NC STATE UNIVERSITY

results.

Summer 2015 • Research, Innovation & Economic Development

COLLABORATION SPEEDS INNOVATION: TEAMWORK DRIVES FACULTY CLUSTERS

ALSO IN THIS ISSUE:

- The Power of Public Science
- Enhancing Economic Engines
- Leading Educational Technology

Reflections on an Excellent Year

• ABOVE: *NC State's record-breaking research expenditures have contributed significantly to the university's upward momentum.*

The 2014-15 fiscal year has been an excellent one for NC State research, innovation and economic development efforts. All indicators are that new records will be set in research expenditures and achievements, innovation, and national recognition.

It has also been a year of change.

At the end of 2014, Terri Lomax joined RTI International after seven years as the vice chancellor for research, innovation and economic development. Those years had tremendous successes, such as two of the largest grants NC State has received in its history — for the Laboratory for Analytic Sciences (LAS) and the Next Generation Power Electronics National Manufacturing Innovation Institute, known as PowerAmerica.

NC State also had record-breaking research expenditures in excess of $446 million in 2013-14. According to National Science Foundation (NSF) classifications, about $189 million of that was in life sciences; about $163 million in engineering and computer science; about $69 million in physical, environmental and mathematical sciences; and about $25 million in social sciences, psychology, education and other disciplines.

The most recent NSF data ranks NC State fifth in the country among public universities without a medical school for expenditures in industry-sponsored research, and 10th in total research expenditures.

Building on the activities and successes of our Institute for Advanced Analytics (IAA), the $60 million-plus LAS, and the data-driven sciences cluster funded by the Chancellor's Faculty Excellence Program, we announced a universitywide Data Science Initiative in December 2014. IAA, which has tripled its enrollment since its inception in 2007, has a new home in the Alliance Building on Centennial Campus.

PowerAmerica — announced by President Obama in 2014 and still the largest grant NC State has ever received at over $140 million — also has new offices, in Venture Place on Centennial Campus.

NC State is the only university in the nation that currently leads two NSF Engineering Research Centers. In May, NSF reaffirmed continuation of funding for both.

In January, a University of North Carolina systemwide study reported NC State's annual economic impact is at least $6.5 billion in added state income. See page 23 for details.

A significant portion — about $1.6 billion — comes from NC State research spending and startup activities. Our researchers, innovators and entrepreneurs have not disappointed us. Indeed, in 2014-15 our innovation and technology transfer activities reached new heights. We close our state fiscal year with a record-breaking 12 startups. Female entrepreneurs lead five of these startups. Look for details in the next issue of *Results*.

In 2014-15 our innovation and technology transfer activities reached new heights. We close our state fiscal year with a record-breaking 12 startups. Female entrepreneurs lead five of these startups.

Of the 155 responses to the 2013 Licensing Activity Survey conducted by the Association of University Technology Managers, NC State ranked 10th for licenses and options executed. Among universities without medical schools, NC State consistently ranked among the top 10, including second in licenses and options executed, seventh in invention disclosures, seventh in startups formed and ninth in U.S. patents issued.

It has been a pleasure and a privilege serving in the role of interim vice chancellor for research, innovation and economic development. I offer a big "thank you" to ORIED staff for your dedication and outstanding services. Thanks also to NC State research support staff and administrators for enabling our scientists, engineers and scholars. And I especially thank NC State faculty, researchers and innovators for your efforts and world-class achievements. I know our successes will continue.

MLADEN A. VOUK, *Interim Vice Chancellor Research, Innovation and Economic Development*

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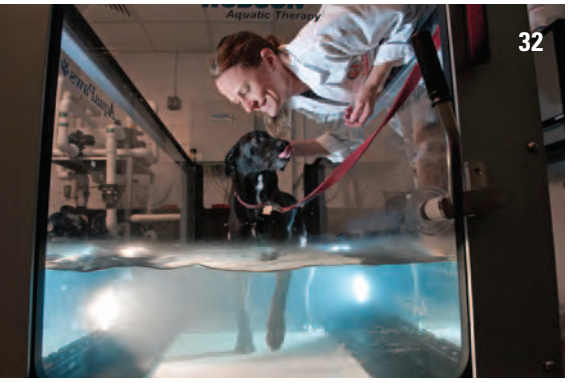

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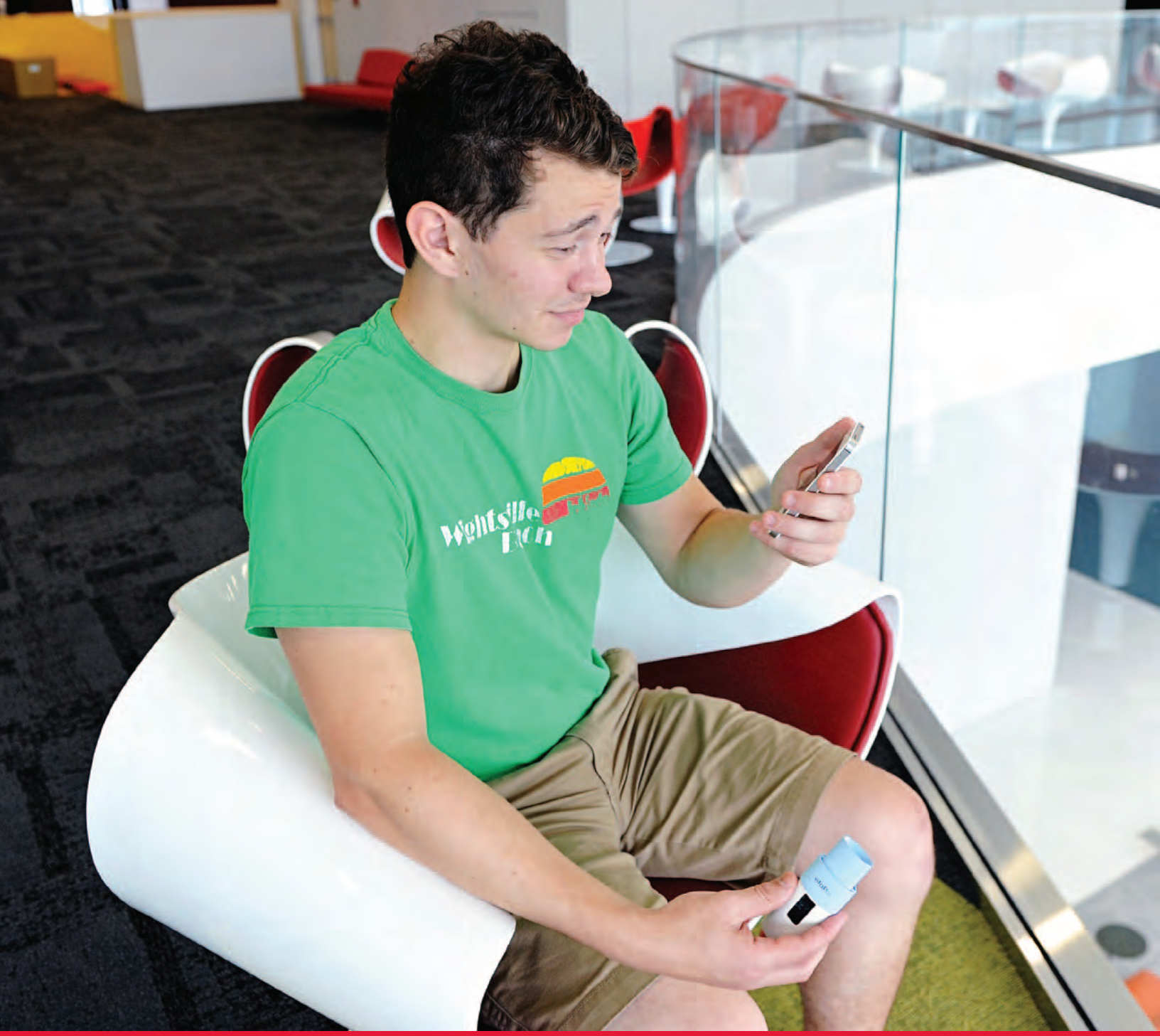
Front Cover: *NC State's Belltower rises over Hillsborough Street at dusk. Photo by Roger Winstead.*



FACULTY FUSION: Reshaping the Academy

By David Hunt

Patients undergoing treatment for asthma and other chronic lung diseases often have to breathe into a handheld device to measure how well their lungs are working. But even though most people with asthma own a peak flow meter, only about one-third of them use it.

That fraction could increase dramatically thanks to new technology developed in the Product Innovation Lab at NC State University.

• LEFT: *Laura Severin, left, and Duane Larick work behind the scenes to smooth the implementation of NC State's innovative faculty cluster program.*
• OPPOSITE PAGE: *Graduate students in the Product Innovation Lab at NC State University developed a low-cost, handheld spirometer that sends results of self-administered lung function tests to a smartphone that uploads them to a remote server for a doctor to view.*

The groundbreaking device — a low-cost, handheld spirometer — can send the results of self-administered lung function tests to a smartphone that uploads them to a remote server for a doctor to view. By reducing the cost and inconvenience of testing, the product, called VitalFlo, could improve the management of asthma, a disease that affects more than 16 million Americans and costs the U.S. economy $64 billion a year.

The brainpower behind the project came from graduate students in three disciplines — engineering, industrial design and business — mentored by faculty members at the forefront of research and scholarship in those fields.

Ordinarily you wouldn't find students with such widely varying interests working together in a classroom or lab. But these are not ordinary times in higher education.

"Nationally there has been a greater awareness that you need people from many disciplines to solve the grand challenges of society," says Laura Severin. "You're not going to find the answers in any one discipline."

Severin, an English professor who has served as a special assistant to the provost for academic planning, was a key player in a pioneering initiative to change the way faculty members educate, collaborate and innovate on the 2,000-acre campus.

The Chancellor's Faculty Excellence Program was launched in response to an ambitious strategic plan adopted by the university in 2011. Since then the program has spurred the creation of 20 interdisciplinary faculty clusters in areas ranging from regenerative medicine to data science to the digital transformation of education.

The clusters, led by some of NC State's most experienced researchers, have recruited and hired 41 new faculty members, including established and emerging leaders in their fields — all with a strong commitment to interdisciplinary collaboration.

In fact, Severin says, the chance to work in a faculty cluster with colleagues from other disciplines was "an exciting intellectual draw" for the new hires.

It's also been exciting for officials in the provost's office, who are busy measuring the program's success against a variety of benchmarks. One important metric, the amount of research funding generated per faculty member, paints a dramatic picture. On average last year, faculty hired through the cluster program brought in more twice the research dollars of other research faculty.

That's particularly good news considering that the program requires a significant investment of dollars by the university — and not just for salaries.

Duane Larick, a food scientist who serves as NC State's senior vice provost for academic strategy and resource management, says the university is updating laboratories, buying new equipment and enhancing existing facilities across campus to support the new faculty clusters.

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"Nationally there has been a greater awareness that you need people from many disciplines to solve the grand challenges of society. You're not going to find the answers in any one discipline."

— LAURA SEVERIN

"We don't have a lot of underutilized space, especially high-quality underutilized space," he says. "But the reality is, if we're going to grow the faculty, we're going to have to invest in our facilities."

Of course, investing in faculty and facilities takes dollars, and those are in short supply in public higher education. Although research funding is on the upswing overall at NC State — new sponsored awards reached a record $300 million in 2014 — state appropriations have had a downward slide.

"They confront all the gnarly issues of what it means to work with other people — and to work with other people who've been educated in different ways than you have. It's been fun and exciting to push at the edges of innovation. Our collaborations have brought us a great deal of delight, especially when we see our student teams coming up with amazing ideas to solve complex problems in novel ways."

— HAIG KHACHATOORIAN

That trend is mirrored across the country. The Center for Budget and Policy Priorities, a nonpartisan research and policy institute based in Washington, D.C., reports that state spending for higher education is down an average of 23 percent from pre-recession levels.

But Larick and other top NC State administrators have no doubts about the value of the faculty cluster program. "It's worth every penny," Larick says.

His confidence in the program isn't just based on monetary returns. Larick says the program is paying dividends in multiple ways: stimulating the creation of new academic programs at the master's and doctoral levels, attracting top graduate students from around the world, generating partnerships with government and industry, and fostering a spirit of collaboration across the university's 10 colleges.

"The campus culture is changing," he says. "And it's changing dramatically."

INNOVATION BY DESIGN

To some extent, faculty members have always worked in interdisciplinary clusters — or at least some faculty members have. Industrial design professor Haig Khachatoorian recalls coming to an informal agreement with colleagues in engineering and management 18 years ago to establish the Product Innovation Lab, a hands-on collaborative course that has spawned innovations such as a smart meter for the power industry, a video conferencing system to deliver physical therapy to rural patients and the VitalFlo asthma monitoring device.

The course is effective because it immerses students in different ways of thinking and learning, and it helps them tackle complex problems as a team. Over the semester, students run through the difficult tasks involved in bringing an idea to market, including developing a business plan, conducting a technical analysis, designing a concept and producing prototypes.

"They confront all the gnarly issues of what it means to work with other people — and to work with other people who've been educated in different ways than you have," Khachatoorian says.

Over the past decade the course has confronted many of the challenges — and reaped many of the rewards — inherent in interdisciplinary clusters. Faculty members grounded in one discipline, with its particular vocabulary, tools and methodology, have gained new perspectives by working closely with faculty and students in other disciplines.

"It's been fun and exciting to push at the edges of innovation,"

• LEFT: *Marketing professor Jonathan Bohlmann, an expert in strategic decision-making, has extensive experience in management and engineering.* • OPPOSITE PAGE: *NC State's faculty clusters have dynamic researchers leading solution-driven, interdisciplinary innovation.*

Khachatoorian says. "Our collaborations have brought us a great deal of delight, especially when we see our student teams coming up with amazing ideas to solve complex problems in novel ways."

When the university announced it was looking for ideas for new interdisciplinary clusters, Khachatoorian and colleagues in management and engineering jumped at the chance to build on their collaboration. They proposed an innovation and design cluster based on lessons learned from a decade of working together.

It was an easy sell, especially because their work has long been recognized as a national model for experiential education. From modest beginnings, the Product Innovation Lab has become one of NC State's most popular graduate courses, engaging more than 100 students working in 13 teams last semester. In 2010, *Forbes* named the lab one of the 10 most innovative business courses in the nation.

