

results.

Fall 2014 • Research, Innovation & Economic Development

DECIPHERING ANALYTICAL DATA: THE POWER OF INFORMATION

ALSO IN THIS ISSUE:

- Maker Movement Momentum
- Returns on Innovation Investments
- Technology Transfer Success





Solving Data Challenges

• ABOVE: The Hunt Library's digital wall cultivates new perspectives on data visualizations.

We're working now to expand undergraduate and graduate programs to close existing gaps in the data science talent pool that will only grow in the near future.

In this issue's cover story, you'll read how excellence in all of the contributing disciplines — such as computer science, statistics and design — are helping to position NC State as a national leader in providing talent and solving “Big Data Challenges.” With NC State's wealth of expertise, we are expecting great things from the new Data Science Initiative that we have created to corral and focus our efforts in this crucial emerging area. I am very pleased that our own Mladen Vouk — one of the fathers of “the cloud” — has agreed to be the founding director of the Data Science Initiative.

The growing volume of data collected in the digital world presents scientists and business leaders with major challenges, along with opportunities for increased understanding. The insights gained by applying data science have the potential to improve decision making across all sectors of the economy including health care, manufacturing, energy and government.

NC State has played a foundational role in establishing the discipline of data science, including when alum Jim Goodnight founded SAS Institute more than three decades ago and NC State launched the nation's first Master of Science in Analytics. The Data Science Initiative will expand our research, teaching and outreach efforts to create a hub of excellence by integrating our existing capabilities, bringing new resources to bear, and building partnerships with leading organizations.

We're working now to expand undergraduate and graduate programs to close existing gaps in the data science talent pool

that only will grow in the near future. We're also working to train more data-savvy managers and analysts who are capable of asking good questions — the ones that create an advantage and proactively manage risk.

As home to the National Institute of Statistical Sciences, SAS, LexisNexis, ABB, NetApp, Cisco, RTI and many other data-intensive organizations, the Research Triangle region is a data science powerhouse. It's a rich environment for collaboration, and the Data Science Initiative will allow NC State to foster more effective partnerships in the region and beyond. In March 2015, we look forward to a high-impact conference, Data4Decisions, in Raleigh to focus on data needs of executives and decision makers.

I have thoroughly enjoyed leading NC State's research enterprise in creating impactful results and achieving record levels of extramural funding over the last six years. My time as vice chancellor for research, innovation and economic development has been one of the most rewarding experiences of my professional life. While I will miss daily interactions with our outstanding faculty, staff and students, I will continue to foster partnerships with North Carolina's universities in my new role as executive vice president of discovery, science and technology at RTI International. I offer heartfelt thanks to the NC State research community and wish you all continued success.

TERRI L. LOMAX, Vice Chancellor
Research, Innovation and Economic Development

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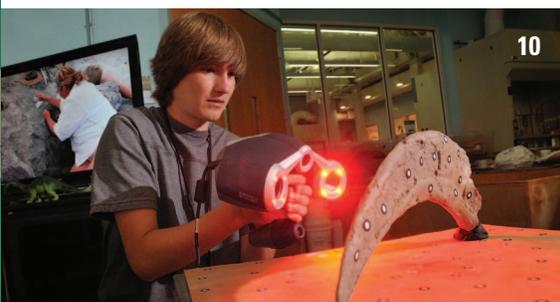
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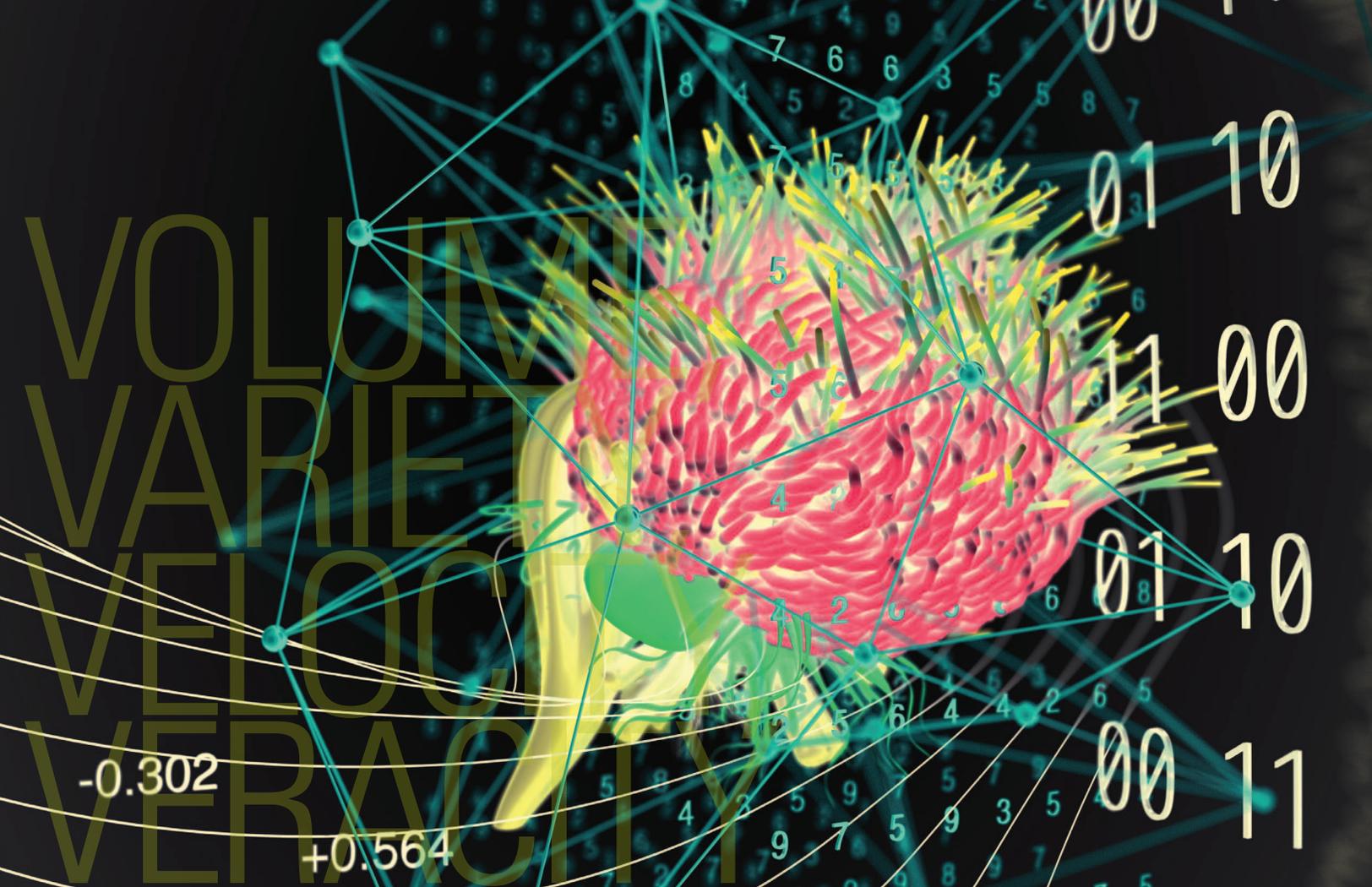
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Big Data Challenges:

VOLUME, VARIETY, VELOCITY & VERACITY

By David Hunt

“We used to do very carefully designed experiments. Every record was full of rich data, very carefully controlled. Today, we often have to deal with ‘found data.’”

— ALYSON WILSON

The field of statistics has undergone a radical change since Alyson Wilson began her career as a mathematical statistician with the National Institutes of Health two decades ago. “We used to do very carefully designed experiments. Every record was full of rich data, very carefully controlled,” says Wilson, now a statistician at NC State University. “Today, we often have to deal with ‘found data.’ When you’re dealing with every Web page written in Japanese or every Wikipedia entry in Polish, the issues are different than when you’re dealing with 30 carefully controlled experiments on one topic.”

The data-processing tools of the digital age give researchers — as well as business managers, public officials and other decision-makers — a staggering volume of data to manage and analyze. Coping with this flood of “big data” is often likened to drinking from a fire hose.

If only it were that simple.

The Internet, one of the fastest-growing channels of digital information, is like a data-driven Niagara Falls, surging with an endless, churning, unstoppable flood of bits and bytes. Trying to pinpoint and analyze a particular piece of information on the Web is like trying to pick out a specific drop of water as it rushes over the falls.

PennyStocks, an online investment company, estimates that well over a million gigabytes of data are transferred over the Internet every minute. Computer chip maker Intel says it would take nearly five years to watch all the video footage that streams over the Internet in just one second.

Of course, the Internet isn’t the only tool that generates swarms of data. Hospitals and medical offices create electronic medical records for millions of patients, utility

companies track power usage by millions of homes and businesses, and retailers maintain sales and inventory records on millions of products.

The huge and growing volume of data available for analysis is just one challenge for scientists, Wilson says. Researchers in the field face a set of often-overlapping difficulties known as the four Vs: volume, variety, velocity and veracity. Information overload, a term coined by social scientist Bertram Gross 50 years ago and popularized by futurist Alvin Toffler in his 1970 bestseller *Future Shock*, is no longer an impending threat — it's business as usual. The world is simply flooded with too much data moving much too quickly for any one person to collect, verify and understand.

That's where math comes in.

Wilson is an expert in working with heterogeneous data to understand complex problems — the variety aspect of big data. To understand the challenges, let's take a look at a real-world example that Wilson described in a 2013 article in the journal *Technometrics*.

A company developing a new missile for the U.S. military needs to assess the reliability of numerous systems, subsystems and components, including the frame, warhead,

propulsion system, targeting system and guidance system.

To do that, companies typically conduct a series of pass/fail tests on individual parts and then apply statistical models to estimate their likely future performance. The analysis is complicated because the components are interrelated, so that a failure in one area affects others downstream. But in almost every case, scientists face the same problem: analyzing a variety of data from different sources in a complex system.

A promising new approach, devised by Wilson and researcher Jiqiang Guo at the Virginia Tech Social and Decision Analytics Laboratory, gives scientists a way to combine component-level data into a unified model for a whole system. The sophisticated mathematical methodology, based on a probability theorem called Bayes' law, allows researchers to more accurately estimate reliability for an entire product.

DIFFERENT DATA

Data falls broadly into two categories, says computer scientist Randy Avent: structured and unstructured. You know what structured data is if you've ever entered numbers into a spreadsheet. It's the type of information that fits

continued

- LEFT: Alyson Wilson leads NC State's new faculty cluster focusing on analytics.
- FACING PAGE: Artwork based on graphic by Yairon Martinez.



neatly in a column or row, like a baseball team's scores for the season or the price of each item in your grocery cart. Unstructured data includes a lot of the digital information that streams over the Internet, such as text, video, sound and images.

Avent, president of Florida Polytechnic University, says making sense of huge amounts of heterogeneous data requires scientists to work across disciplines.

"We used to value very deep disciplinary advances," he says. "But a lot of the problems we're working on today can't be solved by a single discipline."

Avent's academic career mirrors that way of thinking, combining studies in the life sciences, mathematics and engineering. At NC State, where he served as associate vice chancellor for research development for three years before moving to Florida Polytechnic, Avent spearheaded a pioneering effort to create an interdisciplinary cluster of researchers in data-driven science.

That faculty cluster, now led by Wilson, brings together top researchers in computer science, mathematics and statistics to confront the challenges of big data and train the next generation of analytics scientists. With Wilson as principal investigator, it's also leading a nationwide collaboration funded by a \$60 million grant from the NSA — the National Security Agency — to make groundbreaking advances in the science of data analysis.

The Laboratory for Analytic Sciences or LAS, housed on NC State's ultramodern Centennial Campus, is one of the largest sponsored-research projects in the university's history — a testament to the importance the federal government places on solving the challenges of big data.

BIG DATA, HIGH SECURITY

Forrest Allen, program manager at LAS, says NC State was the logical choice to lead the multidisciplinary center because of its culture of collaboration. Although private universities such as the Massachusetts Institute of Technology and Carnegie Mellon may be better known, NC State is quickly gaining a reputation with Washington policymakers as the go-to place for public-private partnerships.

In fact, the university has become a hub for hubs. In addition to the analytic science lab, the university is also leading



multidisciplinary centers combating the spread of nuclear weapons, redesigning the nation's electric power grid, developing wearable health-monitoring devices and helping farmers cope with the effects of a changing climate.

Allen, who spent a decade in Washington, D.C., as a congressional staffer and deputy assistant secretary in the Department of Energy, says NC State delivers both real-world experience and broad expertise. Instead of being strong in just a few scientific disciplines such as engineering and computer science, he says, NC State excels across a broad array of disciplines, including industrial design, genetics, the humanities and social sciences, business management, statistics and clinical sciences.

