work only when they are folded into their correct shapes.

Now an associate professor heading up a structural biology laboratory at the Noble Foundation, Wang has devoted his life to figuring out what molecules look like – an undertaking that would be easier if anyone could really see them. But even the most powerful microscope cannot look at the arrangement of atoms in a protein. So scientists have to rely on

an indirect method called x-ray crystallography. The technique has simple steps: purify the protein, coax it to solidify into a crystal, bombard it with x-rays and piece together a three-dimensional structure based on the pattern of x-rays as they bounce off the crystal. If this sounds straightforward, know that it is, in fact, so difficult that Nobel Prizes are awarded for the task. It was x-ray crystallography that revealed the double helix of DNA – the fundamental building block of all life. Despite the advanced technology involved, the shape for a typical molecule (if any one could be considered typical) takes years to emerge.

Among the challenges – aside from the fact that many key molecules in cells are stubbornly resistant to forming crystals – structural biologists also have to become experts at decoding the x-ray patterns, which appear simply as dots scattered across a page. “Even for a small molecule, we may need thousands of dots to get the shape,” Wang said. To the rest of us, patterns produced by the x-rays look like little more than a Xerox gone wrong.

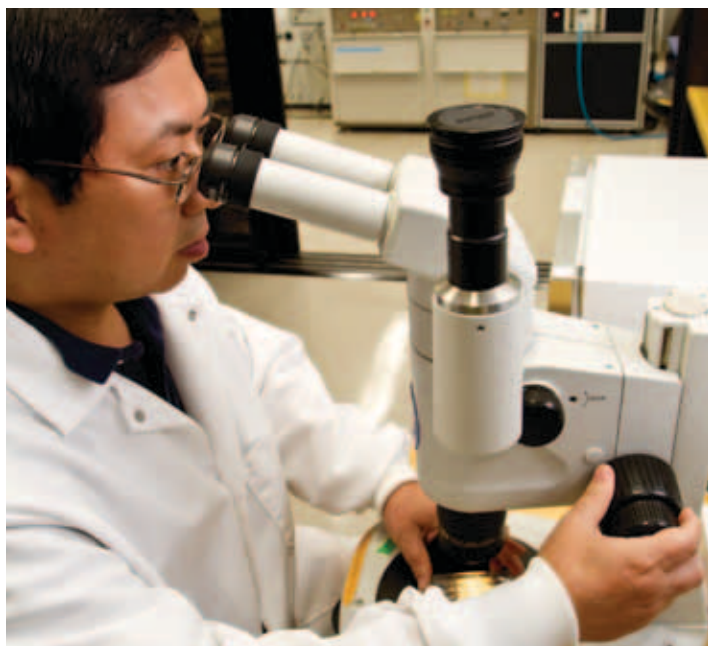
Wang has focused much of his work on enzymes that orchestrate the attachment of “sugars” to molecules – this action being known as *glycosylation*. Glycosylation is the most frequent chemical reaction in nature and is usually the

final step in a long chain of reactions that a plant uses to make key compounds involved in defending the host plant from pests and disease, as well as undertaking basic plant functions. A group of enzymes called uridine diphosphate glycosyltransferases (UGTs) are the most significant for glycosylation in both human and plant physiology. Humans have about 20 UGT versions. However, plants contain a much greater diversity of UGTs since their survival depends on chemical warfare. A focus of research at the Noble Foundation, the model legume *Medicago truncatula* is thought to contain more than 100 UGT versions.

Despite years of intense study, the function of UGTs has remained largely a mystery. While better understanding of these enzymes could provide insight into ways of enhancing plant defenses, the field also has implications for human health – glycosylation can affect the potency of antioxidants and antibiotics, or could one day aid in the synthesis of pharmaceuticals from simple natural

(opposite) X.Q. Wang, Ph.D., associate professor, discusses ongoing research with a postdoctoral fellow in his laboratory.
(photo: Broderick Stearns)





compounds. But none of this can happen until scientists obtain a clear three-dimensional picture of each molecule.

Of the five plant UGTs for which a structure is known, three have come from the Wang laboratory. The first was published in 2005 and the last one in 2009. “It is groundbreaking work with significant implications for plant science research,” said Richard Dixon, D.Phil., senior vice president and director of the Plant Biology Division. “We hope Dr. Wang’s research will generate knowledge on in areas as diverse as plant defense and biofuel production. This could lead to improved varieties of plants, including forages for livestock, in the future.”

In addition to determining the crystal structure of UGTs, Wang’s laboratory has determined the crystal structure of two other types of enzymes vital in plant biology. One is a cytochrome P450, an enzyme that exists throughout nature and assists with a wide range of chemical reactions. Because cytochrome P450s are so difficult to extract and isolate from the membranes of a plant cell, Wang’s research marked the first published

description of the structure of a P450 enzyme in plants.