When NC State announced the launch of the first 12 faculty clusters three years ago, the innovation and design cluster was one of those that got the green light, with Khachatoorian and marketing professor Jonathan Bohlmann as the coordinators. Both professors bring decades of experience in higher education, as well as strengths in the cluster's core disciplines.

Khachatoorian has advanced degrees in industrial design and environmental psychology. He also has studied around the world, from the Pratt Institute in Brooklyn to the Academy of Fine Arts in Poland to the University of Surrey in England. In 1985 he received a prestigious Loeb Fellowship from the Graduate School of Design at Harvard University.

In addition, he has extensive experience in the private sector as a freelance designer and consultant. His research has been supported by grants from major corporations such as Philips, Ford, Caterpillar, John Deere, Daimler Chrysler, GlaxoWellcome, Michelin and IBM.

Bohlmann has extensive experience in business management and engineering. He earned undergraduate and master's degrees in aeronautics at Purdue University and then worked as a senior engineer at General Dynamics, where he designed advanced aircraft structures. He went on to earn an MBA at Texas Christian University and a Ph.D. in marketing with a minor in microeconomics from MIT's Sloan School of Management.

Bohlmann says students in the Product Innovation Lab quickly learn to appreciate the close interplay of marketing and design when attempting a product innovation.

"Part of the art of innovation is problem definition and having a very comprehensive and complete understanding of market opportunities and unmet customer needs and the customer experience," he explains. "As designers often say, 'to design the thing right, you have to design the right thing.'"

CHALLENGES AND CHOICES

The same holds true of designing a new academic program. After their faculty cluster proposal was approved, Bohlmann and Khachatoorian faced the challenge of setting up a program that operates outside the university's traditional organizational structure. They quickly identified two goals: recruit new faculty members with a passion

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"Part of the art of innovation is problem definition and having a very comprehensive and complete understanding of market opportunities and unmet customer needs and the customer experience. As designers often say, 'to design the thing right, you have to design the right thing.'"

— JONATHAN BOHLMANN

for interdisciplinary teamwork, and create new academic courses that help students break free of conventional thinking.

In 2013 they hired Christian Hölljes, an award-winning inventor, designer and serial entrepreneur who served on the original QuickTime team at Apple Computer in the 1980s before leading product development efforts at several other Silicon Valley firms. Hölljes, who studied zoology, mechanical engineering and fine art at Duke University, earned a master's in industrial design at NC State in 1984.

The next year they hired Rosanna Garcia, an expert on agent-based modeling, a simulation technique that helps businesses understand how consumers make decisions in complex market situations. Like Hölljes, she has a multidisciplinary background, holding undergraduate degrees in both chemical engineering and economics and a doctorate in marketing.

The new faculty members are putting their diverse backgrounds to work. Hölljes is rolling out a new design course called Make/Believe, in which students will develop a hypothetical company and go through the necessary steps required in order to launch it. Garcia is working on a curriculum for a program to help students develop and launch technologies in the area of environmental sustainability.

But setting up faculty clusters can raise new and vexing problems — especially for university administrators. In fact, hiring faculty clusters "is so tricky and so time intensive that many of the universities that have tried it haven't succeeded," says Severin.

Traditionally, faculty members are hired by academic departments to work in specific disciplines, such as English or biology. While many universities are excited about the prospect of hiring new faculty in clusters that cross disciplines, they shouldn't neglect the needs of the traditional departments, she adds. "There has to be a careful balance between building your clusters and supporting your departments."

NC State adopted an approach that turned the traditional hiring process on its head. Instead of hiring people at the department level and then seeing how those new faculty members could fit into university centers or institutes — the units on campus that have traditionally spearheaded cross-disciplinary efforts — the university first identified gaps in broad research areas and then assessed how potential new hires could fit in.

It's also noteworthy that NC State purposely turned to its faculty, rather than its administrators, to identify the unmet research needs. Faculty cluster areas weren't created in a boardroom and delivered in a top-down approach; they were selected from among dozens of proposals submitted by teams of faculty members.

"It is key that the faculty propose the areas where we focus our clusters. We need faculty to guide the process because this effort takes a lot of passion and commitment. We need people who are excited about their research and driven to achieve their goals. It has to come from them."

— LAURA SEVERIN

"It is key that the faculty propose the areas where we focus our clusters," Severin says. "We need faculty to guide the process because this effort takes a lot of passion and commitment. We need people who are excited about their research and driven to achieve their goals. It has to come from them."

Despite the university's focus on its new clusters, most faculty members still work outside the clusters, and the administration isn't neglecting them. When the university launched the cluster program, it invested in existing faculty at the department level through two new grant programs. The Chancellor's Innovation Fund provides grants to help commercialize research discoveries, and the University Faculty Scholars program supports high-performing tenured and tenure-track faculty with annual cash awards for five years.

The university also updated the policy for tenure, the system of faculty promotion traditionally granted within individual departments. Now faculty members in clusters can be evaluated either by voting faculty in their home department — the traditional method — or by an interdisciplinary review committee.

MOVING TO A NEW LEVEL

Entomologist Fred Gould is used to working with the challenges of interdisciplinary collaboration. In 2008, he and a team of NC State faculty applied to the National Science Foundation for a grant to set up an Integrated

Graduate Research and Training program to train graduate students across disciplines in the emerging field of genetic pest management.

"In the past we thought we were interdisciplinary if we had an entomologist and a geneticist working together," he says.

In the training program, Gould took interdisciplinary collaboration to a new level, bringing together researchers in communication, rhetoric, public administration and economics as well as biomathematics, molecular biology and, of course, entomology and genetics.

"The first time we submitted the application to the NSF, one of our co-principal investigators was in the English department," he recalls. "That was a little too far out for them."

The project received funding on the third try.

Gould found that NC State's sprawling campus, where faculty work in buildings organized by colleges, didn't exactly support a team working across so many disciplines.

"I had never been in a humanities or social science building," he says. "People would laugh at me because I'd end up sitting in hallways outside my colleagues' offices with my laptop and briefcase."

Despite the inconveniences, the NSF-funded training program got off to a strong start, sending a group of graduate students and faculty to Peru to study a species of mosquito on the Amazon River that transmits dengue fever. Their findings would form the basis for a white paper that would later be published as a chapter in the book *Genetic Control of Malaria and Dengue* by Virginia Tech entomologist Zach Adelman.

Today, the training program has 17 graduate students taking courses in genetic pest management, emerging technologies and society, and advanced modeling techniques for understanding human behavior as well as the behavior of targeted pests.

Like Khachatoorian in industrial design, Gould was excited by the opportunity to turn his highly collaborative program into a faculty cluster. He also realized that genetic pest management was just one aspect of a larger challenge confronting researchers: how to understand the impacts of transgenic organisms on ecosystems and societies.

It was one thing for a researcher to use genetic engineering to disrupt the reproductive cycle of mosquitos near the Amazon River. It was another thing to decide how and when to develop genetically engineered organisms that might end up in Americans' breakfast cereals and salads.

That's why Gould and a group of colleagues made the case for a new faculty cluster in the field of genetic engineering and society. With the approval of the cluster in 2012, Gould pulled together an interdisciplinary hiring committee made up of faculty in public and international

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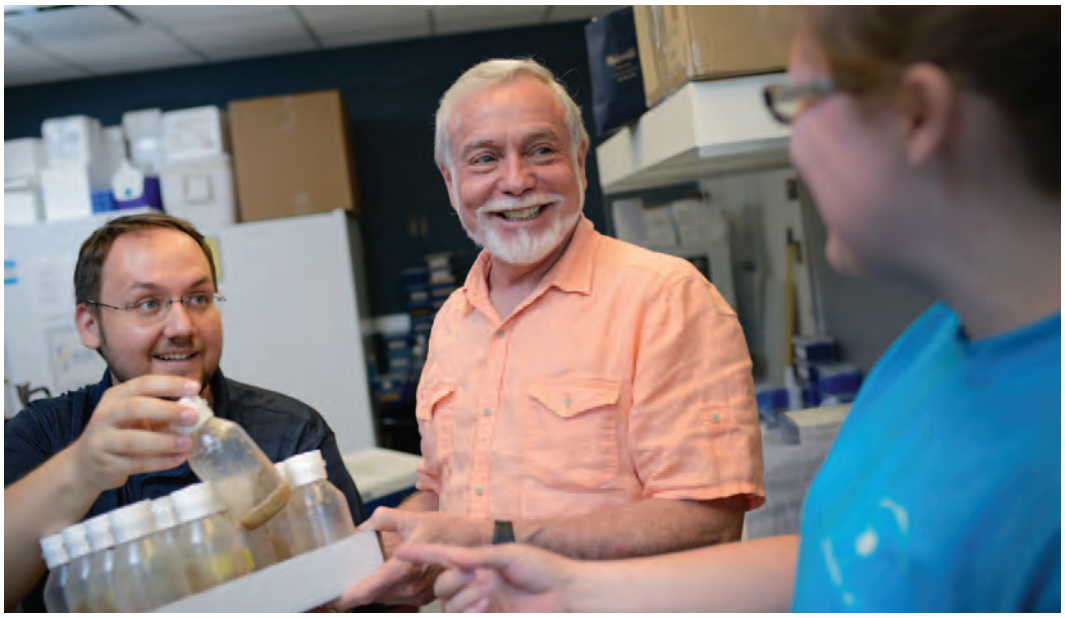
• LEFT: *Rosanna Garcia helps students apply a simulation technique called agent-based modeling to understand consumer choice.* • OPPOSITE PAGE: *Christian Hölljes is an award-winning inventor who served on the original QuickTime team at Apple Computer.*



• RIGHT: *Entomologist Fred Gould trains graduate students in the emerging field of genetic pest management.*
• OPPOSITE PAGE: *Jennifer Kuzma is one of the nation's leading experts on science and technology policy.*

affairs, public policy, agriculture and resource economics, communication, history and biological sciences to begin recruiting key faculty. He also spearheaded plans to create the Genetic Engineering and Society Center to focus the cluster's efforts in research, teaching and outreach.

In 2013 Gould recruited Jennifer Kuzma, one of the nation's leading experts on science and technology policy, and the author of more than 90 academic articles, book chapters and policy reports on governance and emerging technologies. Kuzma, then a professor of public affairs at the University of Minnesota, wasn't looking to make a career change. But when Gould called to explain his plans for the new faculty cluster and center, Kuzma was immediately interested.

"The program matched my research perfectly," she says. "As an interdisciplinary person, it's seldom that you find a perfect fit."

The harmony between the goals of the cluster and Kuzma's work wasn't as random as it seemed. Gould had been following Kuzma's research since he met her at a National Academy of Sciences meeting more than a decade ago.

"We needed someone in social sciences who could move us forward, someone who had a track record," Gould explains. "Jennifer is that key person. Her work in science and technology policy is well known — she's incredibly impressive — and she has a Ph.D. in biochemistry."

How does a biochemist with a patent on the bacterial production of isoprene end up as a distinguished professor in social sciences at a major research university?

"I was not happy working in a lab," she says. "I was always interested in bigger societal issues."

That interest took her to Washington, D.C., where she analyzed policy issues at the U.S. Department of Agriculture as a fellow with the American Association for the Advancement of Science. She also served as a study director for several reports on biotechnology and bioterrorism for the National Academy of Sciences.

"That's where the rubber hits the road, where natural science meets the policymaker," she says. "I got a real sense of where science fits into policy and how they interact."

That experience has already paid dividends in her work at NC State, where Kuzma helped organize a conference in March encouraging a dialogue between U.S. Secretary of Agriculture Tom Vilsack and stakeholders across the nation who have concerns about the impact of genetically engineered crops.

"Our vision is to become the place to go to for balanced analysis and a place for open and honest communication," she says. "We're not going to solve all the issues, but we can help different groups and different people better understand each other and look at the issues more comprehensively and more accurately."

In addition to Kuzma, the cluster recruited two other faculty members: Jason Delborne, an expert in environmental science, policy and management, formerly at Colorado School of Mines; and economist Zach Brown, whose research into the economics of malaria-control programs in Africa won the 2009 Peccei Prize from the International Institute of Applied Systems Analysis in Vienna.

WORKING IT OUT

While every faculty cluster at NC State is a unique combination of people, skills and resources, they share a common goal: putting their heads together to solve some of society's biggest challenges.

For example, the global food security cluster is focused on combating emerging infectious plant diseases. The global water, sanitation and hygiene cluster works to provide sustainable water and sanitation in the developing world. The carbon electronics cluster is pursuing technology advances to provide revolutionary computing approaches, renewable power sources, advanced energy storage and novel device capabilities.

If there were only one institutional obstacle standing in the way of each of these efforts, faculty members and administrators might breathe a little easier. Knocking down the big barriers to interdisciplinary teamwork is a cause nearly everyone in higher education supports, from deans and department heads to budget analysts and accountants.

However, there are a thousand small bumps in the road along the way to implementing a fundamental shift in the way a university functions. That's hardly a surprise in an organization whose structure hasn't changed that much since the Middle Ages.

"There are issues that we have to overcome on a weekly basis," Kuzma says, noting that she wasn't authorized to spend funds in the Genetic Engineering and Society Center for several months after she was named co-director because the center's budget was not allocated to her department.

The fact that issues like this get worked out at all is testament to the efforts of the provost's office to keep the cluster program on track. And it helps that the administrators initially charged with implementing the program are both low-key professionals who have worked at the university for 30 years, giving them a keen understanding of the people and tools available to fix almost any problem.

Larick, the vice provost for academic strategy and resource management, works behind the scenes to smooth out the rough spots in policies and procedures. As the provost's special assistant, Severin was an ambassador for the program, making sure the needs of departments and clusters were met.

In the end, the faculty clusters will only succeed if the benefits are shared across campus.

"It's time intensive," Larick says. "It's the piece that most people don't understand: how important it is to have someone in that role facilitating the changing dynamics between the traditional departments and the new interdisciplinary clusters."

As part of that effort, the Provost's Office has sponsored events to introduce newly hired faculty members to their colleagues, and it's launched an annual research symposium on campus to showcase the latest advances coming out of the clusters. As a result, some clusters have even forged partnerships with other clusters at NC State, creating what can only be described as super clusters.

Nothing could please Larick more. He notes with pride a recent collaboration between the environmental health science cluster and the data-driven science cluster. In an era when federal funding agencies such as the National Science Foundation are encouraging cross-disciplinary approaches to research, collaborations like this give NC State a competitive advantage in grant proposals.