"We have world-class computer scientists, but we also have historians and English professors and psychologists on the same campus," he says. "NC State has been able to integrate those faculty into an interdisciplinary environment that we really think is the special sauce of LAS."

The new lab is off to a strong start, Allen says. The NSA has 20 staff members working on campus to support the effort, and that number will eventually increase to 50. Faculty members from seven of NC State's 10 colleges are already working on projects at LAS. A three-day campus event introducing the lab to faculty attracted more than 150 faculty members eager to discuss research ideas with agency officials.

"We have world-class computer scientists, but we also have historians and English professors and psychologists on the same campus. NC State has been able to integrate those faculty into an interdisciplinary environment that we really think is the special sauce of LAS."

— FORREST ALLEN



Researchers in bioinformatics develop tools to help make sense of the vast, complex and diverse data sets generated by studies in biological and medical science. Much of that data takes the form of strings of DNA that contain all of an organism's genetic information. In humans, that amounts to about three billion base pairs of the compounds adenine, guanine, cytosine and thymine — the rungs on DNA's twisted ladder. The sequence of these bases provides the instructions needed for an organism to develop, survive and reproduce.

In his lab on Centennial Campus, plant pathologist David Bird leads the university's new bioinformatics cluster, bringing together top researchers in genetics, statistics, computer science and biology. Meeting the challenges of big data has sparked "a philosophical change in the way we do science," Bird says.

For one thing, researchers now have the computing power and the statistical tools to take on tasks that would have been impossible a decade ago, like running 10 billion tests on a string of DNA.

DNA sequencing gives researchers a window on the inner workings of the genome, providing a wealth of data that explains how proteins are made, identifies the mutations associated with cancer risks, and shows how parasites interact with their hosts at the cellular level, among other insights.

NEMATODE TROUBLE

For most of his professional life, Bird has studied nematodes, one of the most abundant animals on the planet. Grab a handful of soil and you're likely holding thousands of the microscopic creatures, commonly called roundworms.

With more than 30,000 known species — and perhaps a million more yet to be identified — nematodes have adapted to a wide range of habitats, from freshwater lakes to tropical forests, not to mention the human intestine.

"Half the world's human population is infected with nematodes," Bird says. "We have to get our hands on controlling them."

Of the thousands of species, a few are truly nasty, causing ailments such as trichinosis, a disease that affects more than 10 million people, mostly in the developing world.

continued

• LEFT: David Bird, who leads NC State's new bioinformatics cluster, is an expert in nematodes.

"Everybody on campus does analysis," Allen says. "Business faculty do financial analysis, veterinarians do medical analysis, biologists do genetic analysis. The NSA just happens to do intelligence analysis. There's a lot of commonality."

Allen says researchers at LAS are approaching the big data challenge from several perspectives, ranging from scientific innovations that speed data processing to social science models that seek to understand human behavior. Much of the work involves trying to improve the signal-to-noise ratio inherent in complex data — cutting through the mass of irrelevant information and pinpointing critical material.

"With as many sensors as we have, we don't have a giant vacuum cleaner sucking up every signal that the world produces," he says. "We think the answers are out there in the data. We just have to find the right way to sort through it all."

BIG DATA AND BIOINFORMATICS

It's easy to understand the importance of harnessing big data analysis in the service of national security. After all, we all want to help the good guys and stop the bad guys. But what if the bad guy is a parasite and the good guy is a protein?

Welcome to the world of bioinformatics — one of the hottest fields applying big data analytics to real-world problems.

"Half the world's human population is infected with nematodes.

We have to get our hands on

controlling them." — DAVID BIRD

Plants suffer from nematode infections as well. Parasitic nematodes attack most cultivated plants, including food staples, as well as many common varieties of vegetables, fruit trees and ornamentals, costing the world's growers an estimated \$100 billion a year in lost crops. Unfortunately, nematodes are remarkably efficient killers.

"Some people use the analogy of looking for a needle in a haystack. But that's not what we're doing. We're actually looking for lots of needles in many, many haystacks."

— FRED WRIGHT

Take root-knot nematodes, for example. The tiny parasitic animals hatch in the soil, make their way to a plant and then dig into its roots. There they secrete proteins that instruct the plant to develop a specialized feeding site for the parasite. After feeding on the plant for several weeks, the adult female lays around 1,000 eggs. During this time, the plant appears oblivious to the feeding nematodes, and it is only when another stress comes along — such as a few weeks without rain — that the plant shows symptoms.

While crop rotation is a common pest management technique, it doesn't usually work with nematodes because they're perfectly at home in a wide variety of plants. And they're patient pests; some species can survive in a desiccated, anhydrobiotic state for more than a century, waiting for a host.

As a microbiologist, Bird thinks the best way to combat the parasite is to understand and short-circuit the chemical processes that allow it to interact with its host. That's where big data can help. After all, there isn't one single factor that makes a plant vulnerable to nematodes. Researchers are just beginning to decode the genetic mechanisms that trigger the parasitic proteins responsible for hijacking the host plant during invasion, inducing the formation of feeding sites, manipulating the host's metabolism for the nutritional benefit of the nematodes and suppressing the host's defense responses.

"Evolution has done this big 2-billion-year experiment," Bird says. "We have to look at all that natural variation to infer how the parasite works."

IN OUR GENES

"Some people use the analogy of looking for a needle in a haystack," says statistician Fred Wright. "But that's not what we're doing. We're actually looking for lots of needles in many, many haystacks."

Wright, a member of NC State's new bioinformatics faculty cluster and director of the Bioinformatics Research Center, is studying genetic variations in people with cystic fibrosis, an inherited disorder that causes severe damage to the lungs and digestive system.

"Even with modern medicine, some people with cystic fibrosis die at 15, and some live to 50," Wright says. "It's that variation that we're trying to understand. What is it in the constitution of their DNA that allows some people to survive so long?"

To answer that question, Wright and collaborators at the UNC-Chapel Hill Cystic Fibrosis Center are conducting complex genetic profiling on thousands of cystic fibrosis sufferers — a data-crunching challenge that scientists have only recently been able to address thanks to fast, powerful computers. The raw data come from microarrays, a technology for probing millions of genetic markers and measuring thousands of genes simultaneously to determine which are switched on and which are switched off. By comparing the genetic profiles of different people, the researchers are learning how the disease progresses.

"If we find variations that correlate to reduced lung function, then it becomes a matter of working with medical geneticists to understand how the genes may be interacting or mediating the immune system to cause the lung to become inflamed," he explains. "The eventual hope is that there might be a drug target that could help fix the problem."

If it seems strange that a statistician is leading a medical research project, it's time to update your thinking. In the age

• RIGHT: Michael Kowalenko, left, and Tim Michaelis offer new ways to analyze unstructured data.



of big data, health care solutions are as likely to come from analytics as from traditional clinical trials.

"There's been a change in the last decade," says Bird, head of the bioinformatics cluster. "Statisticians are no longer just service people that you go to for help with your experiment. They're now leading the discipline."

TRACING TOXINS

Among those leaders is David Reif, a researcher trained as both a statistician and a geneticist who joined NC State in 2013 after seven years at the U.S. Environmental Protection Agency, where he worked as a scientist in the agency's National Center for Computational Toxicology. Reif is an expert on the toxic effects of chemicals.

From the pesticides used to protect crops to the pressurized fluid injected into shale formations to extract natural gas and petroleum, toxic chemicals pose a growing risk to people and the environment. Finding the genetic connection between toxins and diseases is crucially important — and enormously difficult.

"Why do people respond differently to the same environment toxins?" Reif asks. "If two people drink the

same tap water, why does one person get sick while the other does not?"

The answer may be found in the genetic variations Reif studies in the lab. But even with all the computing power of a major research university at his fingertips to crunch vast amounts of data and churn out volumes of reports, Reif notes that computers don't perform the most important function in science: thinking.

"The computer doesn't solve the problem without instructions on where and how to look," Reif says. "But it's great at performing a simple task umpteen billion times without getting bored."

Once computers have done their job of highlighting promising associations, Reif begins the challenging work of interpreting the data. The genetic pathways that lead from toxic exposure to physical illness are rarely marked with clear signposts. But that doesn't mean researchers have reached the end of the road when it comes to big data.

DATA-DRIVEN DECISIONS

Ph.D. student Tim Michaelis opens his laptop and pulls up a database he built for a Fortune 500 chemical company in Research Triangle Park using IBM Content Analytics software. To help the company find new clients, Michaelis programmed the database to scour the data on millions of Web pages.

Text on a Web page is, of course, unstructured data — the kind of information that isn't easily sorted, quantified or interpreted. But students like Michaelis need to learn to work with it, especially considering its exponential rate of growth. IBM estimates that 90 percent of the world's data was created in the last two years, and 80 percent of it is unstructured.

As he reviews the data, Michaelis talks through the challenges of handling terabytes of information.

"I come back again and again to the questions, 'How do you know what you know? Is the information good or bad?' You can't compare it to anything unless you started with a question — your hypothesis," he says. "It comes back to basic science."

Michaelis, who earned a master's degree in global innovation management at NC State last year, is working as a research associate in the Poole College of Management while he completes a doctorate in psychology. The college's faculty and students have worked with business partners for

continued

"I come back again and again to the questions, 'How do you know what you know? Is the information good or bad?' You can't compare it to anything unless you started with a question — your hypothesis. It comes back to basic science." — TIM MICHAELIS





• ABOVE: Alan Karr, an expert in statistics invited to speak at a variety of national meetings, notes the synergies in the Research Triangle region.

more than three decades to lay the foundations of innovation management as an emerging field of science. For companies struggling to survive in today's hypercompetitive global markets, it's nothing short of a revolution.

But the real power of innovation management is more than just the ability to read every word on every website pertaining to a business or industry.

"If you have data but no idea how to apply it, then you just have numbers on a page," Michaelis says. "You have to be able to interpret data, to give it meaning."

From a student's perspective, the program offers a new educational paradigm in which questions are as important as answers.

"The old way was: The professor is going to tell me the answer, I'm going to write it down and memorize it, and then I'll get paid a bunch of money because I know that thing," Michaelis says. "The new way is questioning everything, searching for an answer rather than just receiving one."

THINK AND DO

If you guessed that a new way of teaching requires a new breed of teacher, you're on the right track. Take Michael Kowolenko, an assistant teaching professor in the Poole College of Management and the first teacher to offer a class on data-driven decision-making at NC State. With a Ph.D. in immunology from Northeastern and two decades of experience in both research and operations at an international pharmaceutical firm, Kowolenko understands the real-world challenges of succeeding in the information age.

"I'm a technical guy who made it in business," he says.

At NC State, Kowolenko works with teams of graduate students on industry-sponsored research projects in fields as diverse as engineering, computer science and human resource management. Whatever the field, each project starts with a question.

"You can throw a lot of analytics at anything, but if you don't know what problem you're trying to solve or what question you're trying to answer, then you're just throwing good money after bad," he says. "Your goal has to be to convert information to knowledge. Knowledge is what gives you the ability to make a decision."

Business executives who have only dealt with structured data — financial statements and inventory reports, for example — may have a hard time putting confidence in unstructured data such as marketing intelligence and Web search results.

"Unstructured text analytics is really messy," Kowolenko says. "A lot of times you see statisticians and analysts twist in their seats a little bit because our methodologies are so different."

To overcome their reluctance, he has a simple pitch: "The people who do this best, win."

PAST AND FUTURE

At the National Institute of Statistical Sciences in Research Triangle Park, Director Alan Karr was thinking about the future, and not just because he was leaving the agency after 20 years to take a job at nearby RTI International.

"There's no going back on the world's capacity for collecting data," he says. "Soon even your car will have its own Internet address."

As the challenges of big data evolve and grow, Karr says, North Carolina's Research Triangle is the natural place to confront them. After all, the region pioneered many of the tools and processes that helped launch the data analytics industry and have fueled its explosive growth.

At his new office at RTI, Karr works in a building named for the late Gertrude Cox, an expert in experimental research design who came to Raleigh in 1940 to join the faculty at NC State. She is credited with helping to establish the statistics departments at NC State and UNC-Chapel Hill, as well as the statistical division at RTI — a legacy felt to this day.

The region is also home to SAS Institute, a data analytics powerhouse founded in 1976 by Jim Goodnight, an NC State alumnus and onetime faculty member. The company — the world's largest privately held software firm — recently signed a master research agreement with the university to sponsor projects in a wide range of disciplines.

The convergence of major universities, nonprofits and industry leaders such as SAS makes the Triangle a hotbed of collaborative research.