The Wang laboratory has also determined the crystal structures of two enzymes critical to the production of isoflavonoids – compounds involved in plant defenses that also have a significant benefit to human health. After obtaining the structure for both of these enzymes, Wang also determined the sites on the molecules critical to their function.

“From this information,” he said, “we can understand how the enzyme works to catalyze its chemical reaction.”

While extraordinary, the discoveries of the Wang laboratory are merely a starting point that provides fundamental understanding. Eventually this information could lead to altering natural enzymes to improve their efficiency or expand their functionality.

Much like a child adjusts the folds on a paper airplane, trying to improve the way it flies, Wang and his research group are providing the plant science community with information that may one day benefit plant productivity or even improve animal or human health. ●

*(above, left) X.Q. Wang, Ph.D., associate professor, examines plant proteins as part of his research objective.
(photo: Broderick Stearns)*

*(above, right) This crystal of the UGT78G1 protein from the model legume Medicago truncatula was first described by Wang in 2009.
(photo: X.Q. Wang)*

A Summer Like No Other

Summer Research Scholars Program offers opportunities for both students and teachers

by Arthur Dixon

Each summer at the Noble Foundation, a handful of intellectually outstanding university undergraduates have the opportunity to experience an unparalleled trip into the world of plant science and agricultural research.

At the same time, a few hardworking postdoctoral fellows (“postdocs”) have the chance to take these young students under their wings and guide them through a summer of dynamic research.

These experiences are made possible through the Noble Foundation’s Summer Research Scholars Program. Since its inception in 2004, the program has offered students a rare and highly competitive opportunity to work in one of the top research institutions in the United States with professional scientists. “The program is invaluable for both student and teacher,” said Catalina Pislariu, a postdoc who mentored a student from Duke University. “They gain much needed, real-world experience, while the postdocs learn effective teaching methods.”

The Student Experience

Out of a large pool of undergraduate applicants, four or five are chosen by the directors of the Plant Biology and Forage Improvement divisions based on academic excellence and interest in plant science as a career.

The accepted applicants spend 10 weeks at the Noble Foundation during the summer, working alongside their mentors on a research project that is specific to their scientific interests. They are assimilated into the laboratory environment and participate in the research just as a professional scientist would. As well as simply receiving instruction and feedback from their mentors, the students have opportunities to perform experiments and make scientific progress independently.

The personal mentorship that students receive allows them to connect more closely with the instructor. The authentic lab work also prepares the undergraduate for the unpredictability and pace of real scientific research in a way that a textbook and a classroom of 100 students could not.

“The scholars gain remarkable independence during their time at the Noble Foundation, becoming capable of performing complex experiments and planning projects for themselves,” said Ruchi Singh, Ph.D., a postdoc mentor. “They also have the opportunity to pick the postdocs’ brains anytime and discuss any issue,” said Mustafa Morsy, a postdoc in the Plant Biology Division.

The combination of mentorship from a working researcher and their own

independent progress makes for an intense and dynamic educational experience. “Sometimes I feel a little jealous of the students who get to come here as undergraduates,” Morsy said. “They have a mind-opening experience that I would have enjoyed at their age.”

After more than two months at the Noble Foundation, the Summer Research Scholars present their findings to the institute’s scientific faculty. Their time at the Foundation gives them an intriguing look into the life of a research scientist, from the laboratory to the podium and career possibilities. However, the students are not the only beneficiaries of the program.

The Mentor’s Experience

As an independent research institute, the Noble Foundation does not have the traditional classroom teaching opportunities available at universities. However, the intimate combination of research and mentorship that characterize this program allow for deeper and more concentrated education for both the undergraduate student and the instructor.

A regular university teacher cannot focus on each student individually, but the postdoc mentors at the Noble Foundation have the chance to do just that. During the course of the summer, a postdoc can become deeply familiar with ►



his or her student and their interests in a way that a classroom lecturer could not.

Morsy, who taught large classrooms of students before his time at the Noble Foundation, said that working one-on-one with an undergraduate helped him to be more patient and more understanding of different opinions.

The postdocs that have participated in the Summer Research Scholars Program have found that teaching an undergraduate in the lab rather than the classroom can be more focused and enriching for the instructor as well as the student.

“Learning in the lab allows you to experience concepts that you could not in a classroom,” said Singh. “In the classroom, everything is very defined and scheduled, but in the lab a student learns how to solve unexpected problems. You don’t always know what’s going to happen next.”

Pislariu echoed Singh’s sentiment, saying, “The direct interaction and the fact that you can connect with your student and their goals make mentoring more fulfilling than classroom teaching.”

No matter the location, the mentor postdocs all agree that the program is just as educational and enriching for them as it is for their students. “It’s good to see a person progressing under your training,” Singh said. “I’m learning to be more

independent and gaining the confidence to teach and lead somebody else.”