Larick calls the research done by the faculty clusters "work that matters." So, too, is the work of creating the clusters and keeping them going.

"When a cluster has finished hiring all its faculty members, that isn't the end of the process," he says. "That's just the beginning."

"Our vision is to become the place to go to for balanced analysis and a place for open and honest communication. We're not going to solve all the issues, but we can help different groups and different people better understand each other and look at the issues more comprehensively and more accurately."

— JENNIFER KUZMA

THE POWER OF PUBLIC SCIENCE

By Brent Winter

NC State biologist Rob Dunn recalls the watershed moment several years ago when he realized that his lab's scientific research — studying ecology and evolutionary biology — was missing something vital.

"It dawned on us that, as we did research in the lab, people were earnestly asking how our work mattered in their daily lives," Dunn says. "For the most part, we couldn't answer those questions — at least not to the public's satisfaction."

Dunn started thinking about ways to help members of the public see his research as relevant to their own concerns. The ideal approach not only would inform the public about the results and implications of research; it also would find a way to involve them in the actual research itself, engaging them as "citizen scientists."

Dunn's first citizen science project, called School of Ants, sought to learn more about the ants living in backyards, schoolyards and neighborhoods by asking members of the public to collect ants and send them to the lab for analysis. The response was overwhelming: In the first two weeks alone, 20,000 people signed up to participate.

"That turned into the recognition that we could do bigger things," Dunn says. "There was a whole initiative there that was larger than anything we had thought about."

That initiative eventually became Your Wild Life, a public science and outreach program involving ordinary citizens in research on a variety of topics, including tallying species of camel crickets in the United States, and identifying microscopic organisms living on our bodies.

Your Wild Life has become one of the premier public science programs in the nation, and Dunn has become one of public science's chief advocates. "When people ask me what 'public science' is, I tell them it's science that involves the public in the creation of new scientific knowledge," Dunn says.

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"It dawned on us that, as we did research in the lab, people were earnestly asking how our work mattered in their daily lives. For the most part, we couldn't answer those questions — at least not to the public's satisfaction."

— ROB DUNN

• LEFT: *NC State's eMammal project uses volunteer-run "camera traps" to monitor wildlife populations and track the effects of hunting and hiking on mammals, such as these coyotes.*

WISDOM OF CROWDS

Dunn sees tremendous value in the ability of public science to solve problems that researchers can't tackle without the help of ordinary citizens.

One example is FoldIt, a crowdsourced method for predicting the structure of a protein molecule based on the amino acids that compose it.

Scientists at the University of Washington adapted FoldIt as part of a multiplayer online game in which people compete and collaborate to predict how a protein will fold into a three-dimensional structure based on its amino acid sequence. Since 2008, more than 100,000 people have played FoldIt — most of whom have no background in biochemistry. Already the game's players have successfully characterized the structures of a number of proteins. In 2011, FoldIt players attempted to determine the structure of a retrovirus that causes AIDS in monkeys. Scientists had been laboring at this task unsuccessfully for 15 years. FoldIt players solved the problem in 10 days.

"Cat Tracker involves people tracking the movements of their own cats with GPS devices and sharing that data with us so we can determine the effect that cats are having on the wildlife around them."

— ROLAND KAYS

Closer to home, NC State's Cooperative Institute for Climate and Satellites - North Carolina enlists the public in analyzing images of cyclones to help scientists determine the intensity of each storm. Volunteers can go to CycloneCenter.org to help the institute whittle away at their backlog of 200,000 satellite images of cyclones awaiting analysis. The scientists want each image to be classified by 10 different volunteers, to reduce the chance of error. So far volunteers have racked up about 350,000 image classifications.

Dunn applauds his colleagues' projects. "Most of the key knowledge we need to deal with climate change, manage crops and otherwise survive the next hundred years comes from work being done with the public," he notes.

Citizen science has become such a hot topic that an association has been formed to promote it. The Citizen Science Association was launched to help create a community of citizen science practitioners who can share insights, questions and innovations with each other. NC State researchers are leaders in the organization. Ecologist Caren Cooper, an adjunct professor at NC State and an assistant lab director at the North Carolina Museum of Natural Sciences in Raleigh, is co-editor of the association's peer-reviewed journal, *Citizen Science: Theory and Practice*.

"Citizen science has become a valued research approach in more and more disciplines," Cooper says. "And now there are many fields improving our ability to do citizen science well, such as informal science education, human-computer interactions, informatics, environmental psychology, geography, social sciences and science communication."

TALE OF THE CAT

The association's inaugural conference was held in February 2015 in San Jose, California, and members of NC State's Your Wild Life program were there, presenting the results of an innovative project called Cat Tracker.

"Cat Tracker involves people tracking the movements of their own cats with GPS devices and sharing that data with us so we can determine the effect that cats are having on the wildlife around them," says NC State zoologist Roland Kays, who is also a lab director at the Museum of Natural Sciences in Raleigh.

It's a well-known fact that household cats that are allowed to leave the house will kill lots of birds and mammals while they're outside. Pet cats are estimated to kill 5 billion birds and 20 billion mammals each year in North America alone. Zoologists like Kays are interested in the ecological

damage cats might be doing with all that slaughter. "If they're just killing field mice in the back yard, that may not be a big problem; but what about protected species in state parks or conservation areas?" he asks. "That's why it's helpful to know the cats' movements."

Kays is quick to point out that people shouldn't let their cats roam outside. "Cats are best left indoors, for their own sake and the sake of wildlife," he says. "But if you do let your cat outdoors, we want you to let us track it."

Cat owners who want to participate in Cat Tracker can obtain an inexpensive GPS harness that they put on their cat for five days. At the end of that time, the owner sends the data to Your Wild Life, where it's added to an ever-growing database of tracked cat movements. The project, which aims to track 1,000 cats from all over the world, has more than 100.

Cat Tracker is run completely by undergraduates, some of whom are analyzing and interpreting the data for their own research projects. Cat Tracker coordinator Troi Perkins, a senior majoring in fisheries and wildlife science as well as zoology, traveled to the Citizen Science Association conference in San Jose with Kays and other Your Wild Life researchers so she could give the group's Cat Tracker presentation.

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• TOP: *Cat Tracker uses GPS tools to track the movements of outdoor cats to learn how cats affect the wildlife around them.* • BOTTOM: *NC State scientists Rob Dunn and Holly Menninger rely on members of the public to help them conduct research on a much broader scale than they could encompass on their own.* • OPPOSITE PAGE: *As coordinator of Cat Tracker, NC State senior Troi Perkins attaches harnesses to study participants.*

• ABOVE: *NC State zoologist Roland Kays leads eMammal, which relies on members of the public placing infrared-activated camera traps in parks and other natural areas to obtain photos of wild mammals.* • OPPOSITE PAGE: *The 2,000 eMammal cameras in 32 parks across six states have captured a wealth of striking images. Volunteers identify the species in the photos and upload the pictures to the eMammal system, where trained researchers verify the species IDs.*

"Giving the presentation was nerve-wracking," Perkins says. "Even the travel was intimidating. But I'm so glad I went because I got to see this whole new realm of science where you involve the public in your work."

Perkins also works with Kays in his lab at the Museum of Natural Sciences. The Biodiversity Lab is one of several at the museum with glass walls, allowing visitors to observe the scientists as they work on their research. "My second week at State, I went to the museum and saw into all of the labs. I was like, whoa, look at those scientists doing research. I want to do that," Perkins recalls.

NAME THAT MAMMAL

Another citizen science project Kays is managing through Your Wild Life is called eMammal, which involves volunteers placing "camera traps" — infrared-activated cameras — in parks and other natural areas to obtain photos of wildlife, specifically mammals. Volunteers identify the species in the photos and upload the pictures to the eMammal system, where trained researchers verify the reports.

"The purpose of eMammal is to do large-scale wildlife monitoring so we can track the effects of hunting and hiking on mammals," Kays says. "The data we've collected over the last two years comes from 2,000 locations in 32 parks across six states. That's the great thing about citizen science: It's scalable. It allows you to scale your research up to the level of an ecosystem, which you can't do with a couple of scientists and some paid field assistants checking a few cameras near your lab."

One of the unique features of the eMammal project is that middle-school students are running some of its cameras. Students at four Wake County schools — East Cary Middle, North Garner Middle, Carroll Middle and East Wake Middle — have installed camera traps around their schools to see animals that cross the school grounds at night and on weekends, when the campus is deserted.

"These students are collecting real data and doing real research where we don't know what the answer will be at the end," Kays says.

Student participation in eMammal is just one part of a larger K-12 science-education project called Students Discover, also being run by Your Wild Life.

"We've always received inquiries from science teachers who wanted to implement some aspect of our work into

"The purpose of eMammal is to do large-scale wildlife monitoring so we can track the effects of hunting and hiking on mammals. The data we've collected over the last two years comes from 2,000 locations in 32 parks across six states. That's the great thing about citizen science: It's scalable. It allows you to scale your research up to the level of an ecosystem, which you can't do with a couple of scientists and some paid field assistants checking a few cameras near your lab."

— ROLAND KAYS

their classrooms," says entomologist Holly Menninger, a Your Wild Life researcher who is the inaugural director of public science for NC State's College of Sciences.

"The issue for the teachers was that they needed to connect research questions and activities to curriculums and standards, but we didn't have a way to do that at first. To remedy that, we brought a high school math teacher onto our team and partnered with educational organizations on campus — particularly the Kenan Fellows program, the Science House and the Friday Institute for Educational Innovation — to apply for a math and science educational partnership grant from the National Science Foundation."

CLASSROOM CONNECTION

In 2013 the NSF awarded the team a five-year, $7.2 million grant to fund the work of Students Discover. The project involves middle-school teachers in the Kenan Fellows program partnering with early-career scientists in labs at the Museum of Natural Sciences over the summer to develop a citizen science project and associated curriculum modules that the teachers take back to their classrooms. After the curriculum modules are piloted and refined in the Kenan Fellows' classrooms, they'll be shared online so teachers anywhere in the world can use them.

"It's an opportunity for teachers and students to be involved in doing authentic research, real science, where the answers are not known ahead of time," Menninger says. "What students usually see in a science classroom is demonstration science — looking at what is already known. But in this project, students get to help make actual scientific discoveries."

Each year a new cohort of 12 Kenan Fellows from all over the state enters the program. One of the 2014-2015 fellows, Laura Cochrane, says both she and her students had a great time being involved with Students Discover.

"My experience with Students Discover was a game changer," says Cochrane, who teaches sixth-grade science at Mills Park Middle School in Cary. "I see real

continued

potential for engaging students more in the field of science, and it's so smart to use middle schoolers as the jumping-off point. They love feeling like what they're doing in their classroom is making a difference in real-world science."

Cochrane and two other teachers worked with microbial ecologist Julia Stevens in the Genomics and Microbiology Lab at the Museum of Natural Sciences to learn about Stevens' research on the beneficial microbes that dandelions recruit from soil, and how environmental conditions can affect that process.

"In the fall we began implementing the curriculum by asking students to bring in soil samples from their own yards and neighborhoods to use in the experiment," Cochrane says. "Then the students dug up dandelions around the school grounds, and they followed the procedures given by Dr. Stevens to sterilize the roots and replant the dandelions in the soils they brought in from their neighborhoods. The goal was to determine if the dandelion could recruit the microbes it needed from the new soils."

"We have an epicenter of citizen science activity in the Raleigh area. This will be a great place to provide context."

— EMLYN KOSTER

After four weeks, the students pulled the dandelions up, scraped the roots and sent samples to Stevens at the museum, who used polymerase chain reaction to sequence the DNA in the soil to discover which microbes it contained. When the data were ready, Stevens shared it with the class so they could see the results of their research.

"Students got an opportunity to analyze DNA data from the dandelion soil samples they worked with and to actually identify the types of bacteria found in the samples," Cochrane says.

"They were also able to compare the data from their soil samples to those found by the classes taught by my fellow Kenan teachers. This lesson provided much more depth than sixth-graders usually get. They felt ownership of the data, and they were excited to be doing real science and adding to the collective sciences, instead of the data just dying in a lab notebook."

BUILDING MOMENTUM

As extensive as all these citizen science activities are, the movement is still picking up steam. The next cohort of Kenan Fellows is already developing the next set of science curriculums to be used in their classrooms and shared online.

Troi Perkins is adding a new research question to the Cat Tracker project: What do cats eat when they leave the house? Hair samples gathered by cat owners will help to answer that question.

Roland Kays is looking to expand both Cat Tracker and eMammal all over the world; eMammal already has cameras in place in India and Mexico, and Cat Tracker has partnered with researchers in Australia and New Zealand.

Holly Menninger is setting some ambitious goals for her new position as director of public science for the College of Sciences, such as training the next generation of science communicators.

And the Citizen Science Association will hold its next conference in 2017 at the Raleigh Convention Center,

jointly hosted by the Museum of Natural Sciences and NC State. With the conference expected to draw at least 1,000 attendees from around the globe, museum director Emlyn Koster expects to showcase dynamic partnerships at work. "We have an epicenter of citizen science activity in the Raleigh area," he says. "This will be a great place to provide context."

In what may be the most exciting development for NC State researchers working in public science, the university recently announced that the Chancellor's Faculty Excellence Program — an innovative faculty-hiring initiative that recruits world-leading faculty to work in interdisciplinary clusters — will create a cluster in leadership in public science. The cluster will unite faculty across the Colleges of Natural Resources, Sciences, Education, and Humanities and Social Sciences in efforts to design and conduct scientific research that involves, educates and informs the public in a meaningful way.

Rob Dunn, a co-leader of the new cluster, is looking forward to expanding the possibilities of public engagement with science at NC State and around the world.

"We can be a think tank," Dunn says. "Not just do public science, but be a place that innovates how to do public science."

Learn more about Your Wild Life at yourwildlife.org. Follow plans for the 2017 Citizen Science Association meeting in Raleigh at citizenscienceassociation.org.

• ABOVE: *NC State University has strong partnerships with the North Carolina Museum of Natural Sciences, which has a range of citizen science projects, including bird counts. The university and museum will co-host the international conference of the Citizen Science Association in February 2017.*

Focus on Prosperity

NC STATE IS A KEY ECONOMIC DEVELOPMENT PARTNER IN THE TRIANGLE AND BEYOND

By Katie Mosher

"We see a unique role for NC State in its ability to help attract and retain — in collaboration with the state of North Carolina, along with counties and communities — significant economic investments in the state. Companies leverage our research, expertise and workforce development efforts. Our innovation activities bring new jobs to North Carolina."