The revolution sparked by the relentless growth of complex data has, in fact, touched virtually every industry and profession — including academia — making the practice of working across disciplines the new normal in labs and research institutes. This new focus on collaboration can't come too soon, says Karr.

"What's really behind the challenges of big data isn't just that data are complex," he says. "It's that data are complex in ways that we aren't used to."

Or, to quote the futurist Alvin Toffler, "The future always comes too fast and in the wrong order."

"There's no going back on the world's capacity for collecting data. Soon even your car will have its own Internet address."

— ALAN KARR



FROM NOVELTY TO ADVANCED RESEARCH

By Tim Peeler

• ABOVE: During Maker Faire at the NC State Fairgrounds, the Hunt Library's Makerspace booth was a popular stop for attendees eager to learn about 3-D scanning and printing.

"Ten years ago, doing something like [advanced scanning and 3-D printing] wasn't really a thing. So it's just really exciting to be on the cutting edge of technology."

— AUSTIN CARPENTER

At Makerspace, the well-appointed, technologically advanced common room on the fourth floor of NC State's Hunt Library, advanced printing, scanning and cutting technologies are readily accessible to any member of the campus community.

It's a place where dreams, and an occasional daydream, come true. That's why it has become one of the most popular places in the world-renowned Hunt, which may explain why the NCSU Libraries will open a space that's similar — but twice as large — at D.H. Hill Library in the spring of 2015.

The people who run Makerspace helped recent graduates Austin Carpenter and Jonathan Gregory develop a portable three-dimensional scanner with a rotating platform and three tower scanners for their senior design project.

One of the first things they printed, in conjunction with the fifth-annual Maker Faire this summer at the North Carolina State Fairgrounds, was a figurine of Chancellor Randy Woodson. Why exactly did they do this, except for the purpose of creating the nation's first chancellor action figure?

Because they could.

"Ten years ago, doing something like [advanced scanning and 3-D printing] wasn't really a thing," Carpenter says.

"So it's just really exciting to be on the cutting edge of technology."

That's the thing about the emerging technology in the 3-D printing world: With such a low commitment of resources involved, why not find out what's possible? There are practical applications just waiting to be discovered, some of which are ready to hit the market at inkjet speed. How about an on-demand spare part for an aircraft carrier, printed onboard in the middle of the Pacific Ocean? Or a life-sized, fully integrated human skeleton? Or a scale model of a dinosaur found in deepest Mongolia?

Emerging 3-D technology makes all these things possible, and more. For instance, a Belgian-based producer of 3-D technology and software recently scanned and printed a perfectly proportioned replica of Egyptian pharaoh King Tutankhamun for a five-year tour of the United States, along with artifacts from the boy king's actual tomb.

NC State alum Aly Khalifa, founder of Raleigh's Gamil Design and Designbox and the multifaceted SPARKcon, recently introduced his Lyf (Love Your Footprint) Shoes to Sustainable Brands conferences in San Diego and London. His innovative footwear — made of recycled cork and plastics without using environmentally damaging glue or heat — is custom-designed with 3-D scanners and manufactured with the assistance of



It's a whole new form of publishing in a building named for Josephus Daniels, the longtime Raleigh newspaper publisher and charter member of the Watauga Club.

CAMAL co-director Ola Harrysson has been doing such work for more than a decade, especially in medical applications for the NC State College of Veterinary Medicine. He printed out his first artificial orthopedic leg for a cat shortly after he arrived in 2002.

The advances in 3-D printing since then are breathtaking, crossing the boundaries between disciplines, universities and even species.

Harrysson is currently working with UNC-Chapel Hill School of Medicine associate professor Austin Rose to develop printed plastic bones that will enable doctors to do preoperative simulation — a surgical scrimmage of sorts — for difficult ear surgeries such as cochlear implantation. In the past, those simulations have been done on well-worn cadaver bones.



• **TOP:** One of the first things NC State graduates Austin Carpenter and Jonathan Gregory printed with their portable 3-D scanner was a figurine of Chancellor Randy Woodson. • **BOTTOM LEFT:** NC State alum Aly Khalifa uses new technology in production. • **BOTTOM RIGHT:** Khalifa's sustainable Lyf Shoes are made from recycled products like wine corks and 3-D-printed plastics.

a \$2,000 3-D printer, cutting out the costly production of prototype molds that can cost up to a quarter of a million dollars.

He likes to think of the Lyf Shoes model as the first “digital cobbler.” He knows these innovations wouldn't be possible without the use of 3-D scanning and printing technology.

“It allows us to create a totally different business model,” says Khalifa, from his offices in downtown Raleigh. “It's a complete game changer.”

At NC State, there is significant science attached to this once-novel idea in the field of additive manufacturing. In Daniels Hall, in the heart of campus, industrial and systems engineering professor Russell King runs the Center for Additive Manufacturing and Logistics (CAMAL), where desktop and industrial-size printers spit out objects in cobalt chromium, titanium, stainless steel and plastic.

Harrysson, Rose and NC State graduate student Caroline Webster have been working with a team of engineers and physicians to develop near-perfect replicas of those same bones for both adult and pediatric surgeries, all produced on a 3-D printer.

“It's intricate and time-consuming work,” Harrysson says. “You need input from the engineering side and the medical side to validate the model.”

For now the models are used for practice surgeries in doctors' surgical training. Developing replica bones for surgeries on infants is critically important because pediatric cadaver bones are rarely available for simulation.

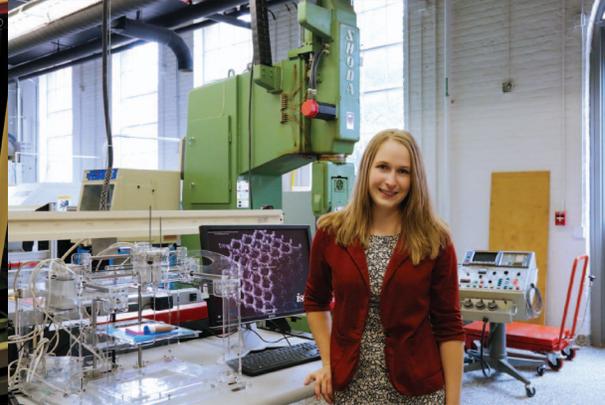
“We've never had this kind of ability to teach and assess our residents,” Rose says. “Before, they just had to get that experience in surgery. The ability for our residents to practice

continued

“It allows us to create a totally different business model.

It's a complete game changer.”

— ALY KHALIFA



• **TOP LEFT:** A 3-D-printed, plastic model of a skull bone that medical students can use in surgical simulations. • **TOP RIGHT:** NC State's Ola Harrysson, left, and UNC-Chapel Hill School of Medicine's Austin Rose combine expertise. • **BOTTOM LEFT:** An advanced 3-D printer offers many possibilities. • **BOTTOM RIGHT:** NC State graduate student Caroline Webster works in the Center for Additive Manufacturing and Logistics.

"We are experimenting with some nifty programs that will allow us to take two bones and compare them in 3-D space.

We can turn that into quantitative data, and in turn, we can use that to understand how bones differ between species in a way we couldn't before."

— LINDSAY ZANNO

preoperatively on a pediatric or otherwise challenging patient is a huge accomplishment. We can now get a scan, have the model printed out and gain valuable surgical experience before we ever touch the patient."

Webster, a native of Orlando who came to Raleigh from Mocksville, North Carolina, began working in Harrysson's lab during her sophomore year as a biomedical engineering student because "students here are allowed to do things and make things that make a difference," she says.

She has since become an expert in integrating MRI and CT scans with digital software called Mimics to map important nerves, the carotid artery, the sigmoid sinus and every variation in and around the delicate temporal bone that a surgical student may encounter during implant surgery. She's also learned to understand and translate the languages of both medicine and engineering.

The work done in Harrysson's lab spans multiple disciplines. In fact, members of the group spent the summer presenting their findings at conferences: Webster at a medical software conference in Chicago and an engineering conference in Austin, Texas; Rose at medical conferences in Las Vegas and Israel; and Harrysson at a medical advance digital conference in Beijing, China.

Medical printing could be the next significant innovation coming from the emerging field. NC State engineers have helped develop a printed cast that conforms perfectly to a patient's broken limb and that delivers ultrasound waves to stimulate healing.

Harrysson has high hopes for the field's not-too-distant

future, including the ability to print with living cells. Though he doesn't expect someone to be able to hit "Ctrl P — kidney" anytime soon, he's working with medical doctors at Wake Forest University to replicate bladders, heart valves and other organs. More immediately, he's developing ways to print small samples of living tissues that can be used to test screening drugs.

"These are tissues that previously you had to get from humans or animals," Harrysson says. "You wouldn't have to print the whole kidney; just a small piece of it. Then you give it the disease and try screening drugs on it. That could be even more beneficial than a fully printed kidney. It will help develop drugs."

While others may be peering into the future with their 3-D printing capabilities, paleontologist Lindsay Zanno is using 3-D scanning and printing, gaming technology and design software to help turn the ancient bones and bone fragments she has found in the field into full models of newly discovered species of dinosaurs.

"We are experimenting with some nifty programs that will allow us to take two bones and compare them in 3-D space," says Zanno, director of the Paleontology and Geology Research Lab at the North Carolina Museum of Sciences. "We can turn that into quantitative data, and in turn, we can use that to understand how bones differ between species in a way we couldn't before."

She has a new handheld scanner that her interns can use in the lab or in the field to get high-quality scans she can use to print full-scale and scaled-down models of bones and fragments. She recently took the handheld scanner on a research trip to Mongolia.



that and allows us to collaborate more and share more. That is huge for us.”

Zanno envisions a day when she can excavate and clean bones but skip the time-consuming process of fully prepping her findings. She’ll be able to get intricate CT scans of the bones and turn those scans into printed models.

“That would change everything we do,” Zanno says. “It would be phenomenal. That’s on the horizon, and we are trying to be a leader in developing that technology.”

Of course, when a new dinosaur is discovered — like *Siats meekerorum*, a 98-million-year-old carnivore Zanno unveiled last November — everyone wants to see a model of what it might have looked like. Zanno also uses digital technology, along with help from students in NC State’s College of Design, to figure that out.

Undergraduate design student Stephanie Huang of Cary, North Carolina, came to NC State to learn computer animation. She took a job in Zanno’s lab that allows her to develop her animation skills by creating digital models of reptiles.

“This gives me experience in the animation software I will use one day,” Huang says. “I never thought about applying my major this way, but now that I’ve seen this is an option, I might continue on this track.”

Zanno is excited about how 3-D scanning and printing technologies will help her dig into the past. Could she print out a full-sized version of her dinosaur? Sure, if she wanted to; she’s more excited, however, about the ability to print a smaller-scale version of it.

“Before, if we wanted to do a model of a dinosaur, we could only do one size,” she says. “The only way to make a model was to hire an artist to hand-sculpt everything. Then you would have to cast those bones to complete a model.

“With digital scanning and the data we have, we can print a model of any size we want. We can make all sizes for all purposes. 3-D printing makes that very simple. That helps speed up the whole process of paleontology, which can sometimes be arduously long.”

At NC State, 3-D printing is one more tool that students, faculty and staff are using to turn ideas into reality.

“I have all kinds of 3-D models we brought back from that,” says Zanno, who is also on NC State’s College of Sciences faculty. “Right now, we’re concentrating on building a database. Once we have a big enough database, that’s information we can share without having to go into the field or to the museums where collections are housed. A huge amount of the money that we need for the science of paleontology is for traveling to other exhibits and museums. This cuts down on

• **TOP:** *Appalachian State University student Devin Hoffman, of Canada, uses a handheld 3-D scanner on a dinosaur bone at the North Carolina Museum of Sciences.* • **BOTTOM:** *Paleontologist Lindsay Zanno, a member of the NC State College of Sciences faculty, works with Hoffman to turn a scan into a printable model.*

“This gives me experience in the animation software I will use one day. I never thought about applying my major this way, but now that I’ve seen this is an option, I might continue on this track.”

— STEPHANIE HUANG



Innovation Investments Deliver Returns

By Lisa Chang

In a world seeking returns on investments, the NC State Chancellor's Innovation Fund is a proven winner.

In its first three annual funding cycles, CIF invested \$1.1 million in 17 research projects that have received more than \$4.2 million in follow-on funding from a combination of federal and private sponsors. CIF projects also have brought the university more than \$460,000 in licensing revenue and seven commercialization agreements. Five startups show potential for long-term returns.

"Bridging the gap between academic research and commercial success of innovative technology is fraught with dead ends and pitfalls. From my perspective, the Chancellor's Innovation Fund at NC State is an innovative and powerful springboard toward bridging that gap."