This confidence is tremendously important to an independent researcher who will have to make decisions and perhaps lead a group of scientists in the future.

“The direct interaction and feedback between mentors and scholars allow the postdocs to see their own projects through a fresh and evolving perspective as they learn how better to impart their knowledge to the next generation of researchers,” Dixon said. “Through this program, we are helping to train two generations of scientists.”

Students and postdocs both come out of the Summer Research Scholars Program with a renewed interest in their field and anticipation of future possibilities.

After the scholars have returned to their respective universities, the postdocs are left with enhanced instructional skills and the sense of fulfillment that comes from educating the next generation.

“The students often discover a new calling or career path during their time at the Noble Foundation,” said Pislariu. “Or they may just continue along their current path with refreshed vigor and a wealth of new knowledge.”

Either way, the summer will have been an unforgettable experience for teachers and students alike. ●

(above, left to right) Summer Research Scholars Michelle Boursier, Luther College; Halli Gutting, Michigan State University; Jared Pembrook, Oklahoma State University; and Jennifer Meoni, North Carolina State University, work in their respective laboratories during their summer at the Noble Foundation.

(photos: Broderick Stearns)

*(opposite) A student at Duke University in Durham, N.C., Kathie Sun came to the Noble Foundation to study molecular characterizations in the model plant *Medicago truncatula* in the laboratory of Michael Udvardi, Ph.D. The Noble Foundation Summer Research Scholars Program has drawn students from some of the United States’ most prestigious universities, including Princeton University, Cornell University, Purdue University and William and Mary College.*

(photo: Broderick Stearns)





Changing Perspectives

Speaker series continues to serve the community and inspire students

by Patrick McSweeney

The Samuel Roberts Noble Foundation initiated its popular speaker series, *Profiles and Perspectives*, in 1999 as a way to expose Ardmore residents to high caliber, nationally known speakers.

Through *Profiles and Perspectives*, the southern Oklahoma community has enjoyed speakers discussing topics ranging from political satire to the Mars Exploration Rover Mission. While each event is open to the public, the presentations have offered particular value to regional students.

"Not many communities provide students an opportunity to hear presentations by some of the most interesting and influential figures in our country," said Mary Kate Wilson, director of granting and chair of the *Profiles and Perspectives* Committee. "In the last few years, we have hosted guests ranging from Gen. Tommy Franks to oceanographer Dave Gallo. By being exposed to these various individuals and their amazing stories, the students come away from the programs with new ideas that – in some cases – have shaped their futures."

The students have truly embraced the program because of its compelling subjects and interesting delivery. As Gallo presented *Neptune's Garden: Exploring the Secrets of the Deep Undersea*, students from every local school packed the Ardmore Convention Center, watching in breathless anticipation as the famed oceanographer played rarely seen video he and his team had captured during their deep ocean explorations.

(opposite) Dave Gallo, Ph.D., from Woods Hole Oceanographic Institution, captivated an overflow *Profiles and Perspectives* audience with video from the deep ocean. (photo: Broderick Stearns)

Profiles and Perspectives opened its 2010-2011 season with Noble Foundation scientist Elison Blancaflor's behind-the-scenes look at the process of putting one of his experiments into space (story on page 16).

Internationally renowned archaeologist Kara Cooney, Ph.D., will follow Blancaflor with an insightful look at the use of pyramids throughout history and around the world (Tuesday, Nov. 2, 2010).

After the winter break, popular radio host and gardening expert Neil

Sperry will present the fundamentals of effective landscape design (Thursday, Feb. 17, 2011), and then Greg Marshall will share how he developed and used the Crittercam to produce award-winning films for National Geographic (Tuesday, April 19, 2011).

The 2010-2011 *Profiles and Perspectives* series is offered at no cost, courtesy of the Noble Foundation. All programs will take place at 7 p.m. at the Ardmore Convention Center. Additional information can be obtained at www.noble.org/profiles.

Ardmore High School senior Kristin Dao went home inspired by the sights she witnessed and spent the next two hours looking on the Internet at images and videos similar to Gallo's. "I was blown away by his talk," she said. "It left me wanting to learn more. Here I am months after that night, and I still can remember almost everything he discussed."

Juliann Jantz, a senior from Dickson High School, was so inspired by Gallo's presentation that she decided to become a marine biologist. "I can't say enough about what that presentation meant to me," Jantz said. "Hearing his stories made me realize what I wanted to do and that I can be successful in that field if I just work hard."