— MLADEN VOUK

When CBC Americas Corporation was considering new locations for its headquarters, company leaders based their decision on more than just money. That's why meetings with NC State University's Japan Center helped them select North Carolina as their new base of operations.

At an April event announcing the company's move from New York, North Carolina Gov. Pat McCrory credited John Baugh, the center's director, with providing key "one-on-one dialogue" that welcomed CBC officials and opened wider discussions about the merits of the state.

NC State Chancellor Randy Woodson also noted that the Japan Center has played similar roles for 35 years by hosting economic delegations, fostering cultural collaborations and offering language classes. North Carolina commerce leaders count at least 180 Japanese companies or subsidiaries in the state, which together employ thousands.

The Japan Center is among resources in the university's expanding toolbox to enhance economic development and prosperity. These efforts complement the $6.5 billion in North Carolina income attributable to NC State's economic impacts in 2012-13 alone, as measured by a recent study from the University of North Carolina system. *(See related story on page 23.)*

"We see a unique role for NC State in its ability to help attract and retain — in collaboration with the state of

• ABOVE: *The North Carolina Japan Center, part of NC State University, offers language classes and cultural programs that are vital resources for Japanese companies in the state and those considering a move here.* • OPPOSITE PAGE: *The Japan Center was the setting as North Carolina Gov. Pat McCrory lauded the announcement that CBC Americas Corporation would move its headquarters and another facility to North Carolina. Other speakers included company CEO Kazuhiko Kondo and NC State Chancellor Randy Woodson.*

North Carolina, along with counties and communities — significant economic investments in the state," explains Mladen Vouk, interim vice chancellor for research, innovation and economic development.

"Companies leverage our research, expertise and workforce development efforts. Our innovation activities bring new jobs to North Carolina."

KEY COLLABORATIONS

Thomas J. White, director of the university's Economic Development Partnership, notes that industry executives often initiate contacts. "We consistently receive a healthy volume of direct requests from business and industry for our NC State support services in some form or fashion."

Each year, NC State is involved in dozens of varied projects. "We work as part of a cohesive team to match demands in the marketplace with our ample supply of research labs, faculty expertise, and student and alumni talent," White explains. "We do so in concert with our local, regional and state economic developers."

When White joined NC State in 2008, the university already was engaged with the Wake Economic Development Program, the Research Triangle Regional Partnership (RTRP) and the North Carolina Department of Commerce to promote capital investment and employment attraction/retention.

"The success of this 'triple helix' collaborative endeavor — involving academia, business and government — held great promise for statewide application," White recalls. "We had an opportunity to uphold the charter of NC State's fervent commitment as a land-grant institution to broad-based economic growth."

White chairs the statewide Economic Transformation Council, working closely with Leslie Boney, a University of North Carolina system vice president with a focus on economic development. White also has been active in the 16-county RTRP since his days as president and CEO of the Durham County Chamber of Commerce.

"Tom's knowledge is especially important in helping counties identified as among those with the greatest economic needs in the state," Vouk notes.

For example, the North Carolina Rural Center selected six locations for meetings this summer to focus on economic development. NC State has new and expanding industry projects in four of the locations: Semprius in Henderson, Aseptia/Wright Foods in Troy, Brooks Brothers in Clinton and Wood Grain Millwork in Lenoir.

White, who previously led the state's $100 million program to help displaced workers and youth get jobs, also continues to work with the Backpacks to Briefcases program. NC State recently received a $386,000 grant from Duke Energy via the North Carolina Community Foundation, to provide training and paid internships to 100 recent college graduates in Wake and Johnston counties. Campus partners include the Career Development Center and Alumni Association. Other partners are the Capital Area Workforce Development Board and EDSI Solutions.

"NC State's amazing strengths include capacity building and networking," White adds. He cites a variety of campus leaders active in economic development, starting with Woodson.

In addition, some programs have regional offices, such as the Small Business Technology Development Center (SBTDC), led by Scott Daugherty, and the Industrial Extension Service, led by Terri Helmlinger Ratcliff. Travis Burke is the

continued

"We work as part of a cohesive team to match demands in the marketplace with our ample supply of research labs, faculty expertise, and student and alumni talent. We do so in concert with our local, regional and state economic developers."

— THOMAS J. WHITE

interim director for the North Carolina Cooperative Extension Service, which has a presence in all 100 counties. Kelly Sexton leads NC State's Office of Technology Transfer, which helps startups to launch and established companies to expand.

The state's official economic development guide even features several centers on NC State's Centennial Campus: the Nonwovens Institute, led by Behnam Pourdeyhimi, the FREEDM Systems Center, led by Iqbal Husain, and PowerAmerica, led by Nick Justice.

White sees a particular NC State strength in working with smaller and midsized companies. Here are just a few examples:

TAKING FLIGHT

Morganton-based VX Aerospace is developing an aircraft dubbed the VX-1 KittyHawk, a tribute to pioneering flights on the North Carolina coast.

"The blended wing/body is a combination of proven technologies, and the result is a light aircraft that will command as much attention for its future-looking design as it will for its interior comfort and fuel cost per flight hour," the Economic Development Partnership of North Carolina noted when announcing a $25,000 grant from the Innovation Fund North Carolina.

With the popularity of the U.S. Federal Aviation Administration's new light-sport aircraft category, VX Aerospace sought NC State's help to move the KittyHawk from idea to proof-of-concept testing. The aircraft expands an existing niche in advanced composite structures. Production also would draw upon expert tool-and-die makers in the region.

Rich Gould, who heads NC State's Department of Mechanical and Aerospace Engineering, identified KittyHawk as a good fit for Chuck Hall, who directs the department's Flight Research Group.

That connection led to computational fluid dynamics analysis and wind tunnel testing, then building a 1:4-scale prototype. Test flights — with videos posted on the company website — demonstrated the design's dynamic stability and flying qualities. VX touts the unique aircraft design as very efficient aerodynamically, while also offering a usable internal volume that is more than twice as large as traditional designs of the same weight.

Robert Skillen, company CEO and chief engineer, enjoys working with the university. "Decisions are made quickly, followed by actions," he notes. "NC State understands business. Here at VX Aerospace, we are thrilled with our association with North Carolina's flagship university."

Gould agrees. "It has been a pleasure collaborating with VX," he says. "Outreach and extension are what make NC State unique, and we are happy to help North Carolina companies in any way we can. It's also a great experience for our students to work with companies — a true win-win."

ENCOURAGING EXPANSION

White and his collaborators often help keep homegrown North Carolina companies in the state as they mature and expand.

When Argos Therapeutics broke ground for a $50 million,

124,500-square-foot automated biomanufacturing facility in Durham, White counted it as a victory — even though it is a spinout enterprise from Duke University.

The new facility will meet strict Food and Drug Administration requirements, and the company anticipates adding at least 230 jobs in research, development and manufacturing in coming years. "Argos' cutting-edge work in personalized immunotherapy may lead to new treatments for people living with cancer, HIV and other serious illnesses," Gov. McCrory said.

Randal Goller, Argos' facilities director, describes construction of the facility as a milestone. "We are in a position now that we can do something very special," he says.

Argos' Arcelis technology platform induces a potent immune response targeted to each patient's disease. One product is in pivotal clinical trials for patients with metastatic kidney cancer. Another is in earlier trials, as

• OPPOSITE PAGE, TOP: *VX Aerospace has worked with NC State to develop and test a scale model of the VX-1 KittyHawk aircraft.* • MIDDLE: *From left, Bob Skillen of VX Aerospace, NC State student R.J. Gritter and Lars Soltman, an aerospace doctoral candidate, review the scale model.* • BOTTOM: *Skillen, center, accepted an economic development partnership award this year from Provost Warwick Arden and Vice Provost Terri Helmlinger Ratliff.* • THIS PAGE, TOP: *The Golden LEAF Biotechnology Training and Education Center on Centennial Campus is a key partner for many companies in the Triangle region and beyond.* • BOTTOM: *Argos Therapeutics worked closely with NC State and other partners in its ultimate selection of a manufacturing facility site in Durham County.*

part of a drug-combination treatment for HIV eradication in adults.

With the science in hand, Argos needed help in business development. A venture capitalist suggested company officials meet with White. "Tom immediately got the ball rolling," Goller recalls. "Everyone respects Tom. He was able to introduce us to a lot of folks, and we were able to connect the dots."

A 2011 meeting of Argos collaborators at the Golden LEAF Biomanufacturing Training and Education Center on NC State's Centennial Campus stands out for White. "It's a salient example of how a venture capital network — and corporate leaders in those networks — can help produce a broad array of support-service delivery from multiple constituencies," he says.

NC Central University's Golden LEAF BRITE program also was a partner. "The retention and expansion of existing companies is a high priority in today's economic development world, and in higher education. This collaboration of Duke, NC Central and NC State epitomizes our collective commitment to that laudable goal," White adds.

He helped to arrange dozens of meetings for Argos to consider sites and opportunities in Wake, Durham, Vance, Granville, Orange and Alamance counties. Argos also looked at locations and incentives in Texas, Florida and Canada.

After all the searching, Argos stayed close to home. "We knew that we wouldn't lose any employees," Goller says, noting the financial support of Durham city and county leaders, state commerce programs and the North Carolina Biotechnology Center. "All the stars aligned."

IDENTIFYING SOCIAL SKILLS

A recent *Newsweek* story gives national attention to the success 3C Institute has achieved by focusing on communication, cooperation and confidence — essential skills for healthy relationships and businesses.

3C's cornerstone product is Zoo U, a suite of research-proven, personalized game programs to help students learn social and emotional skills. An affiliated company, Personalized Learning Games, is marketing Zoo U, with several other products for grades K-8 in the pipeline. 3C also is developing health care apps to help youngsters with chronic illnesses understand their conditions and transition to self-care management as teens.

Melissa DeRosier, CEO of 3C Institute, sees great potential for continued expansion by adding game-based

continued

• TOP: *Zoo U, the cornerstone product for 3C Institute, helps youngsters build social skills.*

• BOTTOM LEFT: *Tom White, who leads NC State's Economic Development Partnership, has worked closely with Melissa DeRosier to help the 3C Institute to grow.*

• BOTTOM RIGHT: *DeRosier leads a meeting with colleagues from the North Carolina Small Business Technical Development Center; from left, Michael Carnes, John Ujvari and Mike Seibert.*

tools to develop workplace skills. In fact, the company moved to larger headquarters near Research Triangle Park.

"My area is social and emotional learning. Those are 21st-century skills that are essential for success in school and for workforce development," she explains. In addition to the three Cs, she cites self-discipline, empathy, collaboration and leadership. "In today's workplace, it is critically important for everyone to have these skills."

DeRosier recalls early meetings with NC State partners in 2002. "Without a doubt, SBTDC supported the growth and development of my company from the very beginning."

Michael Seibert of SBTDC and White offered 3C multiple consultations over the years and referrals for market research and interns. These steps helped the company successfully compete for state and federal grants. DeRosier also has worked with James Lester, who directs NC State's Center for Educational Informatics, and has hired several of his computer science graduates as game developers.

DeRosier's NC State contacts initially suggested leadership workshops. She now accepts their invitations to give keynotes, describing her business model, her community work with North Carolina New Schools and her service on Holly Springs Mayor Dick Sears' anti-bullying task force.

White says DeRosier's company is an example of doing well by doing good. "3C is a wonderful model of social entrepreneurship. Melissa and her team thrive on designing sophisticated products that, at the end of the day, improve and enhance the quality of life for her customers and clients and our communities."

COLLABORATING ACROSS CULTURES

It was no surprise that CBC Americas, a subsidiary of CBC Co. Ltd. of Japan, and state officials chose the NC State's Japan Center as the backdrop to announce the company's relocation

of its headquarters to Wake County and development of another facility in Alamance County.

"John Baugh and Reiko Chosokabe of the NC Japan Center played a leadership role in hosting numerous meetings with company officials and state and local economic development staff as the due-diligence process played out," White says, noting that North Carolina won out over incentives from Pennsylvania.

At the official announcement, John Skvarla, state commerce secretary, shared a list of more than a dozen other partners in the CBC Americas success story, including the state's Economic Development Partnership, town and county boards, economic developers, Meredith College, Elon University and the North Carolina Community College System.

The move is strategic for CBC Americas' organizational updates and growth. The company specializes in security solutions, chemicals, pharmaceuticals, renewable-energy technology and video-surveillance products.

"North Carolina will provide CBC with the economically rich environment so we can continue to thrive while providing the state with secure, well-paying jobs and tax revenues," CEO Kazuhiko Kondo explains. "Our employees will benefit from the educational resources and cultural and leisure activities that North Carolina has to offer."

The move combines the best of both cultures, he adds. "I look forward to a bright future in North Carolina."

NC STATE ADDS BILLIONS TO STATE, LOCAL ECONOMIES

NC State's economic impact includes contributions to the economy of Raleigh, shown above, as well as the Research Triangle region and the entire state.

An economic impact study commissioned for the 16 colleges and universities in the University of North Carolina system shows that NC State University packs a tremendous economic punch for Wake County, the Triangle region and the state.

During the 2012-13 fiscal year, NC State and its various enterprises created $6.5 billion in added income to the North Carolina economy, including $4.8 billion in income for the 13-county regional economy and $3.3 billion in Wake County income.

The study estimates that the added $6.5 billion to the statewide economy is equivalent to creating 91,505 new jobs. The $4.8 billion in added regional income is equivalent to creating 59,237 new jobs. The $3.3 billion in added county income is equivalent to creating 44,538 new jobs.

"This study shows what we've known for many years: Our public universities provide a staggering impact to the local and state economies and are primary drivers of growth across North Carolina," notes NC State Chancellor Randy Woodson. "Every taxpayer dollar that comes in to NC State yields nearly $4 of return on investment in the form of research advancements, new technologies, new companies, the most-prepared graduates and jobs waiting for them."

The study, conducted by Economic Modeling Specialists International, examines a variety of factors to produce what is arguably the most comprehensive picture of the UNC system's economic impact ever undertaken.