— JAY BIGELOW

"The technologies presented in the CIF program are unique and address real problems in the marketplace today," says Bob Creeden, executive director of the Blackstone Entrepreneurs Network and mentor to multiple CIF awardees. "Through the review process and funding, innovators receive significant assistance, guidance and connections that strengthen and advance the commercial application of their innovative technologies."

Jay Bigelow, director of entrepreneurship for the Council for Entrepreneurial Development, agrees. "Bridging the gap between academic research and commercial success of innovative technology is fraught with dead ends and pitfalls," he notes. "From my perspective, the Chancellor's Innovation Fund at NC State is an innovative and powerful springboard toward bridging that gap."

Often the most disruptive concepts are just that: concepts, Bigelow says. "They need more time in development, further testing, prototyping, validation, etc. in order to de-risk the deal and make it more attractive to commercial partners, investors and senior leadership."

Established in 2010 with the support of Chancellor Randy Woodson, the program provides grants of up to \$75,000 for a year or less. Six new projects chosen in 2014 are featured on page 17.

"CIF projects enhance the commercial value of NC State's intellectual property assets," explains Kelly Sexton, director of NC State's Office of Technology Transfer. "While other universities offer similar seed grant programs, the CIF provides additional benefit to awardees through our mentoring program and connections with the Springboard Innovation Hub partners."

Each year, roughly 75 faculty members file CIF proposals. After initial screening, finalists pitch their technology development projects to a selection committee comprising representatives of university innovation partners: Eastman Chemical, Rex Healthcare, the Blackstone Entrepreneurs Network, First Flight Venture Center, HQ Raleigh, the Kenan Institute, NC Idea Fund Partners, Hatteras Venture Partners, the Center for Entrepreneurial Development and the North Carolina Small Business Technology Development Center, or SBTDC.

Kim Mayer, statewide director of technology development and commercialization for the SBTDC, says the CIF blend of grant funding and strong support from the Triangle's entrepreneurial community makes the projects and principal investigators more attractive to other granting agencies, including federal funding for small businesses.

"When utilized correctly, the CIF can lend the necessary credibility to an SBIR or STTR proposal. As the SBTDC has clearly seen through our work with technology-based



companies, this combination can catapult the technology into commercial development,” Mayer says. “The long-term benefits of this fund have been, and continue to be, inspiring.”

GREATEST SUCCESS SO FAR

If you’re using one of the latest Samsung smartphones, software developed in NC State’s computer science department is probably securing it.

TrustZone-based Integrity Measurement Architecture, a system of embedded software/firmware components developed by **Peng Ning** and **Ahmed Azab** to improve security of computer clouds and mobile systems, is now part of Samsung’s Knox security and data-management system.

Ning and Azab received CIF funding in 2012 to develop their software. They later launched a startup company, CellSentry Inc., to commercialize the technology. The team is developing further applications of the technology that may include products for cloud computing and the smart-energy grid.

“This technology is by far the Chancellor’s Innovation Fund’s greatest success to date,” Sexton notes.

KEEPING THE PACE

The CIF allows awardees to develop new perspectives and push boundaries. Check in with a few more past recipients:

Elizabeth Lobo credits her CIF experience for successful funding across multiple projects, going well beyond her original proposal. “The CIF program really opened my eyes as to how to efficiently incorporate translational research at earlier stages than I would have considered before,” she explains.

Featured in *The New York Times* in May, Lobo’s Cell Mechanics Laboratory is investigating the use of hollow, porous nanofiber mats as scaffolding in wound healing and tissue engineering. The mats can be utilized as controlled-release delivery devices for antimicrobials or other medications.

Her CIF project led to a collaborative research grant with the North Carolina Biotechnology Center and Dow, as well as other follow-on funding.

Have you ever been given a personality test as part of an employment screening process? Did you try to influence the outcome by entering what you thought the employer wanted to see?

Adam Meade’s innovative assessment system, PerSight™, allows employers to quickly screen the personality of job applicants for positive hiring traits, while minimizing the opportunity to reverse-engineer results or game the system.

Meade’s startup, Scientific Organizational Solutions LLC, is beta testing the efficacy of the assessment system in predicting the best prospective employees. The company has utilized support through OTT’s Venture Development for business model development, company and product logo designs, trademark, and software and website development assistance.

By using OTT’s shared space at HQ Raleigh, Meade says he has been able to “network with other startup companies and learn more about the process of getting a business off the ground.” This exposure is helping him to identify his own best practices as he builds his new venture.

LEFT TO RIGHT: • *The Cell Mechanics Laboratory* has earned national media coverage. • *Michael Dickey’s* prototypes are leading to collaborations with industry partners. • *An exoskeleton* is being improved with funding from the National Institutes of Health.

“CIF projects enhance the commercial value of NC State’s intellectual property assets. While other universities offer similar seed grant programs, the CIF provides additional benefit to awardees through our mentoring program and connections with the Springboard Innovation Hub partners.”

— KELLY SEXTON

continued

Michael Dickey's CIF project on shape-reconfigurable electronics resulted in the fabrication of sufficient liquid metal antenna prototypes to attract the attention of industrial partners. The prototypes, in turn, led to collaborations with Samsung's Antenna Research and Development group.

Dickey's research team studies interdisciplinary problems that involve thin films, interfaces, soft materials, and micro- and nanofabrication, including liquid metals that are stretchable and flexible. The team is currently optimizing antenna fabrication processes and furthering their understanding of impacts of voltage on the position and velocity of liquid metal movement.

Greg Sawicki's Human PoWeR — or Physiology of Wearable Robotics — Lab is developing an exoskeleton walking aid for rehabilitative, military and recreational use. Through the CIF project, the boot was tested on healthy and post-stroke subjects.

Data collected from the testing allowed the team to refine the configuration and mechanics of the boot, reducing it from more than 1.5 kilograms to only about 300 grams. The researchers also developed an electromechanical clutch.

Since the CIF award, Sawicki has received a five-year grant from the National Institutes of Health to continue to develop the exoskeleton.

As university student enrollments rise, academic advisors struggle to keep track of how well students are progressing toward completion of prerequisite classes and extracurricular activities required for solid applications to professional health graduate programs.

Anita Flick's comprehensive software platform, Livitae™, developed via her CIF project, documents a student's achievements, across academic, community service, clinical experience and social factors. A gap analysis identifies needs to be addressed prior to application to professional programs.

Currently in beta development, Livitae allows academic advisors to generate recommendation letters aligning students' strengths with professional program objectives. The institution also can track overall acceptance rates into professional programs.

Mentoring within the CIF ecosystem resulted in a more comprehensive product solution and brought several

investor groups to the table for further development and commercialization. "The support of CIF allowed me to navigate failures and setbacks safely, and challenged me positively in many ways. The final result of the project and business planning includes capabilities that I never would have thought of incorporating — and far exceeds my original expectations," Flick explains. Intelligent Campus Solutions Inc., a recently launched startup company, is working to commercialize Livitae.

The CIF program does a good job getting researchers to look at their scientific production outside of the usual academic metrics of degrees awarded and journal articles published — and to combine these academic endeavors with more of an entrepreneurial spirit," notes **Steve Shannon**.

Just 12 months ago, the VHF atmospheric plasma source at NC State was a solution looking for a problem. **Detlef Knappe** and Shannon had developed a device capable of operating under a wide range of conditions at atmospheric pressure. They had demonstrated the source's ability to modify water chemistry through both addition and additive removal.

Since receiving the CIF grant, the team has targeted specific water treatment applications, demonstrated scalability for industrial use, and obtained vital data to demonstrate the basic mechanisms that enable water-chemistry modification. The team has met with several companies, not only in water treatment, but also others working with surfaces, textiles and resins.

"We are really excited about what the future holds for this technology and our new company, Air Glow Inc.," Shannon says.

Led by Walter Brown and recent NC State doctoral graduate Brandon Byrns, the startup received early mentoring from the HiTEC Program in the Poole College of Management. The team is currently pursuing several federal SBIR opportunities with support from OTT's Venture Development and the SBTDC. Air Glow hopes to obtain capital to construct a prototype commercial system.

"The mentoring that we received has been instrumental in moving this technology closer to commercialization," Shannon says.

Learn more about NC State's Chancellor's Innovation Fund at go.ncsu.edu/cif. NC State University Communications contributed to this report.

(SEE related story on page 17.)

"The support of CIF allowed me to navigate failures and setbacks safely, and challenged me positively in many ways. The final result of the project and business planning includes capabilities that I never would have thought of incorporating — and far exceeds my original expectations."

— ANITA FLICK

INCUBATION

Incubating Innovation

From new methods for creating biofuels and determining cardiovascular risk to fridge-free food processing and a more efficient fuel injector, NC State researchers are developing innovative approaches to global challenges.

The Chancellor's Innovation Fund is helping those researchers and others move their research to the marketplace. Each year since 2010, the fund has supported a new group of projects with the potential to yield marketable solutions to pressing problems.

Six research teams received funding from the 2014 Chancellor's Innovation Fund:

'CUT AND REPLACE' GENE EDITING

The ability to edit select DNA sequences of interest — to add, delete, activate or suppress specific genes — is the holy grail of genetics research, including the molecular basis for many diseases.

Rodolphe Barrangou uses a system called CRISPR-Cas to take aim at certain DNA sequences in bacteria. CRISPR stands for "clustered regularly interspaced short palindromic repeats," and Cas is a family of genes and corresponding proteins associated with the CRISPR system. Essentially, bacteria use the system as a defense mechanism and immune system against unwanted invaders such as viruses. Now, that same system is being harnessed by Barrangou and colleagues to quickly and precisely target certain genes for editing.

Barrangou, faculty member in food, bioprocessing and nutrition sciences, is working on a new set of genome editing tools that cuts the targeted DNA and sets the stage for precise genetic modifications. His work holds promise in manipulating relevant bacteria for use in food and biotechnology applications and in model organisms used in agriculture, biotechnology and medicine.

CREATING EXTREME BIOFUELS

Saltpwater algae produce oil that can be converted to biofuels without using up valuable land and freshwater resources. The problem? It's not cost-effective. NC State researchers Heike Sederoff, Amy Grunden, Robert Natelson and Kelly Zering have figured out a way to solve that problem with the help of extremophiles.

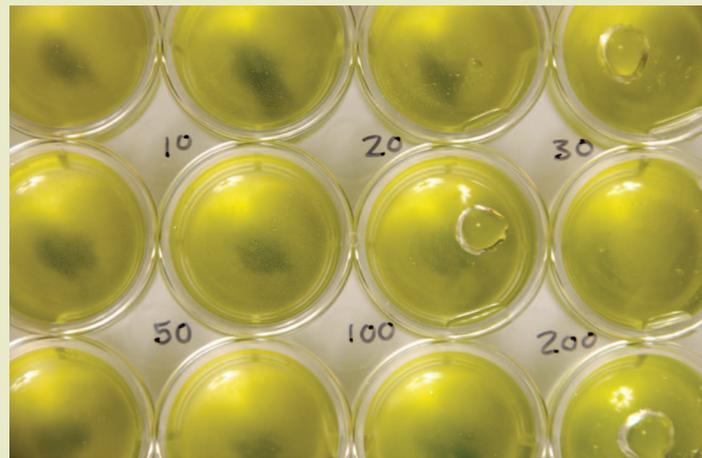
Extremophiles are organisms that live in extreme environments, like hot springs, acid lakes or polar ice caps. These organisms produce enzymes that are useful in industry — "extremozymes" that can work under extreme conditions and are used in detergents that help clean our laundry, or in food to make your cheese taste less bitter, or even to help dispose of deadly chemical weapons like sarin gas.

The researchers figured out a way to take the gene responsible for a particular enzyme's production from the extremophile and put it in the algae. The algae then produce both the oil for biofuels and the extremozyme of interest. The cost of biofuel production is offset by the sale of the extremozyme and enables production of a commercially viable renewable liquid transportation fuel.