The *Profiles and Perspectives* programs impacted entire classes around the region as well. Ardmore Middle School science teacher Jacqueline Jones noticed that the day after each *Profiles and Perspectives* speaker, the students who attended enter her classroom eager to discuss the previous night's topic. "It is a powerful statement when middle school students want to continue talking about a subject the next day," Jones said. "The discussions

would ultimately pique the interest of those students who didn't attend. That's how engaging these programs have been."

The spark that was created in Jones' students is exactly what the program attempts to accomplish – an exciting learning environment for everyone.

"When the *Profiles and Perspectives* Committee looks for a speaker, we don't just pick someone with an attractive topic," Wilson said. "We look for someone with an exciting presentation and an interesting story that will captivate and move the audience."

In January 2010, Capt. Scott O'Grady, an Air Force pilot, spoke of his life-and-death struggles after being shot down over Bosnia. The pilot posed for pictures with audience members after his talk, including a Boy Scout troop who stood around him in obvious awe of the war hero.

"The best part about our speakers is their willingness to stay after the program and talk to the attendees," she said. "It shows the students that they are just regular people who have accomplished great things through perseverance. It makes the entire experience more tangible and that leaves a lasting impression." ●

A Prescription for Action

by J. Adam Calaway

On the scale of enjoyable activities, my annual physical ranks somewhere between math camp and having a bowling ball dropped on my foot.

The process finds a way of trying my patience: out-wait the waiting room; comment on how their perfectly calibrated scale must be off today; endure the grip of the blood pressure cuff; and, finally, end up in a closet-sized exam room with nothing to read, but the creepy informational posters.

After toggling between the “Is it the flu or a cold?” sign and a series of increasingly stomach-churning photos of rashes, I was left to think.

At first, the situation dictated the usual ponderings. *I really should have eaten more salads this year. When was the last time I jogged? Why am I sitting on butcher paper?*

As I shifted awkwardly on the thinly padded table, feet dangling off the side like a 6-year-old, I hit upon an inevitable question: If I could go back 10 years, what would I change?

Hindsight being what it is, the list was admittedly extensive. Even as the doctor outlined a well-worn game plan – eat better, exercise more, stress less – my thoughts swirled around my past failings. I had plopped down in a trough of regret. I was not just bemoaning the lack of exercise, but my deficiency in vision and the resolve to act upon a solution.

For the past four years, I’ve worked at the Noble Foundation, which was established by a man with profound foresight. In the years following the Dust Bowl, Lloyd Noble watched as Oklahoma struggled to re-establish its productivity. The land lay in ruin. The economic foundation was as cracked as the drought-stricken prairie. And people continued to flee the Great Plains for the promise of prosperity in the West.

As one of Oklahoma’s famed oilmen, Noble could have simply ignored the problem, content to hold his resources, but he looked beyond his personal self-interest. He wrote extensively



photo: Broderick Stearns

about the need to properly steward the state’s natural resources and assist agricultural producers, believing that revitalization was rooted in the soil tilled by the farmers and ranchers.

In an editorial, Noble penned, “We believe that while at times we have felt the overshadowing presence of oil, we are living in an area that is essentially agricultural. This is easily realized when one takes the time to remember that the land must continue to provide for our food, clothing and shelter long after the oil is gone.”

Noble’s perspective on the future of his state was not shaped by his current situation or the despair of past failings. His perspective remained on what could be accomplished, not what had been lost.

Even though his vision was far-reaching, he knew that a lack of determination voided any intent. “The only degree to which we can make real progress is the degree to which, when we have ideas, that we can get those ideas motivated into action,” he said.

Noble created a sustainable solution for a state in its most critical hour of need. He established this organization 65 years ago with the sole purpose of benefiting mankind. It certainly has honored his wishes.

Through the decades, the Noble Foundation has assisted tens of thousands of regional agricultural producers; bred new plant varieties for the Southern Great Plains; granted millions of dollars in support to worthwhile causes nationwide; and developed into one of the premier plant science research institutions in the world.

These phenomenal outcomes have positively impacted millions of lives. And all of them were a result of one man who, rather than anguish over the past, envisioned and worked for a better future.

When you think of life in those terms, it’s pretty easy to get up and go jogging.



photo: Noble Foundation Archives

Farmers and ranchers from the southern Oklahoma community gather for a Noble Foundation Agricultural Field Day in March 1963. Supporting agricultural producers has been the focus of the Noble Foundation since it was established by Lloyd Noble in 1945. As a visionary philanthropist, Noble understood the

importance of providing resources – be it education, demonstration or research – to the region's land stewards. The Noble Foundation continues to provide educational events for agricultural producers in its service area, which spans from Oklahoma City to Dallas, and from Paris, Texas to Lawton, Okla.

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(below) Research Associate Shipra Mittal, Ph.D., examines petri dishes containing plant seedlings. The Noble Foundation is home to more than 110 Ph.D. scientists who traveled from 29 countries to work at the institution's Ardmore, Okla., campus.