The report shows that for every $1 that society spent on education at NC State throughout the 2012-13 fiscal year, it will gain $9 in added state income and societal savings for as long as the 2012-13 NC State students remain active in the North Carolina workforce. For every dollar spent by taxpayers, they gain $3.80 in added taxes and public sector savings.

The accumulated contributions of NC State alumni currently employed in the North Carolina workforce amounted to $4.2 billion in added state income, which is equivalent to creating 67,465 new jobs. Alumni impact totaled $2.3 billion of the $4.8 billion in additional income in the region and $1.5 billion of the $3.3 billion of additional income in Wake County.

The study also shows that university-related startups created $1.2 billion in added state income, which is equivalent to creating 5,799 jobs. Startup impact also created $1.1 billion in added regional income and $471.1 million in added county income.

About 19 percent of NC State's graduate and undergraduate students are from outside the state. The expenditures of these students who relocated to the state during the analysis year added approximately $60 million in state income for the North Carolina economy. About 71 percent of NC State's resident students came from outside Wake County in 2012-13, while 60 percent came from outside the 13-county region surrounding the university. Their relocation to Wake County and the corresponding expenditures on rent, groceries, transportation and the like added $133 million to the regional economy and $126 million to the county economy.

Out-of-state visitors attracted to North Carolina for activities at NC State brought new dollars to the economy through their spending at hotels, restaurants and other businesses. Visitor spending added approximately $17.6 million in state income to the North Carolina economy. Spending by those who live in North Carolina but came from outside the county and region to attend an NC State activity added $26.8 million to the regional economy and $26.5 million to the Wake County economy.

NC State University Communications contributed to this report.

WebAssign Leads Educational Technology

By Gene Pinder

Few physics professors become entrepreneurs. Fewer still build a company that goes on to service more than 1 million students at more than 2,300 educational institutions, becoming the leading independent provider of online instructional tools for faculty and students in the world.

That's the legacy of NC State professor John Risley. Colleagues were saddened by his death in 2013. But the company he launched in 1997 — Advanced Instructional Systems, known as WebAssign — has become a formidable innovator in customizable online instruction.

From its headquarters on Centennial Campus, WebAssign has built an online class management system that allows instructors to build assignments, administer secure tests, provide practice problems and track student progress and results with analytical tools.

The system also has built-in email capability, and it provides interactive content such as simulations, videos and tutorials to enhance learning. All major academic publishers have adopted WebAssign and have integrated it with more than 900 textbooks.

In short, WebAssign has become the go-to tool for thousands of college and high-school faculty members.

"I find that WebAssign has all of the features I want in a learning management system, with fewer things I don't use — and thus, less complexity," explains Betty Black, professor of biological sciences at NC State. "Development within WebAssign is intuitive and easy to learn. It also has an excellent grade book, and the website is very reliable, even with large numbers of simultaneous users."

Lori Petrovich has a dual perspective on WebAssign. She began using the platform in her NC State chemistry lectures in 2003 and in laboratory sessions in

• ABOVE: *Collaborating at the WebAssign headquarters on Centennial Campus are, from left, Alicia Hundley, Chris Gearing, Robert Davis and Annie McQuaid.*

2006. "The instructional support provided by the WebAssign platform allows me to focus on what I truly enjoy: interacting with students as individuals and teaching them chemistry," she says.

For lectures, the program provides immediate and constant feedback to students. "Students are always aware of their grades in the categories of homework, participation and exams — and of their overall grade," Petrovich explains.

"The e-textbook is hosted by WebAssign, such that students can easily find reference materials, charts and constants," she adds. "I also find the ability to view all of a student's submissions to a question helpful. I have often pulled up this view when a student visits me during office hours or emails me and have been able to easily recognize and explain their misconception by the submissions they made."

In the lab, WebAssign keeps teaching assistants and students on schedule with assignments and lab grades. "With WebAssign doing the heavy lifting of grading and calculating grades, the TAs have more time to invest in assisting students during the lab period and explaining chemistry," Petrovich says.

WebAssign courses can roll over from one semester to another. "This has freed up time in my schedule so that I am able to work on improving my classroom presentation and developing supportive materials for students to learn outside of class," she adds. "The diagnostics on each question have helped me discover where improvements in the lecture presentation and additional resources are needed."

That kind of feedback is music to the ears of Mark Santee, vice president of product development and marketing for WebAssign. Since joining the company in 2009, Santee has seen it go through the usual growing pains of a technology company gaining traction in the marketplace, while ironing out technical glitches. He says it's a never-ending process of releasing new functionality and features that better serve WebAssign's users.

The company's future looks bright. WebAssign continues to increase its new business by 12 to 15 percent each year. In addition to providing services to faculty and students in the United States, the company also provides services in other countries, including Canada, Australia, New Zealand, the United Kingdom, Hong Kong, the Philippines, South Africa, Israel, Saudi Arabia and Mexico.

Company leaders want to move WebAssign into other disciplines, such as statistics and business. The management team also sees growth opportunity in the secondary education market as high-school teachers move toward online interaction with students.

At the core of successful educational technology is an understanding of the data related to use of that technology.

One new trend in education, often called adaptive learning, involves companies such as WebAssign capturing data on how a student is progressing and then using that data to tailor-fit the learning experience to better match the student's needs.

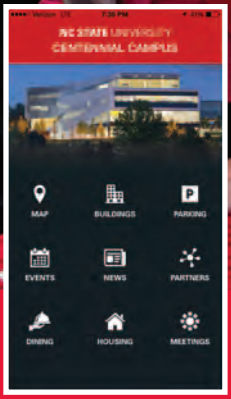
Santee says WebAssign and others are just now scratching the surface in terms of what's possible in this emerging field. "From a technology standpoint, we're still feeling our way through this, with a few bumps along the way," he says. "Next year, though, our goal is to provide better data to students."

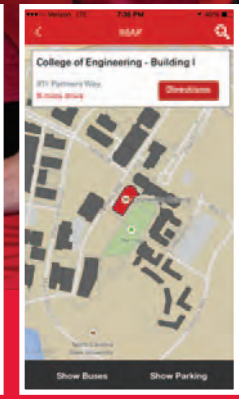
Whatever the future holds for this educational technology company, being located on Centennial Campus has proven to be an invaluable asset for WebAssign.

"It's energizing," Santee says. "We feel that having this close access to faculty and students gives us a huge competitive advantage. We talk to teachers every day about their experiences and get their opinions, and that feedback is invaluable."

With nearly 200 full-time employees and bold new plans for future growth, WebAssign continues to realize the vision John Risley set out for the company nearly 20 years ago. His legacy extends to the overall campus through the annual John S. Risley Entrepreneur of the Year Award.

"The campus environment today is extremely supportive of faculty entrepreneurship," says Kelly Sexton, director of NC State's Office of Technology Transfer. "This is due in large part to pioneers such as Dr. Risley. His example continues to inspire NC State faculty to engage in commercialization of their innovations."





• ABOVE: *Chancellor Randy Woodson shared stories with Bob Geolas, now executive director of the Research Triangle Foundation, Mimi McKinney, widow of Claude McKinney, and Carla Skuce.* • RIGHT: *Check out a new app for Centennial Campus.*

Centennial Campus Celebrates Collaborations

By Gene Pinder

NC State's Centennial Campus marked 30 years of success recently with an event that drew corporate, governmental and nonprofit leaders, along with current tenants and university partners.

Chancellor Randy Woodson cited the importance of the campus in the university's overall strategic plan — and encouraged all gathered to continue making it one of the finest research campuses in North America.

From empty farm fields to an internationally recognized innovation center, Centennial has seen tremendous progress in the 30 years since 1,227 acres, originally part of the Dorothea Dix hospital complex, were deeded to NC State. Soon the campus had buildings with businesses and academic programs.

Today, Centennial has more than 70 corporate, governmental and nonprofit partners, along with more than 75 academic programs. It is also home to the renowned Hunt Library, the Lonnie Poole Golf Course, the Park Alumni Center, the chancellor's residence known as The Point, privately built apartments and townhomes, the Wolf Ridge student housing complex, walking and bike trails, a nine-hole disc golf course, ball fields and the publicly accessible Lake Raleigh. Centennial also includes the biomedical campus housing the College of Veterinary Medicine, located across from the North Carolina State Fairgrounds.

But the best may be yet to come.

Woodson also unveiled a video of Vision 2034, the university's strategic vision to turn Centennial Campus into North America's premier innovation destination.

The campus will be a proving ground for new and innovative technologies — including some for advanced transportation — as well as collaborative spaces and places. The plan also calls for remotely connecting NC State equipment, classrooms and labs with researchers globally.

Vision 2034 calls for a vibrant campus that not only encompasses a town center but also celebrates the arts and honors achievements by NC State's leading innovators and scholars. Learn more at centennial.ncsu.edu.

QUICK TAKES

RESEARCH ADVANCES SAFETY OF UNMANNED AIRCRAFT

NC State has joined a coalition of leading research universities selected by the Federal Aviation Administration to study ways to safely integrate unmanned aircraft systems into the nation's airspace.

The new Center of Excellence for Unmanned Aircraft Systems, led by Mississippi State University, will develop secure, reliable and robust data links to ensure connectivity between unmanned aircraft and other users of the National Airspace System, such as air traffic controllers and piloted aircraft. The center also will develop communication protocols and standards for evaluating the performance of links in nominal, contingency and emergency flight operation scenarios.

"NC State is proud to be a leader in this important research effort," Chancellor Randy Woodson notes. "The collaboration and innovation that happen at NC State will bring critical advances to the rapidly evolving field of unmanned aircraft."

NC State's research will be centered in its NextGen Air Transportation program on Centennial Campus. NGAT was established in 2012 under the North Carolina Department of Transportation's Division of Aviation. The program has approval from the state and the FAA to conduct research operations for purposes such as agricultural research, emergency response, and surveying and mapping. In just over two years, NGAT has made more than 300 flights and logged 100 flight hours at six locations. NGAT is developing the statewide infrastructure for research and operational integration of unmanned aircraft systems.

• TOP: *NC State has joined a coalition of leading research universities to study ways to safely integrate unmanned aircraft systems into the nation's airspace.* • BOTTOM: *A prize-winning bite-sleeve design will be used to train police and military dogs.*

K9 TRAINING TECHNOLOGY MOVING TO MARKET

Police and military dogs may soon have a training tool they can really sink their teeth into. NC State and K2 Solutions Inc. have entered into an exclusive option agreement to commercialize a realistic bite sleeve that mimics a human arm.

The technology was developed and refined by teams of NC State students and professors in textile engineering and materials science. Originally funded by the U.S. Army Research Office and the University of North Carolina system, it was named best overall project at NC State's Senior Design Day in 2014, then refined by another team in 2015.

K2 is a disabled-veteran-owned small business in Southern Pines that provides canine training, handler instruction and other consulting services to national security and defense clients.

STUDY EXAMINES GENETIC LINK TO CHEMICAL SENSITIVITY

NC State researchers are working with colleagues from across the United States to discover why genetic differences in humans affect the toxicity of some chemicals but not the others. The project is the first large-scale, cell-based screening to test variations in environmental chemical sensitivity across a range of human populations and link them to genetic data. The data will improve risk assessment and shed light on the ways in which genes interact with certain chemicals.

Testing chemicals for potential human health hazards involves testing hundreds of chemicals in vitro by exposing a cell culture to differing concentrations of a chemical and recording various responses in hundreds of assays. However, the cell cultures used in these tests are usually derived from either rodents or a small sample of humans.

"The current method is good for establishing rough averages in toxicity response, but we know that different people react differently to chemical exposure," says Fred Wright, who has dual appointments in statistics and biological sciences at NC State and is a co-lead author of a paper describing the project. "We wanted to design an experiment that could quickly test a lot of different chemicals against a large variety of populations, both to determine variability among responses and to see if toxicity responses could be linked to specific genes."

Results reveal that, for some chemicals, the range of sensitivity among individuals is greater than previously thought. The NC State team, including statistician Alison

continued

Motsinger-Reif and biostatistician Yi-Hui Zhou, was instrumental in discovering several genetic variations that correlated to chemical sensitivity.

OUTFITTING FIRST RESPONDERS

What pant and shirt combination should a well-dressed EMT or firefighter be wearing? That's a challenge that NC State's textiles experts are tackling.

They're creating the next generation of uniforms for first responders — clothing that's more comfortable, with better protection.

Researchers with T-PACC, the Textile Protection and Comfort Center, are designing and testing a new base ensemble of shirts and pants for emergency workers as part of a $718,000 grant project funded by the U.S. Department of Homeland Security.

"This base ensemble is what a firefighter would have on before grabbing a helmet and turnout coat on the way to a call," says Marc Mathews, a T-PACC research associate. "We want to equip first responders with clothing that's more flame resistant, repels water and protects against jagged debris at a scene. At the same time, the clothing has to be comfortable and appealing enough for a firefighter to wear while working a 24-hour shift."

The T-PACC team will create and test prototypes using commercially available materials. A subcontractor, Protect the Force, will help manufacture 150 prototypes for field testing.

The project builds on T-PACC's longstanding research. NC State researchers have pioneered many tests used to evaluate clothing for emergency workers, military personnel, high-performance athletes and others who use protective gear.

REBAR TO LEAD NC STATE RESEARCH INNOVATION EFFORTS

Alan Rebar, an internationally recognized expert in clinical laboratory medicine, will take the helm of NC State's Office of Research, Innovation and Economic Development this fall.

Rebar comes to NC State from Purdue University, where he served as a professor of clinical pathology, headed the research office and oversaw Discovery Park, the university's 40-acre research park.

Rebar is a diplomate of the American College of Veterinary Pathologists, a former member of the Council of the American College of Veterinary Pathologists, past president of the American Society for Veterinary Clinical Pathology, former editor of the journal *Veterinary Clinical Pathology* and current editor of the *Journal of the American Animal Hospital Association*.

He has authored or co-authored 120 refereed publications and eight textbooks, and he has made nearly 300 invited lectures at workshops and conferences in the United States and around the globe. He has also served as a scientific advisor to numerous federal agencies and companies.

In recognition of his achievements, Rebar received the Award of Merit from the American Animal Hospital Association in 1989 and its Gaines Cycle Fido Award for outstanding contributions to small animal medicine and surgery in 1994. He also received the 2001 Waltham Award for his work to improve the well-being of companion animals.

Rebar earned two doctorates — in veterinary medicine in 1973 and in veterinary pathology in 1975 — both from Purdue.