IDENTIFYING 'VULNERABLE' ARTERIAL PLAQUE

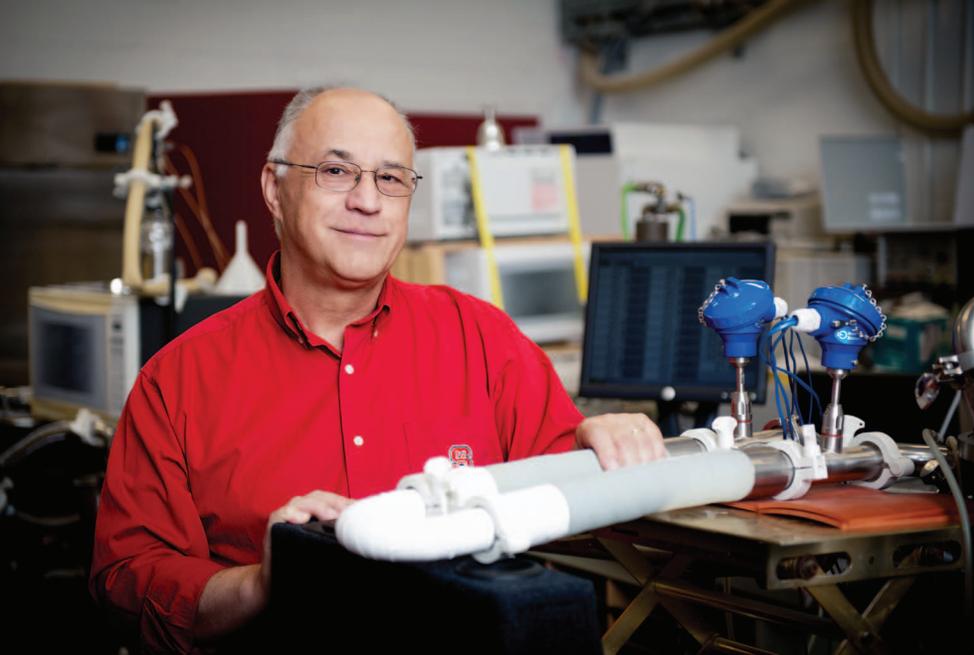
Engineering professors Xiaoning Jiang and Paul Dayton have developed a new ultrasound device that could help identify arterial plaque that is at high risk of breaking off and causing heart attack or stroke.

Existing state-of-the-art technologies are capable of determining if plaque is present in the arteries, but they can't tell whether it's vulnerable. That makes it difficult to assess a patient's risk.



- TOP: Rodolphe Barrangou is targeting genes for editing, work that holds promise in biotechnology.
- BOTTOM: NC State researchers develop novel and cost-effective techniques to produce biofuels.

continued



TESTING THERMOELECTRIC TEXTILES

Half of the energy generated in the U.S. is lost as waste heat, much of it during manufacturing.

But what if wasted power could be harvested and be re-purposed to power other electronics in an industrial plant, like LED lighting? That's the vision of textile researcher Jesse Jur and former research professor Mark Losego, now at Georgia Tech. They're creating flexible thermoelectric textiles that harvest power from temperature differentials, such as those between heated pipes and cold air.

Textiles with embedded electronics are flexible enough to wrap around a pipe, stretch over walls and fit into nooks and crannies, generating DC voltage that could supplement other power sources. Thermoelectric textiles work with low-temperature heat loss — something that current technologies don't do — and are less expensive to manufacture than existing designs.

The team, which recently added postdoctoral student Krishamraju Ankireddy, is developing a prototype for testing in the lab and with industry partners.

CLEANER CAR ENGINES

While the development of new technologies to replace fossil fuels is the focus of many researchers, NC State engineering professors Tiegang Fang and Greg Buckner are working on a simple change to the geometry of spray fuel injectors that they believe will offer a double dose of improvement for an American economy that consumes 385 million gallons of gasoline a day.

They are developing a new injector that optimally adapts both the direction and rate of fuel flow in an internal combustion engine and automatically changes the timing of when fuel is sprayed in the up-and-down cycle of a cylinder. They hope to increase engine efficiency by 10 percent, while also reducing emissions in a cleaner-burning engine.

Major car makers have shown interest in the first- and second-generation prototypes the researchers have made in their labs on Centennial Campus, but they would like to see a working engine before they commit to installing something in an upcoming model. That's the next step in the researchers' goal of making your engine less prone to pit stops.

NC State News Services contributed these profiles.



"Our goal was to develop something that could effectively identify which plaques are vulnerable," Dayton says. "The Chancellor's Innovation Fund will enable us to test contrast-enhanced intravascular ultrasound imaging in preclinical models and further validate our technology for commercialization and eventual translation into patients."

NO FRIDGE? NO PROBLEM

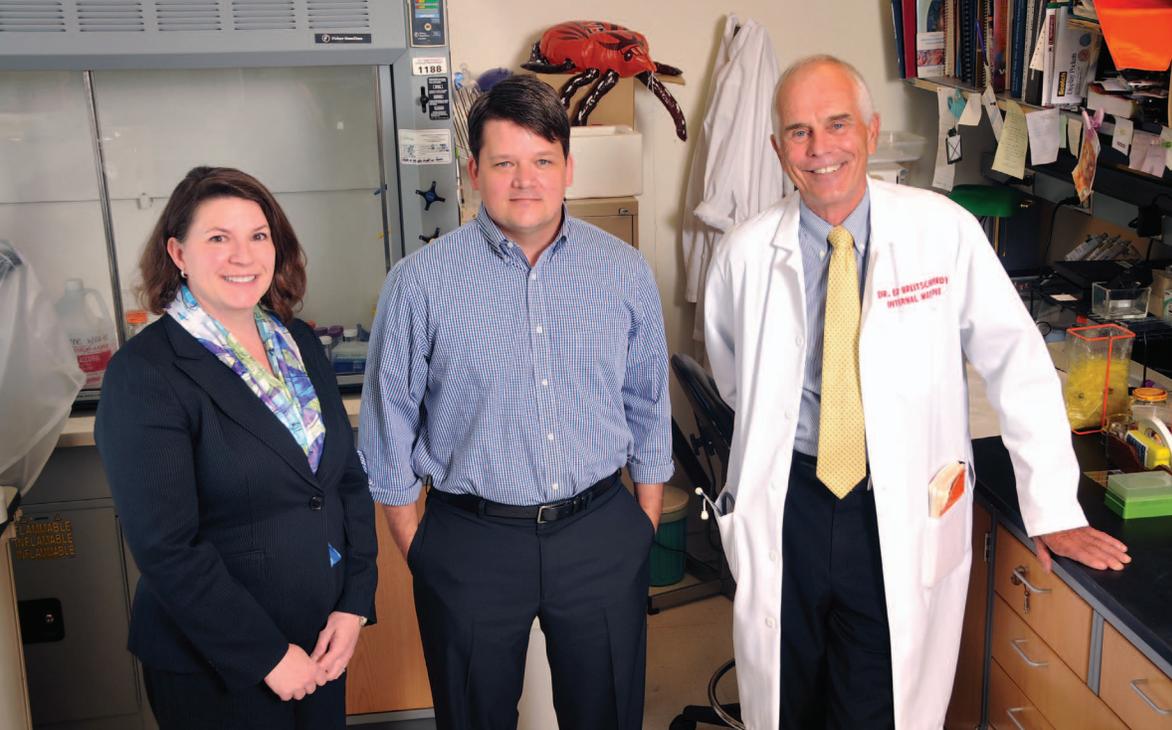
NC State food scientist Josip Simunovic is a pioneer in the field of aseptic processing, a system for rapidly heating and packaging food products in a sterile environment. His

innovations, which have earned 10 U.S. patents, have made it possible for the food industry to deliver shelf-stable foods like soups and fruit snacks in packaging that preserves their flavor and nutritional value without requiring refrigeration.

Now, Simunovic is developing a prototype of a modular aseptic processing system that could be used by R&D labs and small-scale food processing companies for a fraction of the cost of an industrial-scale system.

Simunovic says the lower-cost system will give "insurgents" in the food industry the tools to develop a wide variety of innovative food products such as daring new hot sauces for an emerging generation of food enthusiasts.

- **TOP:** Josip Simunovic is developing a low-cost, aseptic food-processing system.
- **BOTTOM:** Jesse Jur is making strides in thermoelectric textiles.



• **ABOVE:** From left, Amanda Elam of Galaxy Diagnostics, Wade Fulghum of NC State's Office of Technology Transfer and Ed Breitschwerdt of the College of Veterinary Medicine.

Unmasking a Stealth Pathogen

By Katie Mosher

Contrary to its common name, cat scratch fever requires neither a cat, nor a scratch. And its impacts can extend far beyond a fever. Even when patients have telltale symptoms of *Bartonella* infections, including swollen lymph nodes, the potential culprit can lurk for months or more.

"The basis of good medicine is an accurate diagnosis. It is the kindest form of therapy," explains veterinarian Edward Breitschwerdt. His work in the Intracellular Pathogens Research Laboratory in NC State's College of Veterinary Medicine led to startup Galaxy Diagnostics' incorporation in 2007.

Using a novel culture material and multiple levels of DNA testing for *Bartonella* bacteria, the company is pushing a new frontier of precision medicine for people and pets. "We have the best test in the word for *Bartonella*," says Breitschwerdt, chief scientific officer for Galaxy.

Since the 1990s, *Bartonella* has been identified not only in cats but also in

dogs, marine mammals and humans, and now horses, farm animals and wildlife, notes Breitschwerdt, who serves on state, national and international panels with a One Health focus that cuts across traditional medical boundaries. According to the Centers for Disease Control and Prevention, about 75 percent of recently emerging infections are of animal origin, and 60 percent of all human pathogens are zoonotic — or transferred from animals to people.

"NC State research has shown *Bartonella* infections often go undiagnosed as a mysterious illness or may be misdiagnosed as an immune-mediated disorder, like rheumatoid arthritis or multiple sclerosis," adds Amanda Elam, company president since Galaxy's clinical testing service was launched in 2009.

Since that time, Galaxy has performed more than 10,000 tests in animal and human medicine. Elam describes a bootstrap approach to company growth, through a mix of customer revenue, corporate sponsorship, and government loans and grants, such as \$130,000

in loans from the North Carolina Biotechnology Center and \$168,000 in funding from the National Institutes of Health Small Business Innovation Research, or SBIR, program.

Summer 2014 brought the company \$550,000 from new investors. "We are looking to expand our range of testing to include other emerging stealth pathogens, such as Lyme disease, or *Borrelia burgdorferi*, and other tick-borne infections," says Elam, who is also on the entrepreneurship faculty at NC State's Poole College of Management.

Bruce Boucher recently joined Galaxy Diagnostics both as an investor and as chief financial officer. He was most recently a co-founder, launch president and CFO of Liquidia Technologies, a Research Triangle Park-based spinout from the University of North Carolina at Chapel Hill. Boucher started his entrepreneurial career as CFO and general manager of Magellan Labs, which was sold to Cardinal Health and later acquired by The Blackstone

Group to become what is now called Catalent Inc.

A new partnership with IDEXX Laboratories, a leading veterinary diagnostics company, will help get information out to countless veterinarians about the risks of *Bartonella* infection for cats, dogs, horses and the people who care for them, along with Galaxy's *Bartonella* ePCR™ test and other testing options. Physicians and veterinarians will still route blood samples directly to Galaxy as a specialty lab.

"The Galaxy story illustrates university technology transfer at its best. Dr. Breitschwerdt developed the technology needed to address an unmet medical need, then formed a startup company to make the technology available to patients," notes Kelly Sexton, director of NC State's Office of Technology Transfer.

High-risk groups are of interest. The research team — including Breitschwerdt and Ricardo Maggi, also of NC State and Galaxy, along with physician colleagues from Duke University, where Breitschwerdt is also on faculty — found DNA of at least one *Bartonella* species in the blood of 28 percent of 114 veterinarians or veterinary technicians.

"The public needs to be aware that fleas carry up to five species of *Bartonella*," adds Breitschwerdt, a recipient of NC State's Alexander Quarles Holladay Medal for Excellence.

Cats remain a key factor, as one in three are infected with naturally occurring *Bartonella*. That rate increases to four of five feral cats. To stop the spread of related infections, he offers a simple mantra: "Kill fleas. Kill fleas. Kill fleas."

[Learn more about Galaxy Diagnostics at galaxydx.com.](http://galaxydx.com)

[Learn more about Edward Breitschwerdt's research at go.ncsu.edu/ed_breitschwerdt.](http://go.ncsu.edu/ed_breitschwerdt)

Leadership and Prosperity:

5 Questions for Chancellor Woodson



• **RIGHT:** Chancellor Randy Woodson served a year leading the Association of Public and Land-Grant Universities.

Chancellor Randy Woodson stepped into one of the top leadership roles in higher education in the fall of 2013 when he was elected chair of the board of directors of the Association of Public and Land-grant Universities (APLU).

Over the summer, APLU included NC State in its second class of Innovation and Economic Prosperity Universities, recognizing its commitments to public and private-sector partnerships and to economic engagement in the state and across the country. NC State was one of 14 institutions recognized this year and reinforces the school's mission to foster a culture of innovation on campus and strengthens the impact it makes on the communities of the state.

Woodson discusses some of the issues APLU addressed during his year as chair.

Q: First, explain what serving as chair meant to you.