STUDY EXAMINES ENVIRONMENTAL IMPACTS ON HEALTH

Researchers from NC State's planned Center for Human Health and the Environment have received a five-year, $6.5 million grant from the National Institute of Environmental Health Sciences to investigate the effects of environmental factors on humans.

Through interdisciplinary research and collaboration, the center seeks to construct a complete picture of how environmental stressors influence human-health outcomes.

The grant will advance research and support community outreach. The grant will make the center one of 22 across the nation dedicated to studying environmental-health impacts.

The center brings together 70 investigators from 13 departments and six colleges at NC State, as well as investigators from East Carolina University's Brody School of Medicine, North Carolina Central University, the North Carolina Department of Health and Human Services and the RTI National Institute of Health Eastern Regional Comprehensive Metabolomics Resource Core.

• TOP: *A U.S. Department of Homeland Security grant is funding design and testing of protective gear for emergency workers.* • BOTTOM: *Alan Rebar takes the helm at NC State's Office of Research, Innovation and Economic Development.*

RESEARCH AIMS TO PERSONALIZE CLINICAL TRIALS

As interest in personalized medicine increases, physicians and researchers require even more data about their patients to recommend

• ABOVE: *Studies show that coyotes kill one out of every two deer fawns born in the Fort Bragg area.*

the best treatment options. However, most clinical trials are not currently designed with personalized medicine in mind.

A $10.4 million grant from the National Cancer Institute will help researchers from NC State, the University of North Carolina at Chapel Hill and Duke University develop new statistical methods to design clinical trials for cancer treatments and to analyze resulting data.

These new trials, designed to incorporate a large variety of factors, will help physicians ensure the best outcomes for patients based on individual characteristics. The new funding is an extension of a $12.5 million grant awarded in 2010.

"Currently, most clinical trials offer a randomized snapshot of one moment in time," says Marie Davidian, William Neal Reynolds Professor of statistics at NC State and a principal investigator on the project. "These trials can tell you whether treatment A or B is more effective, on average.

"But effective treatment of individual patients, especially for a progressive and recurring disease like cancer, requires a physician to make a series of decisions over time while taking the patient's information into account. And as we get access to more patient data, like genetics, medical history and characteristics called biomarkers that might be associated with the patient's response to a particular drug, it only makes sense to try and design clinical trials that can take those factors into account as well."

To address the problem, Davidian and colleagues are designing clinical trials that not only take many factors into account but also that can take place at each decision point in a course of treatment.

COYOTE IS NEW TOP DOG

It's believed that wolves once roamed the southeastern United States before they were eliminated by overhunting and habitat loss. Now the region has a new top dog, the coyote, but because coyotes are native to western North America and only moved to North Carolina in the last few decades, little is known about how they affect the state's environment — especially prey populations. To learn more about coyotes and their place in North Carolina's ecosystem, NC State researchers have conducted a series of studies at Fort Bragg that shed some light on the habits of this predator.

The researchers found that coyotes range widely across the state's landscape, with the annual space they cover averaging 33 square miles. Some individual coyotes dispersed up to 214 miles away from Fort Bragg before establishing new home ranges. The coyotes studied ate a variety of foods, including insects, fruits, mice, rabbits and white-tailed deer.

Most impressive was the apparent top-down influence coyotes had on deer populations. A research paper on the Fort Bragg studies recently published in *PLoS ONE* showed that coyotes killed one out of every two deer fawns born in the study area.

"Only 14 percent of fawns survived for the first 16 weeks of life," says Colter Chitwood, the study's lead author, now a postdoctoral research associate at NC State. "With such low survival, the deer population inevitably is in decline."

Chitwood and colleagues also documented four instances where coyotes killed adult female deer, adding to the evidence that the species may be filling the regional niche once occupied by wolves. Although wildlife scientists are only beginning to understand how coyotes affect native plant and animal communities, Chitwood suggests that deer herd managers will need to make adjustments where coyotes are suppressing deer populations.

continued

NEW MODEL PREDICTS SIZE OF GULF 'DEAD ZONE'

A computer model developed at NC State by environmental engineer Dan Obenour is one of four models being used by the National Oceanic and Atmospheric Administration to predict the size of the hypoxic dead zone in the Gulf of Mexico.

Hypoxia is caused by a combination of factors, but the two most significant variables are the nutrients that the Mississippi River dumps into the Gulf and the stratification of the waters in the Gulf.

Each year the Mississippi River delivers nutrients — largely stemming from agricultural runoff across the Mississippi River basin — that serve as fertilizer for aquatic plant life, resulting in algal blooms. As the algae decomposes or is eaten and excreted by animals, it creates enormous amounts of organic matter that sinks to the bottom of the Gulf.

This increase in organic matter presents a smorgasbord for the bacteria that devour it. But those bacteria use up oxygen. As they thrive on their newfound meal ticket, they consume more and more oxygen in the water. The resulting dead zone has so little oxygen that fish and shellfish — including economically important species, such as shrimp — can't survive there.

GU JOINS TEAM TAPPED TO STOP DIABETES

An NC State faculty member is one of six scientific researchers tapped by the American Diabetes Association to join an ambitious effort to combat the pervasive disease. Pathway to Stop Diabetes will fund the work of more than 100 scientists in the coming decade.

A biomedical engineer, Zhen Gu will receive $1.625 million over five years to accelerate his research to develop an artificial closed-loop system that mimics pancreas activity and releases insulin in response to glucose level changes.

More than 30 million Americans suffer from diabetes, a long-term condition marked by high blood glucose levels. The American Diabetes Association estimates that one in three Americans will suffer from diabetes by 2050 if the current trend continues. The disease can lead to serious health complications, including eye and skin disorders, a type of nerve damage called diabetic neuropathy, high blood pressure and stroke.

Pathway to Stop Diabetes, now in its second year, is sponsored by Sanofi, Novo Nordisk, AstraZeneca, and the Eli Lilly and Company Foundation.

PROJECT PREPARES ACADEMIC LEADERS

As a number of top community college leaders across North Carolina prepare to retire, the John M. Belk Endowment has awarded NC State a grant to fund a professional development program for the next generation of leaders.

"Envisioning Excellence for Community College Leadership" is led by NC State in partnership with the Aspen Institute, an educational and policy studies organization, to integrate evidence-based best practices into the institute's leadership training programs, which are primarily targeted toward department chairs, deans, administrators and doctoral students.

"Excellent leaders make an exceptional difference in student success," notes Robert Templin, former president of Northern Virginia Community College, who joins the NC State faculty for this initiative through a joint appointment with the Aspen Institute. "Investing in community college leaders now will pay dividends for decades to come by strengthening North Carolina's middle class and contributing to the state's economic prosperity."

Research shows that community colleges with the highest levels of student success have exceptionally talented leaders whose expertise enables them to inspire student, academic and organizational excellence. At the same time, North Carolina partners see pending retirements as both a challenge and as an opportunity to align professional development programs with ambitious goals for student success.

CLEAN ENERGY CENTER HELPS N.C. 'FUEL WHAT MATTERS'

A public service center based at NC State is leading a federally funded campaign to clean up the state's air — and citizens who lend a hand can win prizes for participating.

The North Carolina Clean Energy Technology Center, formerly the Solar Center, has launched "Fuel What Matters." The campaign helps individuals and organizations make transportation choices that will reduce emissions in North Carolina. More than half of our state's citizens live in counties that don't meet national air quality standards, and transportation is the No. 1 source of air pollution in the state's urban areas, explains Anne Tazewell, manager of the Transportation Program at the center.

"That's why, to address this problem, the federal government provides Congestion Mitigation Air Quality funding to the North Carolina Department of Transportation, and the DOT in turn granted the funds to us," Tazewell adds. "CMAQ funding is focused on transportation because if you can reduce emissions from that one source, you can make a major improvement in air quality."

To help North Carolinians cut down on petroleum use, the Fuel What Matters website, at www.fuelwhatmatters.org, provides tools designed for individuals and others for transportation fleet managers. For individuals, the site offers information to help consumers purchase automobiles that run on alternative fuels, such as electricity, biodiesel, ethanol, natural gas and propane. It also provides a handy mapping and scheduling tool for planning trips via walking, biking or public transit.

For fleet managers, the site offers information on how to implement the use of alternative fuels across a fleet, first by conducting a fleet assessment and then by determining alternative fuel vehicles that are best for a business or organization.

To encourage North Carolinians to spread the word about clean transportation, the campaign has offered cash prizes to those who post about the campaign on social media. Include the hashtag #fuelwhatmatters in a post on Facebook, Twitter or Instagram to be entered in a random drawing for a $100 prize. Prize drawings will be held monthly through mid-October. You can also submit a Fuel What Matters video for a chance to win $500.

COPING SKILLS ARE DYNAMIC

A study led by NC State psychology researcher Shevaun Neupert finds that people are not consistent in how they prepare mentally to deal with arguments and other stressors, with each individual displaying a variety of coping

• ABOVE: *Engineers are working to save dairy farmers time and money by tracking cows via RFID tags.*

behaviors. In addition, the study found that the coping strategies people use could affect them the following day.

The findings stem from a pilot study of older adults, which is the first to track the day-to-day coping behaviors people use in advance of stressful events.

"This finding tells us, for the first time, that these behaviors are dynamic," says Neupert, who is lead author of a paper describing the study.

"This highlights a whole new area for researching the psychology of daily health and well-being," he adds. "The more we understand what's really going on, the better we'll be able to help people deal effectively with the stressors that come up in their lives."

SAVING DAIRY FARMERS TIME AND MONEY

Tucked away in the corner of a laboratory in Raleigh, five electrical engineers are engaged in an unlikely pursuit: finding a way to make the U.S. dairy industry more profitable.

The team is poised to launch a proof-of-concept project that they hope will demonstrate how a wireless tracking system can improve the health and productivity of dairy cows.

"Our goal is to help farmers survive and ensure their operations are economically viable," says Anthony Laws, an undergraduate at NC State who signed on to the project as part of his senior design class in electrical and computer engineering.

At the heart of the project are radio-frequency identification (RFID) tags, which can be equipped with sensors that allow them to transmit information back to a reader.

Each dairy cow would have an RFID ear tag, and RFID readers would be placed at the dairy's milking station and at a nearby weighing station. The readers would transmit data to a remote system that records when cows enter and leave the milking station, as well as how much each cow weighs. Farmers can access that data.

William Carr, who retired from the New Jersey Institute of Technology and founded RFID Sensor Systems, developed the concept. But Carr came to NC State for assistance in turning his concept into reality.

The system also notifies farmers if a cow is staying too long in the milking station, if the cow is exhibiting significant changes when it comes to the milking station (which can be a sign of health problems) or if its weight changes significantly (another possible sign of health problems). The system also can notify farmers if a cow that requires medication enters the milking station.

"Ultimately, this system could be expanded to record and track a variety of other data, such as how much milk each cow is producing," Laws notes.

EXECUTIVES SCORE PERCEIVED RISKS

Worries about government regulation, economic conditions and cybersecurity topped the list of risks perceived by corporate board members and C-suite executives, according to results of the third annual survey of business executives by global consulting firm Protiviti and the Enterprise Risk Management Initiative in the Poole College of Management at NC State.

"Executive Perspectives on Top Risks for 2015" summarizes concerns of the 277 board members and other top-level executives across industries who participated in the survey, identifying the perceived impact of macroeconomic, strategic and operational risks for the upcoming year.

More than half of the global-survey respondents indicated insufficient preparation to manage cyber threats is a risk that will "significantly impact" organizations this year. Following a string of recent data breaches, cyber threats jumped to number three this year, up three rank positions in year-over-year survey results.

Regulatory change and heightened government scrutiny was the No. 1 perceived risk, identified by nearly two-thirds of respondents. Uncertain economic conditions took second place, noted by 56 percent.

KUDOS

BALIGA EARNS GLOBAL ENERGY PRIZE

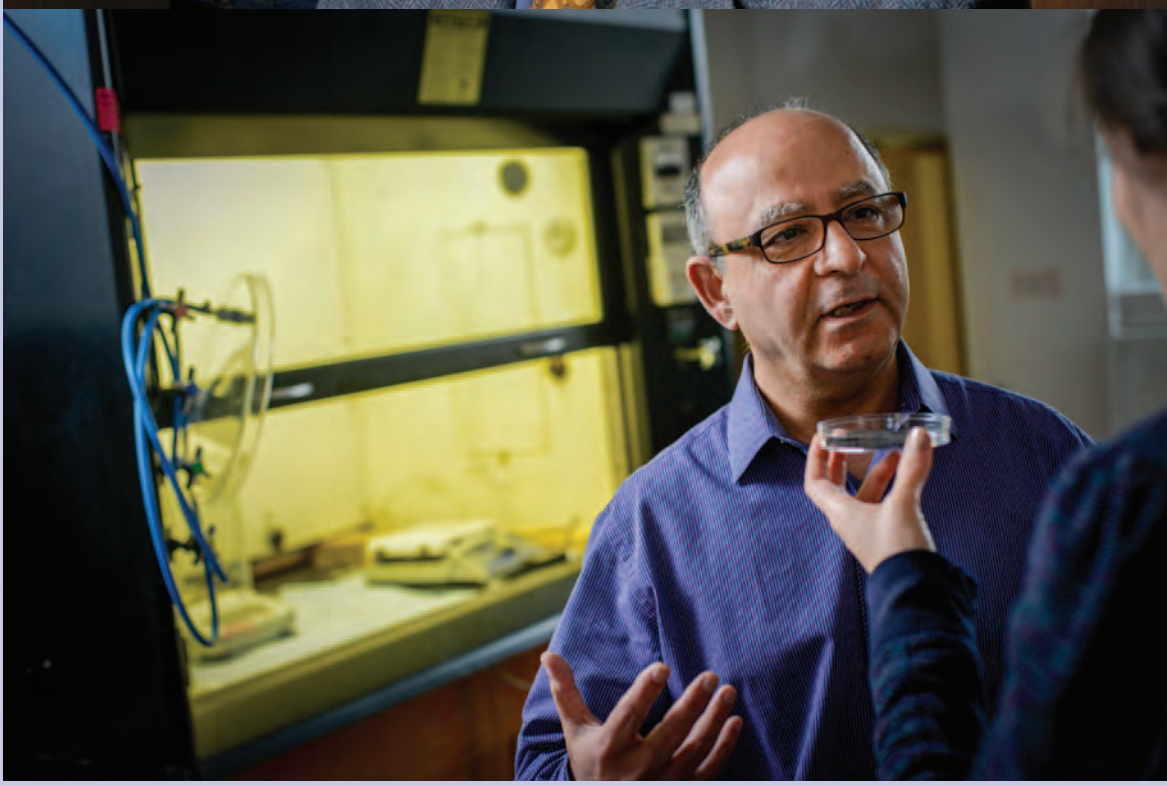
Electrical engineer Jay Baliga is a 2015 winner of the Global Energy Prize, an annual award presented at the St. Petersburg International Economic Forum.