APLU is the leading organization in the country representing public and land-grant universities. It's the professional organization that all of us who serve in public higher education, particularly those of us who have the land-grant tradition, have always looked up to as representing our interest broadly in Washington. For me, personally, it's an organization that I have always been affiliated with in different capacities, and to be elected to serve as chair of the board is for me a great honor. It's also great for NC State because it puts our university in a position to be front and center as we discuss all the issues we face in higher education.

Looking back on the past year as chair, I believe and I hope others would say that it's elevated NC State's visibility to our public university peers and strengthened our reputation as a leading public university. I also think

it's given me a chance to talk to other chancellors and presidents about what NC State is doing to address some of the most pressing challenges in higher education and demonstrate that NC State is making a huge difference in our own state but also in the nation as a research, teaching and service university. It's given me a chance to serve NC State and our fellow public universities and move us forward during a critical time in history of public higher education.

Q: What were the most pressing issues for APLU and all of higher education?

One of the reasons I was so excited to serve in that position was that there has never ever been a more critical time in the history of public universities. There are a lot of issues we are grappling with, so I think we are going to continue to be focused on affordability and how public universities can continue to be accessible and

affordable to the citizens in their states. In the national debate we are currently having about return on investment, we need to ask whether colleges and universities are doing all they can to produce graduates who are valuable to the marketplace. This has become a national issue because President Obama and the Department of Education are really focused on being very transparent on the success rates of graduates of various universities, what their starting salaries are, what their job prospects are. It's a very important time for public education and public universities to continue to remind the citizens of their states, and in APLU's case, the nation, about the value of higher education. It's all about the value proposition of affordability versus return on investment.

During the year, APLU worked with President Obama and the Department of Education to improve the affordability, accountability and

accessibility of higher education and to continue to improve the education students receive. Many APLU members met with President Obama and his key advisors at the White House in January to announce new programs to make public universities more accessible to students and families. APLU and member universities are also in the midst of an ongoing conversation with the Department of Education about how to better measure and rank universities in terms of outcome and value. It's important to get those metrics and measurements right, because public universities and students will react to those rankings. APLU and the member universities are also implementing new programs to improve graduation rates, learning outcomes and produce graduates that are ready for the marketplace and to be informed and engaged community members.

Q: APLU has asked Congress and the president to address the "innovation deficit," as federal research dollars are now becoming more limited through budget cuts and sequestration. What clarity are you looking for on behalf of APLU on the research side?

I think this is the other big issue we have to address. On the education side, it is affordability and access, and on the research side, it is the key role that public universities historically have played in the "innovation economy," that is producing not only graduates but also, through the research that they do, stimulating the economy, particularly in areas of technological innovation. So APLU is concerned about the lack of consensus in Congress on budgets for various agencies and whether Congress will pass budgets that will allow the critical investments that our government makes in research.

APLU continues to advocate for growth in federal research funding and partner with other organizations like Council on Competitiveness that can give a strong

business case perspective on why federal investments in research are critical for future economic growth and prosperity. But it goes beyond research and extends to all forms of scholarship in the humanities and the arts. APLU continues to advocate for humanities, arts and social science scholarship as well. APLU is doing a lot in this area because continuing to do fundamental and applied research and scholarship is critical to our nation's future economic prosperity and national security.

Q: The challenges of education and research are fairly constant. What new concerns are coming over the horizon?

I think a third issue where APLU will get involved is in immigration. That's been a big topic of conversation as people come from all over the world to study in America and then don't always have opportunities here because of challenges with immigration. Frankly, we are facing challenges because people have come to America to work and find themselves not in the position to benefit from higher education.

APLU has engaged on the importance of high-skills immigration and the importance of making it easier for U.S.-educated students to stay and work in America. Many in Congress agree with that view. Our continued success as a country is tied to bringing the best and the brightest to stay and work in the United States.

Q: How does NC State's strategic plan and its implementation mesh with the broader challenges and issues facing APLU?

I think it is right smack dab in the middle when you think of what we are trying to do at NC State: putting our students first, making sure they

are successful and giving them the skills they need to be successful in the marketplace. We are structuring the university in a way that gets the best value out of the dollars that are invested by the state. We are working hard to have organizational excellence so that the money that we get from tuition and from state appropriations can be used as much as possible for our educational mission. And we are working hard to hire and retain faculty and staff who can move the research agenda of the university forward. I think the issues we face in the state, the strategic plan of the university, are very consistent with the issues we face nationally.

Having a clear plan and a strong sense of focus has helped us remain on track during some difficult budget years. Our Faculty Excellence Program has brought amazing talent to North Carolina to join our current faculty in moving us forward in a number of emerging fields.



- **TOP:** Centennial Campus earned national honors for innovation of place.
- **BOTTOM:** Judges cited Centennial's new housing options and the Hunt Library.

Centennial Campus: Economic Engine

What do you give the research campus that has everything? In the case of Centennial Campus, nothing fits better than an award honoring the science campus as one of the nation's most innovative and productive economic engines.

That's exactly what North America's oldest higher education association delivered to NC State just ahead of Centennial's 30th birthday.

APLU, the Association of Public and Land-grant Universities, announced the four winners of its second-annual Innovation and Economic Prosperity University Awards. Georgia Tech, the University of Massachusetts Boston and the University of Houston also received honors.

NC State was singled out for the "Place" award, given in recognition of "its reinvention of the very notion of what a research park should be." Judges lauded the university for "creating a self-sustained city" on Centennial Campus, where residential and retail establishments are located near NC State research labs and industry facilities to spur collaboration.

The award also praised the ultramodern Hunt Library — the centerpiece of Centennial Campus — calling it "a smart library for the 21st century."

NC State's research chief, Terri Lomax, said the "Place" award makes perfect sense for a campus where collaboration between students, faculty and industry partners often spills out of labs into restaurants, coffee shops and greenways across the 1,200-acre campus.

"There's no place like Centennial Campus," she notes. "This is the place to live, learn, work and play — all in one location."

Forestry researcher Steve McNulty with the U.S. Department of Agriculture and his counterparts within NC State's Department of Forestry and Environment Resources don't like to talk about climate change.

It's not that they are ignoring it. Just the opposite. Much of their research focuses on the stress that forest ecosystems face due to climate variability and ways to mitigate and manage that stress. They prefer to avoid the politically charged atmosphere that has stymied effective and important collaborations among landowners, government officials, environmentalists, researchers and the general public. In fact, McNulty and his colleagues work hard to find common ground.

"We work with a lot of different working landowners, some of whom are receptive to the topic of climate effects and some who are not," explains McNulty, who is with the U.S. Forest Service within USDA.

"So if you tell people you're there to fix their climate change problems, that will often be the end of the discussion. From an individual standpoint, they all want the same thing, which is the sustainability of their range, agricultural and forest lands. If we talk to landowners, regardless of their property size, they're going to be receptive if we have something they feel is going to benefit and help them maintain their land — and so that's what we focus on."

EDDY FLUX TOWERS

One way NC State and USDA Forest Service researchers help monitor the effects of climate variability in North Carolina is from towers extending into or above forest canopies in key ecosystems. The towers hold several sensors, including a gas analyzer, hygrometer and thermocouple.

The system allows for continuous monitoring of changes in wind velocity, temperature and water vapor amounts, as well as exchanges of trace gases, such as carbon dioxide.

The data collected from the three towers along North Carolina's coast are combined with a statistical method called eddy covariance or eddy flux. When the results from the towers are analyzed with comparable results from sensors in the ground, such as in the nutrient-rich swampy ecosystems of the Alligator River National Wildlife Refuge near the coast, researchers can better understand forest timber production, carbon sequestration and water yield potential from these similar forests.

Combined with climate data, the results help researchers better understand

how this exchange process works. "The towers help us evaluate the overall performance of an ecosystem," says John King, head of the Tree Physiology and Ecosystem Sciences Laboratory in NC State's College of Natural Resources. "It's both a top-down and bottom-up approach at the same time, allowing us to see if the forest is taking up or giving off CO₂, that is, the next balance with the atmosphere."

NC State and USDA researchers say this information is vital to the region for a number of reasons.

First, North Carolina and other Southern states are highly dependent on forests and trees, especially the loblolly pine or



Saving the Forest for the Trees

MONITORING CLIMATE EFFECTS THROUGH COLLABORATIVE RESEARCH

By Gene Pinder

Pinus taeda L. In some states, such as Alabama, Georgia and North Carolina, about two-thirds or more of their land area is forested, most of which is under private ownership and an important natural resource for the forest products industry.

Second, any long-term climate variability could not only affect sea levels from Cape Cod to the Florida Keys but could also result in a decline in forests' role as a kind of carbon "sink."

Currently the forests store large amounts of carbon, helping remove greenhouse gases from the atmosphere. Research also suggests that climate fluctuations bring on droughts, more pests, and larger

and more dangerous fires as well, all contributing to increased stress on forests.

"It's really risk assessment and putting the probabilities of change in context," King notes.

"We're basically asking — what is the likelihood that a given ecosystem is going to change and to what extent? Society needs to make the best decisions going forward. We want to help by getting this information out to the public. People can see changes now. They can see forests along the coast changing, but they don't know why. We try to help by developing ecosystem models that will provide decision support for future forest management activities."



• FAR LEFT: A 3-D sonic anemometer and open-path CO₂/H₂O analyzer sit atop an eddy flux tower in the Alligator River National Wildlife Refuge. • LEFT: An eddy flux tower rises above the Alligator River refuge canopy. • BOTTOM: John King, left, and Steve McNulty collaborate to identify the effects of climate on Southern forests.



CLIMATE HUBS

The eddy flux towers may be the most visible example of the collaborative work between the USDA Forest Service and NC State researchers, but several other recently launched projects promise to have even greater impact in the field of forest management.

In February 2014, the USDA announced the launch of seven “climate hubs,” officially named Regional Hubs for Risk Adaptation and Mitigation to Climate Change. The Southeast Regional Climate Hub is led by McNulty and located in the USDA Forest Service’s Centennial Campus offices.

The hub has three goals: to deliver

science-based knowledge and practical information to farmers, ranchers and forest landowners that will help them to adapt to climate variability; to act as a repository for the latest climate and working lands science so that it’s readily available to local and regional partners in federal and state agencies, universities, nongovernmental organizations, environmental groups, private companies and tribes; and to learn what information and tools landowners need to maintain and enhance the sustainability of their working lands, then pass this information to USDA leadership as funding priorities in the southeastern United States.

“We’re really excited about the hub and think it’s the best way to get information to and from landowners,” McNulty says.

“In the past, the science being conducted wasn’t always getting to the landowners who might be able to use it. There wasn’t much emphasis on how we make sure the information was actually making a difference. That’s all changing with the hub.”

A good example is the development and implementation of TACCIMO, an online tool for accessing climate change impacts and management options. TACCIMO has a number of features, including a searchable database of various forestry management options that are based on peer-reviewed literature.

There’s also a geospatial mapping application that provides downscaled climate data for most forest ecosystems in the lower 48 states. Visitors to the site can type in their zip code and the map will show how the models predict how the climate will change over time for that zip code. TACCIMO can create climate, planning and literature reports, which can be used by governmental agencies, landowners and other groups.

“It’s a powerful feature,” McNulty explains. “What used to take forest planners three months of study at the library now takes five minutes. Landowners and managers can see a real use for it because it’s very inclusive with the most recent scientific information included, and we’re also adding more literature all the time.”

The tool can be found at www.forest-threats.org/taccimotool.

PROXIMITY PAYS OFF

Whether it’s working on TACCIMO or the eddy flux towers, USDA Forest Service scientists attribute the speed and success of their collaborative efforts with NC State to their proximity.

“We couldn’t do what we do without physically being on campus,” McNulty notes. “You don’t really think about it until you’re on the phone and you have an idea

and need to get together, so we’ll all meet at Hunt Library in an hour. You just can’t do that unless you’re close.”

USDA researchers also appreciate being close to NC State students.

“We have great relationships with graduate and undergraduate interns,” says Jennifer Moore Myers, a resource information specialist with the USDA Forest Service. “They get to work in this professional environment and produce something we use as a pilot for what becomes a larger project, so we benefit tremendously from those interactions. Just being able to participate in other campus activities and the working relationships we have with professors — we definitely enjoy being here.”

NC State researchers share USDA’s enthusiasm for joint efforts.

“Our collaboration with the U.S. Forest Service is crucial,” King adds. “Not only have they historically been a funding source and supporter of our research, but their scientific skills are invaluable. For example, their modelers have really helped us in terms of ecosystems and watersheds. We’ve been able to apply the results of our tower studies across the region using their models.”

Whatever the effects the changing climate will have on natural resources and human communities, researchers from NC State and the U.S. Forest Service agree more funding for research is needed.

“It’s critical that we continue to invest in science, education and the stewardship of our natural resources not only to produce an educated electorate, but to continue to provide answers to some of the most important questions of our time,” King explains.

“These are highly complex problems, the solutions to which will go a long way toward sustaining economic well-being and quality of life for all.”

QUICK TAKES

MEET NC STATE SCIENTISTS

In 2013, the U.S. Census Bureau reported that women, African-Americans and Hispanics are significantly underrepresented in STEM fields. Part of the problem appears to be that women and people of color don't see themselves in many STEM fields. One step forward in addressing this imbalance is to highlight diverse role models in STEM.

In April 2014, the university launched "This Is What Science Looks Like at NC State," an online series that highlights the diversity of researchers in science, technology, engineering and mathematics. Rather than featuring glossy profiles, the series allows researchers to write about their own experiences and what drew them to their respective fields.

Since launching, the series has profiled more than three dozen researchers — from undergraduates to well-established faculty — all of whom are members of under-represented groups in STEM fields.

It's received an enthusiastic response, and other universities have contacted NC State about starting similar projects. To learn more about the series, visit <http://news.ncsu.edu/tag/what-science-looks-like/>.

CONSORTIUM FOCUSES ON NUCLEAR NONPROLIFERATION

NC State has been awarded a five-year, \$25 million federal grant to develop the next generation of leaders with practical experience in technical fields relevant to preventing the spread of nuclear weapons around the globe.



- **ABOVE:** "This Is What Science Looks Like at NC State," a series in The Abstract blog, highlights the diversity of researchers.
- **OPPOSITE PAGE, TOP:** Collars designed by an NC State team keep elephants away from African villages. • **OPPOSITE PAGE, BOTTOM:** Scientists are looking at how Salmonella can be transferred from pigs to people.

The National Nuclear Security Administration's Office of Defense Nuclear Nonproliferation Research and Development noted that NC State was selected over 22 other proposals.

The university's new Consortium for Nonproliferation Enabling Capabilities, or CNEC, will serve as a research and education hub for the development of enabling technologies and technical talent in the field over the coming decade.

"For NC State to be selected to lead this vital national effort is a testament to our great faculty and strong leadership in nuclear engineering," says Chancellor Randy Woodson.

CNEC will implement educational activities aimed at developing a pool of future nuclear nonproliferation and nuclear security professionals and researchers. In addition, the consortium will provide the U.S. government with cutting-edge research and development to identify and address multidisciplinary

and cross-functional technology and research needs that are critical to detecting foreign nuclear weapon proliferation activities.

"This grant will link students with world-class researchers and introduce them to career possibilities at the national labs while providing education in areas of great importance for the nonproliferation mission," says Anne Harrington, NNSA deputy administrator for defense nuclear nonproliferation.

Robin Gardner, professor of nuclear and chemical engineering and director of the Center for Engineering Applications of Radioisotopes, will lead the consortium. John Mattingly, associate professor of nuclear engineering, is co-principal investigator on the project.

CANCER COP TARGETS UV DAMAGE IN DNA

We know that prolonged sun exposure damages skin — the sun is a nuclear reactor, after all. But how does our

body respond to and repair this damage at the DNA level?

NC State experimental biophysicist Hong Wang is part of a team led by Bennett Van Houten of the University of Pittsburgh School of Medicine that studied a DNA repair protein called UV-DDB (which stands for UV-damaged DNA-binding protein) and how it does its job.

UV-DDB is constantly scanning strands of DNA looking for sites of damage. UV-DDB is the first protein at the scene of UV-induced DNA lesions. If these lesions aren't located and fixed, they could impair a cell's ability to divide properly, leading to mutations and, over the long term, to cancer.

When UV-DDB spots a lesion, it calls for backup. A team of 20 different "first responder" proteins show up and remove the DNA lesions, allowing the cell to divide normally.

The researchers wanted to know how,



away from African villages, where bull elephants in particular do considerable damage.

The collar, created in collaboration with electrical and computer engineering students Layne Whaley, Peter Panburana, Courtney Comford, Emma Besaw and Justin Keaton, transmits sounds and vibrations that mimic bees and ants, which elephants avoid. Powered by solar-panel-charged batteries, the waterproof collar has GPS tracking capability and uses a strategy similar to an invisible pet fence.

With support from the U.S. Army Research Office and a partner agency, Adventures with Elephants, the NC State team headed to

South Africa over spring break to try out two prototypes on the animals — a real think-and-do challenge.

Obstacles included detours caused by flooding. The powerful, water-loving elephants gave the collar and its electronics a serious workout, too, forcing students to improvise on the spot. “You can’t just run down to Lowe’s for replacement parts,” Barnes says.

Hampered by limited Internet connections in the field, enterprising team members had to figure out ways to make the device function. All of the students’ work led up to the moment when results played out in real time.

As an elephant approached a GPS-mapped boundary, team members activated the collar and held their collective breath. “The elephant heard

the sound and felt the buzz on the side of the neck, and turned away,” Ray recalls with a smile.

The results lasted longer than the students had hoped. “Almost two months later, the elephant still didn’t want to go back to the area,” Besaw says.

DO PEOPLE AND PIGS SHARE *SALMONELLA* STRAINS?

If antimicrobial-resistant *Salmonella* is showing up in pigs, then are bacon-loving people also at risk? In his latest research, NC State population health and pathobiology professor Sid Thakur looked at serotypes, or groups, of antibiotic-resistant *Salmonella* in people and pigs to try to determine whether these strains are being passed from pork to people.

Thakur took samples from 30 North Carolina farms — from the pigs and their surrounding environments, including everything from feed to floors — and found seven predominant serotypes of antimicrobial-resistant *Salmonella*. One of them, *Salmonella* Typhimurium, was also found in human clinical samples Thakur collected.

“Depending on the serotype we’re looking at, we can find similar serotypes in pigs, people and the environment,” Thakur says. “However, the individual genetic ‘fingerprints’ of serotypes can differ. In this case, only *Salmonella* Typhimurium was the same for people and pigs; however, that doesn’t mean that we can say people are getting this illness from pigs or vice versa.”

Thakur also notes that while the serotypes were the same, the resistance profile — in other words,

continued

exactly, UV-DDB walks its beat. In each cell, there are about 180,000 of these protein “cops,” but there are several billion DNA base pairs in the human genome, so the cops have a lot of ground to cover on every strand of DNA.

Proteins can move along strands of DNA in different ways: They can slide along the strand like skateboarders grinding a rail (called a one-dimensional search), or they can jump on and off of the strand at different points — a three-dimensional search.

To learn how UV-DDB moves, the researchers tagged it with fluorescent nanoparticles that allow researchers to track individual UV-DDB proteins. Using a high-speed camera (20 frames per second) and a fluorescence microscope, researchers captured video of UV-DDB’s movements on DNA. They learned that

UV-DDB prefers a three-dimensional search, or jumping, to a one-dimensional search, or sliding, when it “interrogates” the DNA for damage. That’s because the 3-D search makes it easier for UV-DDB to navigate obstacles like histones and other proteins when it’s searching for lesions.

RED-COLLAR RESEARCH HELPS VILLAGES

Thanks to the real-world ingenuity of NC State textile and engineering students, there’s a passel of elephants in South Africa who’ll find it impossible to forget which villages they’re supposed to avoid.

Kristi Barnes, Keegan Ray and Caryn Siggins applied their textile engineering and technology muscle to create a rugged collar to steer pachyderms

the drug that the serotype is resistant to — differs from human to pig populations. “In pig populations and their environment, all of the samples we looked at were primarily resistant to tetracycline, which is an antimicrobial commonly used in production environments,” he says. “In humans, the resistance profile was much different.”

So what does this mean for consumers? As always, proper cooking and food handling practices eliminate 99 percent of the problem. “Further studies to determine the role played by different reservoirs — people, pigs and environment — in the food chain will be key to determining which direction the infection is flowing from,” Thakur says.

Thakur’s results appear in *Foodborne Pathogens and Disease*.

IMPROVING AFRICAN SWEET POTATOES

NC State will receive \$12.4 million over the next four years from the Bill and Melinda Gates Foundation to improve a crop that is an important food staple in sub-Saharan Africa — the sweet potato.

The grant will fund work to develop modern genomic, genetic and bioinformatics tools to improve the crop’s ability to resist diseases and insects and tolerate drought and heat.

Craig Yencho, an NC State horticultural expert who heads the university’s sweet potato breeding program in the College of Agriculture and Life Sciences, is the project director. He says that sweet potatoes have a number of valuable characteristics that make them an attractive African crop.

“Sweet potato is a hardy crop that can be planted in drought-prone and low-fertility soils,” Yencho says. “Orange-

fleshed sweet potatoes, which are an excellent source of vitamin A, rank first in nutritional quality among root and tuber crops grown in sub-Saharan Africa, providing vitamins for millions of people.”

Chancellor Randy Woodson praised Yencho’s work on sweet potatoes in Africa and in North Carolina, which leads the United States in sweet potato production.

“Dr. Yencho’s work on this important crop has led to a number of new varieties and improvements in sweet potatoes grown across the world, and is an excellent example of NC State’s think-and-do mentality,” Woodson says. “The international collaboration he’ll head will use interdisciplinary teams to gain critical knowledge — and share that knowledge — to help feed a continent.”

NC STATE LEADS POWERAMERICA

NC State’s leadership of the \$140 million Next Generation Power Electronics National Manufacturing Innovation Institute, or PowerAmerica, continues to move forward with four other universities, 12 industry partners and two government labs in the consortium.

Announced by President Obama earlier this year, the institute will develop advanced manufacturing processes that will enable large-scale production of wide bandgap (WBG) semiconductor-based power electronics, which allow electronic systems to be smaller, faster and more efficient than power electronics made from silicon.

“NC State couldn’t be more proud to have been selected to lead this institute, which truly embodies everything that our university stands for — from our think-and-do philosophy to our

collaborative spirit and commitment to solve the grand challenges of society,” says Chancellor Randy Woodson.

A recognized leader in developing WBG technology, NC State will unite the industry, academic and government partners in their effort to revolutionize energy efficiency across a wide range of applications, including electronic devices, power grids and electric vehicles. In addition to developing manufacturing processes, the consortium will develop devices and packaging materials that take advantage of the technology’s higher temperatures and voltages.

But the payoff could be huge. WBG power electronics technology has the potential to reshape the global market for power electronic components by increasing the efficiency of everything that uses power electronics, from industrial motors and consumer electronics to data centers and renewable energy systems. The WBG share of the international lighting market alone is expected to reach \$84 billion by 2020.

WBG technology also eliminates up to 90 percent of the power losses that occur when converting from alternating current to direct current and vice versa. It can handle voltages more than 10 times higher than silicon-based devices, greatly enhancing performance in high-power



• ABOVE: Craig Yencho of NC State will lead a sweet potato study in Africa. • RIGHT: Lessons learned in North Carolina will help feed a continent.

applications. And it can operate at more than twice the temperature of silicon-based devices, resulting in better reliability and efficiency.

“The innovations developed by PowerAmerica will give U.S. manufacturers a head start and competitive edge in the emerging WBG market. This is a game changer,” says Terri Lomax, vice chancellor for research, innovation and economic development.

Learn more at ncsu.edu/power.

HARNESSING CROWDS TO ANALYZE CLOUDS

When it comes to analyzing hurricanes and other tropical cyclones, lack of data isn’t the problem. Scientists have 30 years of satellite images of these massive storms. What they don’t have is reliable data about cyclone intensity, because analysis methods have changed through time and from one region to another.

One of the best methods for determining cyclonic intensity remains human observation and classification of images. But the volume of data is daunting, especially when each image needs to be analyzed by several different people for consistency. Researchers from NC State's Cooperative Institute for Climate and Satellites — North Carolina (CICS-NC) have come up with an innovative solution to the problem: Recruit and train citizen scientists to analyze the images online.



CycloneCenter.org launched in 2012, with a backlog of 200,000 satellite images of cyclones that needed analysis. A collaboration among CICS-NC, the University of North Carolina at Asheville, the National Oceanic and Atmospheric Administration and the Citizen Science Alliance, the website recruited volunteers and taught them to classify images.

In a paper in the *Bulletin of the American Meteorological Society*,

the Cyclone Center gave preliminary results. "We've had about 350,000 classifications in two years," says Carl Schreck, CICS-NC research associate. "We want each of our 200,000 images to be classified by 10 different volunteers, in order to reduce uncertainty or error."