Baliga shares the honor with Shuji Nakamura, a University of California, Santa Barbara professor who won the Nobel Prize in physics last year for inventing the blue LED. The award comes with a cash prize of 33 million rubles, equivalent to about $645,000.

Director of NC State's Power Semiconductor Research Center and a Distinguished University Professor of electrical and computer engineering, Baliga is renowned for his invention of the insulated-gate bipolar transistor (IGBT), a power semiconductor device primarily used as an electronic switch in modern appliances, from electric cars to air conditioners.

The improved efficiency gained by using the IGBT has resulted in saving more than 1 trillion gallons of gasoline and reducing electrical energy consumption by more than 50,000 terawatt-hours, equivalent to not having to build 600 1-gigawatt coal-fired power plants. This has saved consumers $15 trillion while reducing carbon dioxide emission by more than 75 trillion pounds.

Baliga has received numerous awards, including the 2014 IEEE Medal of Honor, the 2012 North Carolina Award for Science, the 2011 National Medal of Technology and Innovation from President Obama, the 1999 IEEE Lamme Medal, the 1998 IEEE Ebers Award, the 1998 O. Max Gardner Award and the 1993 IEEE Liebman Award. He is a member of the Rensselaer Alumni Hall of Fame, the Electronic Design Engineering Hall of Fame, the European Academy of Sciences and the National Academy of Engineering, and he is an IEEE Life Fellow.



• TOP: *Electrical engineer Jay Baliga is a 2015 winner of the Global Energy Prize.* • BOTTOM: *Textiles scientist Behnam Pourdeyhimi has won the UNC system's highest faculty honor.*

POURDEYHIMI WINS GARDNER AWARD

NC State textiles visionary Behnam Pourdeyhimi has won the 2015 O. Max Gardner Award — the University of North Carolina system's highest faculty honor — for contributions to health and human safety.

Pourdeyhimi's research focuses on technologies to improve water purification, air filtration, biomanufacturing, drug delivery systems, agricultural production and protective materials for military and civilian applications. Pourdeyhimi, associate dean for industry research and extension in the College of Textiles, holds more than 80 U.S. and international patents and has been instrumental in launching three startup companies.

As director of NC State's Nonwovens Institute, Pourdeyhimi has his finger on the pulse of the industry. The institute unites experts from industry, government and academia to create next-generation engineered fabrics.

North Carolina has attracted more than $720 million in investment

• TOP: *Elizabeth Parry, flanked by federal officials, holds the mentoring award presented to her in the White House.* • BOTTOM: *Richard Linton, dean of NC State's College of Agriculture and Life Sciences, chairs the new N.C. Food Manufacturing Task Force.*

from nonwovens companies in the past 10 years. In addition to American businesses, corporations from Israel, Japan, Switzerland, the Netherlands, Germany, Brazil and Mexico have invested in nonwovens in the state.

With teaching based on cutting-edge research, Pourdeyhimi is educating a new generation of international textiles leaders at NC State. More than 100 Ph.D. students sponsored by the institute in the last 15 years are now transforming the industry. More than 45 Ph.D. students are currently being funded thanks to Pourdeyhimi's work, which includes basic and applied research worth more than $30 million.

Pourdeyhimi is the 30th professor from NC State to win the Gardner award, given annually to one faculty member from the UNC system for significant contributions to the welfare of the human race.

PARRY RECEIVES PRESIDENTIAL AWARD

Elizabeth Parry, a partnership coordinator for the Engineering Place, an NC State education and outreach program in the College of Engineering, is one of 14 individuals selected to receive the Presidential Award for Excellence in Science, Mathematics and Engineering Mentoring.

The White House gives the award to individuals and organizations to recognize the crucial role that mentoring plays in the academic and personal development of students studying science and engineering — particularly those who belong to groups that are underrepresented in these fields. By offering expertise and encouragement, mentors help prepare the next generation of scientists and engineers while ensuring that tomorrow's innovators represent a diverse pool of science, technology, engineering and mathematics talent.

Their mentoring can involve students at any grade level from elementary through graduate school and professional development mentoring of early-career scientists. In addition to being honored at the White House, recipients receive $10,000 from the National Science Foundation.

"These educators are helping to cultivate America's future scientists, engineers and mathematicians," President Obama said. "They open new worlds to their students and give them the encouragement they need to learn, discover and innovate. That's transforming those students' futures, and our nation's future, too."

LINTON LEADS N.C. FOOD MANUFACTURING TASK FORCE

Richard Linton, dean of NC State's College of Agriculture and Life Sciences, has been named chair of the new North Carolina Food Manufacturing Task Force. In June, Gov. Pat McCrory announced the task force, which also will have leadership from Dan Forest, lieutenant governor; John Skvarla, secretary of commerce; and Steve Troxler, commissioner of agriculture and consumer services.

The 30 members, with experience in all aspects of food manufacturing, including farming, transportation, packaging, processing and economic development, will develop a strategic business plan to leverage existing activities in food processing and manufacturing; establish a statewide food processing and manufacturing organization; and create a plan to develop a proactive industrial-recruitment campaign for new business development. The panel also will foster the growth of food-manufacturing entrepreneurial endeavors, enhance development of innovative food products and processes, and identify sector-specific regulatory training and outreach.

FIVE FACULTY NAMED AAAS FELLOWS

Five NC State University faculty members have been elected as fellows of the American Association for the Advancement of Science (AAAS).

continued

• **Nancy L. Allbritton**, professor and chair of biomedical engineering, elected for invention and implementation of new tools for biomedical research and for development of miniaturized devices to enable more accurate disease diagnosis.

• **David C. Dorman**, professor of toxicology, elected for distinguished contributions to the field of toxicology, particularly research investigating the neurotoxicity of environmental chemicals.

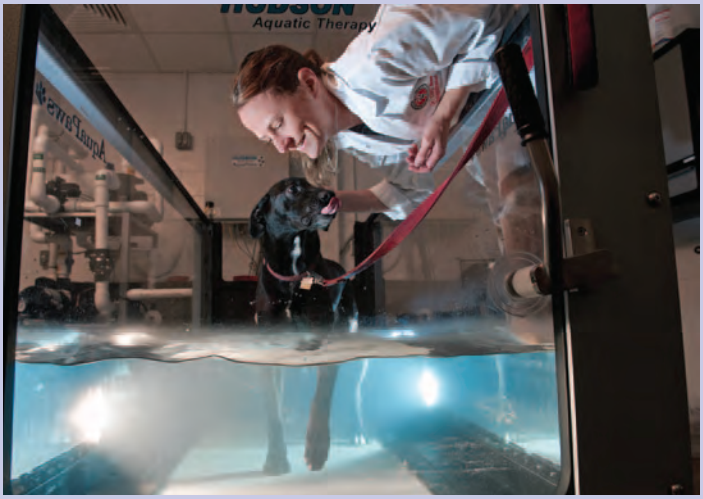
• **Justin Schwartz**, Kobe Steel Distinguished Professor and head of NC State's materials science and engineering department, elected for outstanding contributions to the field of applied superconductivity, particularly for developing materials for use in superconducting devices, the advancement of high magnetic fields and the integration of experiment and computation.

• **Bruce A. Sherwood**, professor emeritus of physics, elected for far-reaching insights and contributions to both applied and computational physics, particularly for tools demonstrating the value of computation in undergraduate physics.

• **Mohammed A. Zikry**, professor of mechanical and aerospace engineering, elected for distinguished contributions to the field of computational materials science and mechanics, particularly for predictions at scales ranging from the nano to the micro.

They are among 401 scientists to be honored this year by AAAS, the world's largest scientific society and the publisher of the journal *Science*.

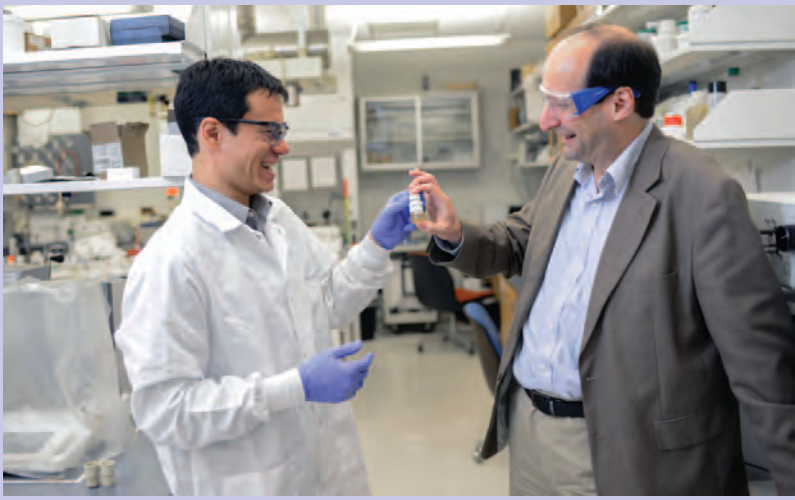
Each year, the AAAS Council — the policymaking body of the society — elects members who have shown "scientifically or socially distinguished efforts to advance science or its applications." Fellows are nominated by their peers and undergo an extensive review process.



CVM THIRD IN NATION

NC State's College of Veterinary Medicine is ranked third among the nation's 30 colleges of veterinary medicine in the 2015 higher education rankings issued by U.S. News and World Report.

According to the magazine's stated methodology, the rankings are based solely on the results of peer assessment surveys sent to deans, other administrators and faculty at accredited degree programs or schools in each discipline. Respondents rated the academic quality of programs on a five-point scale.



• ABOVE: *Graduate student Alexander Richter has won a $15,000 Lemelson-MIT Student Prize for work to improve agricultural pest control.*

ENGINEERING GRADUATE STUDENT WINS LEMELSON-MIT STUDENT PRIZE

Alexander Richter, a graduate student in NC State's Department of Chemical and Biomolecular Engineering, has won a $15,000 Lemelson-MIT Student Prize for work to improve agricultural pest control that could bolster the global food supply. Richter won in the "Eat It" category for inventions that can improve food and agriculture.

Richter, a Ph.D. candidate working with Orlin Velev, is developing a novel approach to deliver antimicrobial and antifungal pest control agents via lignin-core environmentally benign nanoparticles. These biodegradable particles could be the basis for reduced-risk conventional pesticide products that have the potential to reduce the amount of chemicals used in plant protection by as much as 90 percent, save farmers more than 25 percent on pest-control initiatives and, in a world facing looming food shortages, help increase crop yields for more and better food.

The technology is being developed by BENANOVA Inc., a startup company founded by Richter and Velev that is based in the Technology Incubator on NC State's Centennial Campus. Richter is the first student from a North Carolina university to win the honor. Founded by Jerome H. Lemelson and his wife, Dorothy, in 1994, the program is funded by the Lemelson Foundation and administered by the MIT College of Engineering.

PAUL'S CROSS SCORES AWARD, NEW FUNDING

During the Reformation, the open-air pulpit outside Old St. Paul's Cathedral in London was the scene of radical Protestant preaching and more than one riot. Such was the enthusiasm inspired by some of history's greatest orators in the shadow of England's grandest cathedral.

Although the churchyard pulpit, Paul's Cross, was destroyed in the English Civil War in 1643, it continues to attract a new generation of enthusiasts thanks to NC State's Virtual Paul's Cross Project. The multidisciplinary effort recreates the sights and sounds of the historic churchyard in the digital realm, and includes a reenactment of the

• ABOVE: *An interdisciplinary team that created the Virtual Paul's Cross Project won a 2014 Digital Humanities Award for best data visualization.*

Gunpowder Day sermon delivered by poet and cleric John Donne in 1622.

The project — drawing on the work of an international team of scholars coordinated by English professor John Wall and architecture professor David Hill — recently won a 2014 Digital Humanities Award for best data visualization. Plus, the National Endowment for the Humanities has awarded the scholars $325,000 for the next phase of the project, which will extend the 3-D and acoustical models to encompass the interior of St. Paul's Cathedral.

The multimedia project can be experienced online at the project's website (http://vpcp.chass.ncsu.edu) as well as in the Teaching and Visualization Lab in the Hunt Library on Centennial Campus.

NATIONAL ACADEMY OF INVENTORS SELECTS NEW FELLOWS

Jay Narayan, John C.C. Fan Family Distinguished Chair of materials science and engineering, and Nancy Allbritton, Distinguished Professor of chemistry and professor and chair of the biomedical engineering department, have been named Fellows of the National Academy of Inventors (NAI).

NAI was founded in 2010 to recognize and encourage inventors with patents issued from the U.S. Patent and Trademark Office, enhance the visibility of academic technology and innovation, encourage the disclosure of intellectual property, educate and mentor innovative students, and translate the inventions of its members to benefit society.

Being named an NAI Fellow is a high professional honor for academic inventors who have "demonstrated a highly prolific spirit of innovation in creating or facilitating outstanding inventions that have made a tangible impact on quality of life, economic development and the welfare of society."

FIVE FACULTY RECEIVE NSF CAREER AWARDS

Five members of NC State's world-leading faculty received Faculty Early Career Development Awards from the National Science Foundation (NSF). Also known as the NSF CAREER award, it provides funds over five years to support a research project. It is one of the highest awards the foundation bestows upon young faculty.

• **Joshua Pierce**, chemistry — "Novel Methods for the Stereoselective Synthesis of Nitrogen Containing Heterocycles." The project will develop new and efficient ways to convert simple molecules to complex, highly functional molecules that could be used as building blocks in developing new drugs.

• **Ana-Maria Staicu**, statistics — "Next Generation Functional Methods for the Analysis of Emerging Repeated Measurements." To gain more insights into the natural evolution of multiple sclerosis, the project will seek to develop new statistical methods for analyzing emerging data structures that are correlated because of their longitudinal design.

• **Kristy Boyer**, computer science — "Fostering Collaborative Dialogue for Rigorous Learning and Diverse Student Retention in Computer Science." The project will gather data on collaborative learning in computer science classrooms; examine that data to determine which aspects of collaborative learning are effective; based on that data analysis, create theoretically informed models of collaborative dialogue; and implement and evaluate those models.

• **Rosangela Sozzani**, plant and microbial biology — "Modeling Emergent Behaviour of Gene Networks Controlling Plant Stem Cells." To improve crop productivity, the project will identify the essential features that govern stem cell regulatory networks in developing roots and will develop mathematical models that describe the behavior of those networks.

• **Chase Beisel**, chemical and biomolecular engineering — "Harnessing Endogenous Defense Systems as Genetic Tools for Microbial Communities." The project will harness the defense systems of microorganisms as a basis for developing genetic tools that could be used to improve crop health and combat insect crop pests.

SCHOOL FUNDING EXPERT HONORED

Education faculty member Kevin Brady won a national award for two decades of research and contributions to school finance equity. Brady accepted the 2015 National Education Finance Distinguished Research and Practice Fellows Award in March.

He studies financial, legal and

continued

technological issues that school leaders face. The doctoral program coordinator in educational research and policy analysis, he also teaches best practices in school budgeting and finance. He previously served as an education finance budgetary adviser and state government analyst working to improve public education funding formulas.

He serves on the editorial boards for *Education and Urban Society, Education Law & Policy Review, Journal of Disability Policy Studies* and *West's Education Law Reporter.* Brady has studied school finance litigation patterns among states and contributed reviews of two major legal decisions to the *Encyclopedia of Educational Economics and Finance* in 2014.

VETERINARY PHARMACIST RECOGNIZED

NC State veterinary pharmacist Gigi Davidson has received the highest honor awarded by the U.S. Pharmacopeial Convention (USP), the Beal Award for Distinguished Volunteer Service. The award includes a $10,000 prize, which Davidson donated to the pharmacy residency program in the College of Veterinary Medicine.

Davidson, director of clinical pharmacy services in the college, recently completed a five-year term as chair of USP's Compounding Expert Committee. Under her leadership, the committee developed a guidebook with compounding standards for use by practitioners and regulatory authorities.

USP is a nonprofit organization that sets standards for the identity, strength, quality and purity of medicines. Since 1820, the USP has relied on volunteer experts to develop programs and standards to ensure the quality of medicines and foods.

Recently, Davidson was appointed to represent USP on the U.S. Food and Drug Administration's Pharmacy Compounding Advisory Committee, a group charged with implementing the compounding provisions of the Drug Quality and Security Act of 2013.

Davidson sits on numerous professional boards and committees, including the American College of Veterinary Pharmacists and the Pharmacy Compounding Accreditation Board Standards Committee.

JONES NAMED ACE FELLOW

The American Council on Education announced that Lisa Guion Jones, professor and assistant dean for diversity, outreach and engagement in the College of Agriculture and Life Sciences, will be an ACE Fellow in the 2015-16 academic year.

Under her leadership, the college has implemented initiatives and programs that have increased recruitment and retention of faculty, postdoctoral fellows and graduate students. Her transformational leadership of retention efforts targeted toward minority undergraduates has received widespread recognition. These and other strategic efforts have resulted in NC State being ranked ninth in the nation for graduating minority undergraduate students in agricultural disciplines in 2014, a significant increase from five years ago, when the university ranked 21st.

Jones will spend the year at another higher education institution working with senior leaders. The ACE Fellows program was established in 1965. Forty-seven fellows were selected this year.

HUNT LIBRARY WINS POPULAR CHOICE AWARD

NC State University's Hunt Library received the 2015 Architizer A+ Popular Choice Award for educational libraries in the typology category. Designed in collaboration by the NCSU Libraries, Snøhetta and Clark Nexsen, the Hunt Library was the only U.S. library named as a finalist. Finalists were candidates for the Architizer A+ Jury Award, which was selected by a distinguished jury, but public voting determined the Achitizer A+ Popular Choice Award.

RURAL SCHOOL PROGRAM EFFECTIVE

An NC State University program to train leaders for rural schools in northeastern North Carolina has received a national award for effectiveness — one of only two programs to receive the distinction.

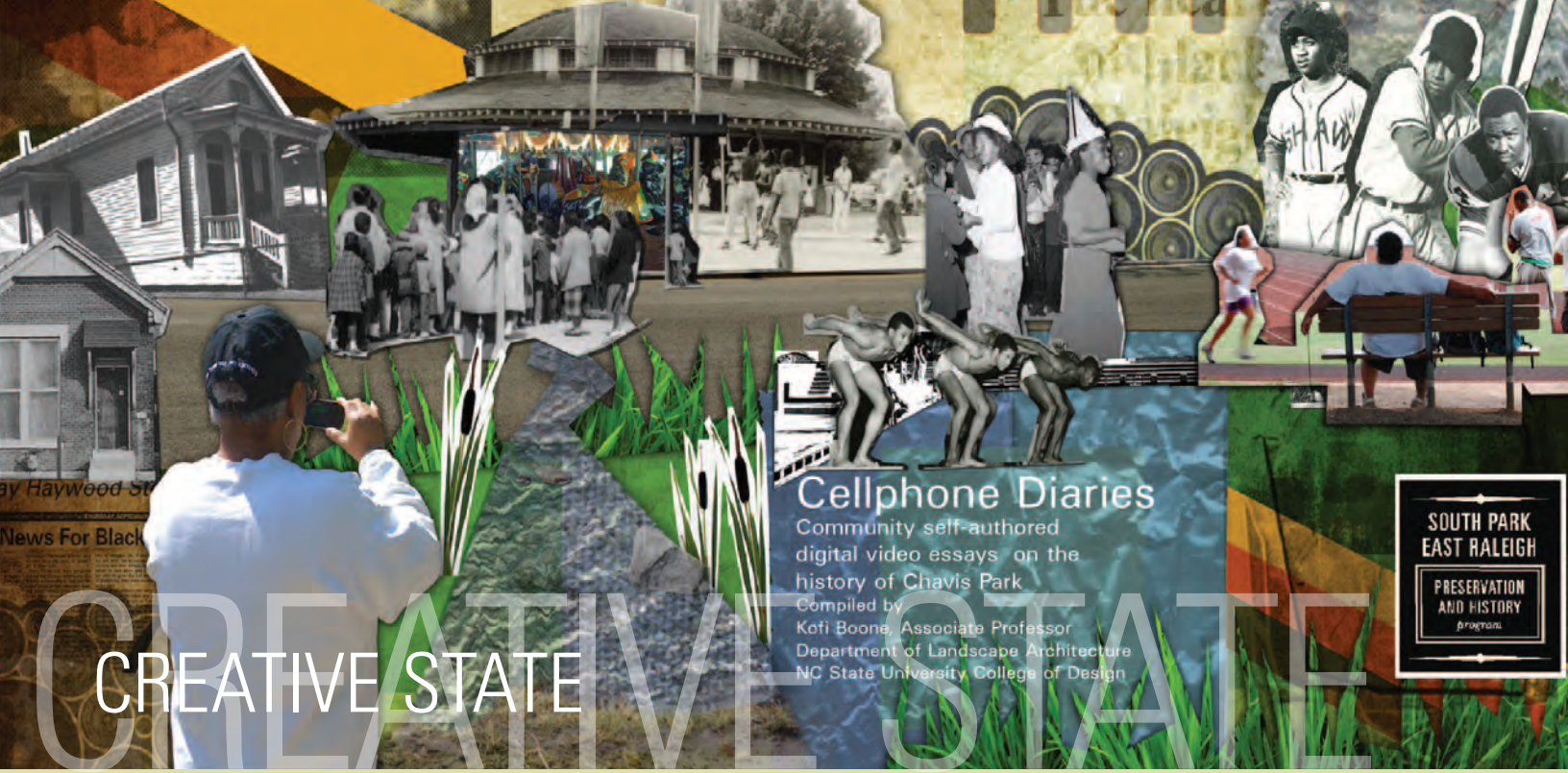
The University Council for Educational Administration has given an Exemplary Educational Leadership Program Award to the Northeast Leadership Academy (NELA), a rigorous two-year program that prepares principals and assistant principals to work as turnaround specialists in high-need districts in northeastern North Carolina.

News of the award came just after NELA received an additional $2 million grant from the U.S. Department of Education through its Turnaround School Leaders Program. NELA also received a $4.7 million grant from the Department of Education in 2013.

"NC State is committed to serving the needs of North Carolina's rural schools, which educate almost half of the state's students," said NC State education professor Bonnie Fusarelli, who directs the program. "NELA is based on research that demonstrates how school leaders retain effective teachers and create a school culture of achievement."

To prepare for the challenge of leading schools with limited access to resources and training, NELA graduates complete a yearlong internship and work with a community agency. They earn a master's degree in school administration and commit to take a leadership position in one of the participating counties for three years after completing the program. Training includes a summer institute and mentoring from executive coaches. The first-year placement rate for NELA is more than twice the national average, Fusarelli says.

Launched in 2010, NELA serves 14 school districts: Bertie, Edgecombe, Franklin, Granville, Halifax, Hertford, Martin, Nash-Rocky Mount, Northampton, Roanoke Rapids, Vance, Warren, Washington and Weldon City.



CREATIVE STATE

• ABOVE: *NC State College of Design faculty and students have worked with residents to document a Raleigh neighborhood.*

CELLPHONE DIARIES SPARK DIALOGUE

As residents and Raleigh city planners shape a neighborhood's future, they're using "cellphone diaries" to document its past and present.

Professors and research assistants in NC State's College of Design helped residents create short videos to tell stories about the people, places and events that have shaped their lives.

Landscape Architecture magazine is featuring the project in which the videos — shot and edited by residents, with the assistance of faculty and students — are linked to an online map showing where they were filmed.

Landscape architecture professor Kofi Boone spearheaded the project, in collaboration with the South Park East Raleigh Neighborhood Association. Faculty with expertise in research, sociolinguistics and graphic design also participated in the project.

Downtown Raleigh's reinvestment boom is bringing changes to the area, sparking anxiety among current residents. In South Park and East Raleigh, where working-class African-American families have lived for more than a century, residents are concerned that the growth could displace them and wipe out their community's history.

Videos created at Chavis Park, which include references to park elements that no longer exist and events that no longer take place, directly informed the John Chavis Memorial Park master plan. Locations highlighted in the park and throughout the neighborhood were also included in the South Park East Raleigh Heritage Walk, a community revitalization initiative.

The community project has been featured at Raleigh's Block2 Gallery as well as *The State of Things with Frank Stasio* on radio station WUNC.

SPIRITS REJOICE: BIVINS ON JAZZ AND RELIGION

Poet Ted Joans once wrote, "Jazz is my religion." If he had said jazz *is* religion, he wouldn't have been far off the mark. The two subjects are intertwined at the root.

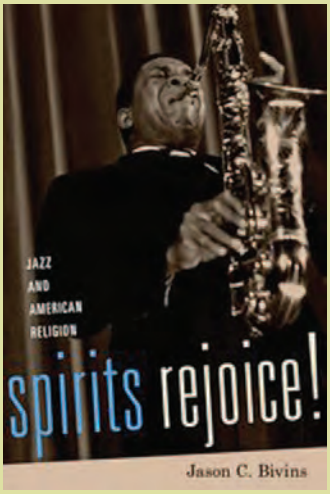
Jazz is indigenous to the United States, shaped by a confluence of cultures and musical traditions, including faith-based traditions. As a religious studies scholar — and jazz musician — Jason Bivins explores the relationship in a new book that addresses how religion has shaped jazz and the way people think about it.

In his academic life, Bivins specializes in the nexus of religion and U.S. politics. As a musician, he has recorded improvisational albums with bands such as the Unstable Ensemble, the Micro-East Collective and the Impermanence Trio.

In his book, *Spirits Rejoice! Jazz and American Religion* published by Oxford University Press, Bivins explores a variety of issues, from how jazz musicians have drawn on specific religious traditions to inform their music to musicians who view performance as a ritual.

"The more I researched, the more I found confirmation that jazz has been a part of larger American developments in — and improvisations on — key religious concerns and practices like historical narrations, communitarian experiments, ritual, meditation and cosmology," Bivins explains.

"That so many different themes were accreting convinced me that it was simply not possible to understand the history of jazz without accounting for this abundant religiosity."



• TOP: *Jason Bivins is a religious studies scholar and a jazz musician.* • BOTTOM: *He explores the links between jazz and religion in a new book.*

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Andy Tong (left) and Robert Jamison work on the cube.

Art, Engineering and Infinity

By Matt Shipman

The concept of infinity and the desire to illustrate the creative process have given college students the opportunity to showcase their work alongside that of M.C. Escher and Leonardo da Vinci.

A collaboration between NC State and the North Carolina Museum of Art (NCMA) is part of a series of STEAM initiatives that combine science, technology, engineering and math (STEM) with art and design to promote innovation. NCMA came to NC State seeking engineers to use electronics to create a visual display that tied together works of da Vinci and Escher. The resulting student exhibition, *Engineering Infinity*, will coincide with *The Worlds of M. C. Escher: Nature, Science, and Imagination* and *Leonardo da Vinci's Codex Leicester and the Power of Observation* that open in October.

Evan Heiman, Andy Tong, Robert Jamison and Jesse Davi took on the project in their senior design course. All four graduated in May with degrees in electrical and computer engineering.

The team developed a cube made up of 512 light-emitting diodes (LEDs), 64 on each side, which is suspended on translucent columns. The LEDs display 19 visual routines. The cube is surrounded by a second made of two-way mirrors, allowing viewers to see inside, but trapping and reflecting light from the LEDs.

"The LED cube makes the first image, but it is reflected repeatedly – back and forth between the mirrors – making the images appear to retreat into infinity. Much like Escher did in his work," Jamison says.

The cube will be displayed alongside sketches, schematics and other materials documenting the design process. These process-oriented artifacts connect to da Vinci's *Codex Leicester*, a 500-year-old notebook featuring the artist's notes, sketches and observations, providing a glimpse into the artist's scientific mind.

Michelle Harrell, associate director of education at NCMA, is thrilled. "These students have created an interactive solution that not only required great technical skill but also a great deal of imagination and a fine eye for design."

Video of the cube in action can be seen at https://youtu.be/j5fhjTrBzoM.

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