So far, the results are encouraging. "Beyond classifying and cataloging these storms, we've also demonstrated that you can get people with nonscientific backgrounds involved in scientific research, with positive results," Schreck says.

Interested in volunteering? Go to CycloneCenter.org.

SURVEY OF TRIANGLE ENTREPRENEURS SHOWS OPTIMISM

NC State has launched a new quarterly survey to measure the outlook of Triangle entrepreneurs — and the initial results show significant optimism for increased revenue, spending and employment well into spring 2015.

"The goal of the Quarterly Outlook of Triangle Entrepreneurs (QuOTE) survey is to help entrepreneurial companies and state and local government officials in the Triangle anticipate business decisions and plan for growth," says Jeff Pollack of the Poole College of Management at NC State, who developed the survey.

Conducted by the NC State Entrepreneurship Clinic, QuOTE is adapted from a similar national survey of large national companies that is conducted by the Business Roundtable, an association of CEOs of American companies.

In the initial results, 86.9 percent of the

199 Triangle-area entrepreneurs who were surveyed expected an increase in revenue over the next six months, while only 4 percent anticipated revenue declines. Meanwhile, 60.3 percent of respondents expected to hire new employees over the next six months, as opposed to 2.5 percent who anticipated decreases in staff. And 55.8 percent predicted an increase in domestic capital spending, with 5.5 percent anticipating spending cuts.

"The optimism found in the survey confirms what we hear from entrepreneurs on the street," says Lewis Sheats, senior lecturer of entrepreneurship in Poole College and the director of the NC State Entrepreneurship Clinic.

A full report on the findings is available online at <http://tec.poole.ncsu.edu/engaging/quote-results/>. Anyone who wishes to participate in the survey or who would like to receive email updates about future quarterly surveys should contact the organizers at TheEClinic@ncsu.edu. Participation is free. Responses are confidential.

STUDY OFFERS INSIGHT INTO CHALLENGES FOR COLLEGE ATHLETES

A new study from NC State sheds light on how some collegiate student-athletes deal with uncertainties ranging from excelling in both school and sports to their career prospects outside of athletics.

"We wanted to explore how student-athletes at top-tier universities cope with the dual challenges of meeting the expectations of their teams while simultaneously complying with their responsibilities as university students," says Lynsey Romo, a

communication faculty member at NC State and lead author of a paper on the work.

The study was based on in-depth interviews with 17 student-athletes at a university that is considered to be elite in both its academic and athletic programs.

The researchers found that student-athletes reported feeling uncertain in three areas: personal uncertainty, such as uncertainty about injury or about balancing school work and sports; social uncertainty, such as uncertainty related to who their "real" friends are; and future uncertainty, such as uncertainty concerning their post-collegiate careers and whether the time they spend pursuing athletics will hurt their career prospects.

Most of the student-athletes reported using a variety of techniques to reduce uncertainty. These uncertainty-reduction strategies included seeking social support from friends, family or academic counselors; socializing with friends to take a break from sports and school pressures; negotiating with coaches in an attempt to increase their scholarship; and sometimes concealing their athlete status from peers to minimize people befriending them for the wrong reasons or to prevent negative stereotypes. Other student-athletes came to terms with uncertainty as a natural part of life and turned to prayer to help them cope.

The paper, "'You Never Know What's Gonna Happen': An Examination of Communication Strategies Used by College Student-Athletes to Manage Uncertainty," is published online in the journal *Communication & Sport*. The paper was co-authored by NC State undergraduates Christine Davis and Alyssa Fea.

KUDOS

NARAYAN EARNS MAJOR N.C. HONORS

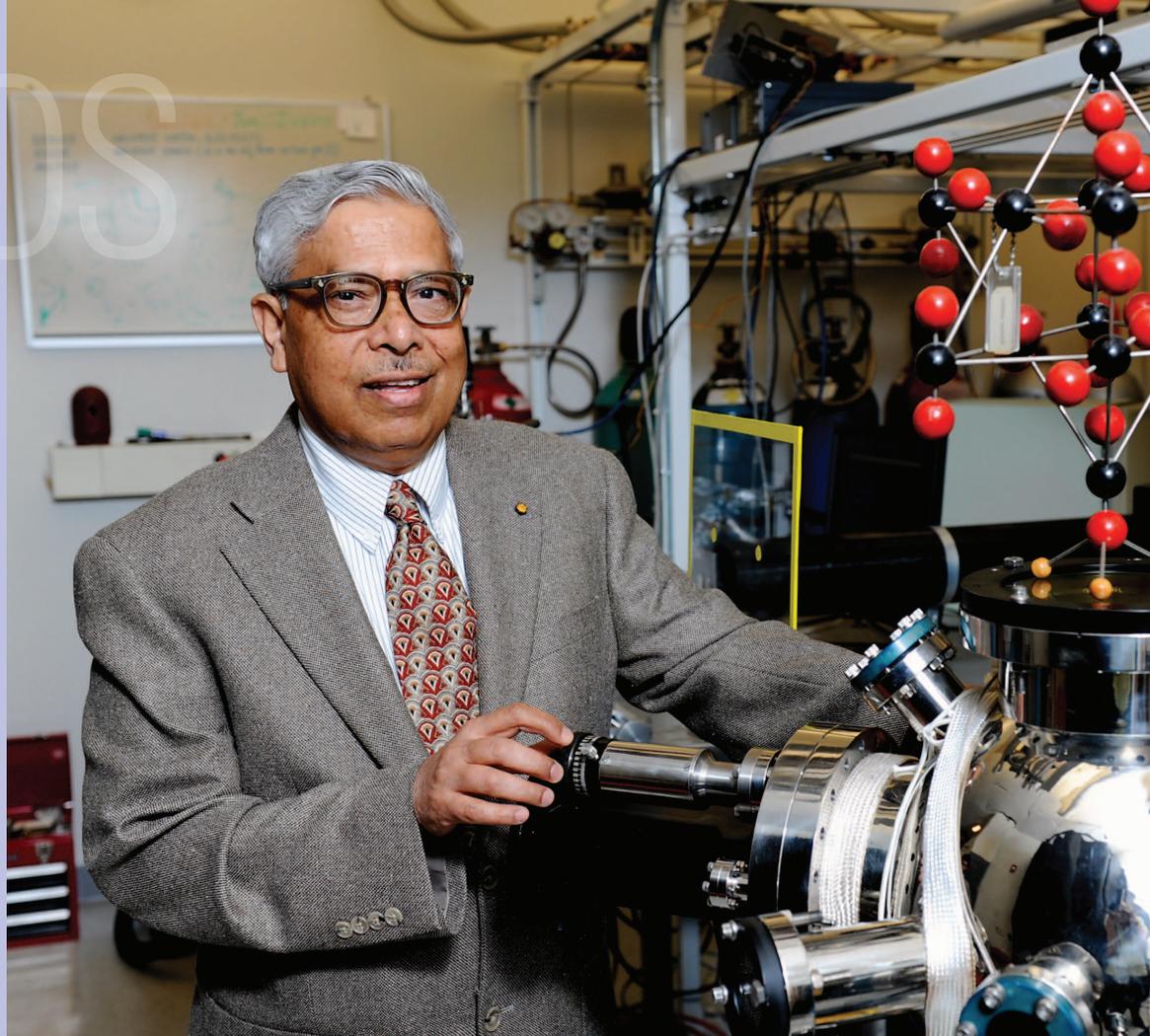
Jay Narayan, John C.C. Fan Family Distinguished Chair Professor of Materials Science and Engineering at NC State, has been awarded the 2014 North Carolina Award in Science.

The North Carolina Award is the highest civilian honor bestowed by the state of North Carolina. Past winners have included Maya Angelou, Charlie Rose, John Hope Franklin, Charles Kuralt and four Nobel laureates. Walt Wolfram, the William C. Friday Distinguished Professor of English at NC State, received the North Carolina Award in Public Service last year.

Narayan is also the 2014 recipient of the O. Max Gardner Award — the most significant honor given to faculty by the University of North Carolina Board of Governors.

The Gardner award is presented each year to a faculty member from one of the system's 17 campuses who is recognized as having "made the greatest contribution to the welfare of the human race." Narayan is the 29th faculty member from NC State to win the O. Max Gardner Award since its inception in 1949.

Narayan has made groundbreaking contributions to the field of materials science, most notably in domain matching epitaxy, a method of combining nanomaterials that reduces defects in the semiconductor materials that affect LED efficiency. This work led in turn to the development of high-efficiency LEDs that will save energy, reduce greenhouse emissions and contribute to our nation's energy independence. He holds 40 U.S. patents and has published nine books and more than 500 papers in scholarly journals, which have more than 20,000 citations.



- **ABOVE:** Jay Narayan earned top honors from the state of North Carolina and the University of North Carolina system.
- **OPPOSITE PAGE, TOP:** Joseph DeSimone is among few researchers elected to all three U.S. National Academies.
- **OPPOSITE PAGE, BOTTOM:** Carolyn Miller is recognized as a catalyst for the field of rhetorical genre studies.

Elected in 2008 as an inaugural fellow of the Materials Research Society, Narayan is also a life member and fellow of the Materials Society, a fellow of the American Association for the Advancement of Science and a life member and fellow of the American Physical Society.

DESIMONE ELECTED TO INSTITUTE

Joseph DeSimone, an interdisciplinary researcher on faculty at NC State and the University of North Carolina at Chapel Hill, has been elected to the Institute of Medicine, one of the highest honors in the fields of health and medicine a U.S. scientist can receive.

His election to Institute of Medicine represents the third time DeSimone has been named a member of a U. S.

National Academy. He was elected to the National Academy of Engineering in 2005 and the National Academy of Sciences in 2012. Fewer than 20 people in history have achieved election to all three U.S. National Academies.

DeSimone is the first professor in the state of North Carolina to be named to all three U.S. National Academies. "It is humbling to join such an elite group," DeSimone said. "This is a tribute to my students at UNC-Chapel Hill and NC State whose research at the intersection of diverse fields enables us, as a team, to create significant impact in and beyond medicine."

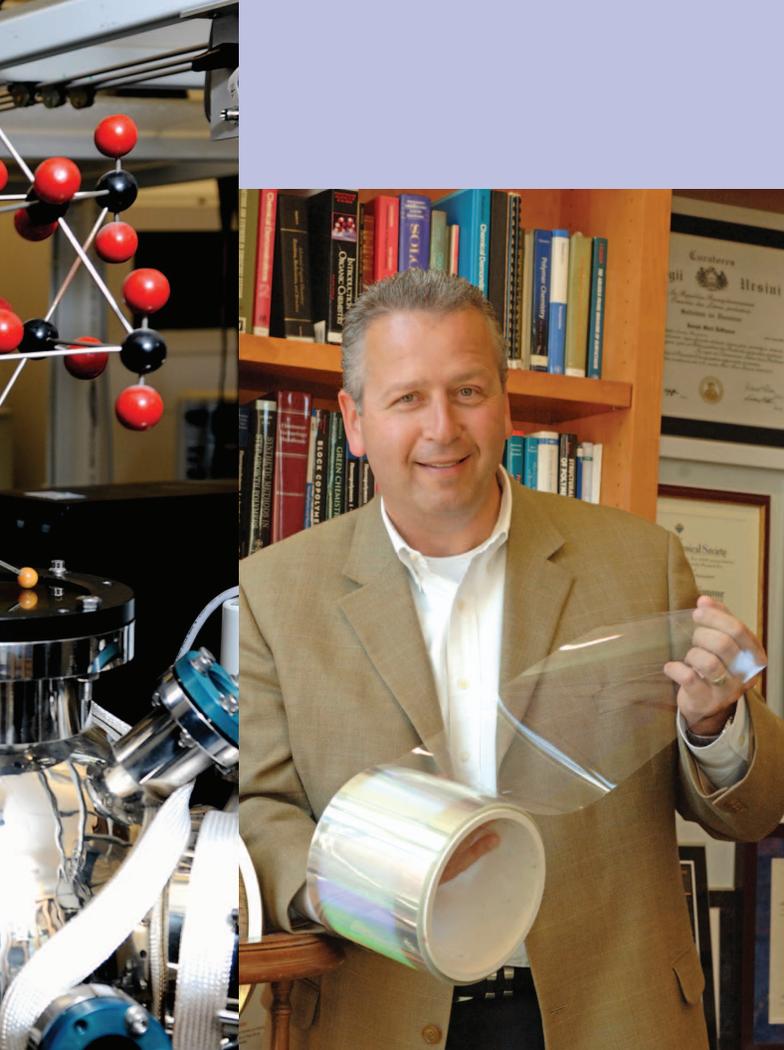
With dual titles of William R. Kenan, Jr. Distinguished Professor of Chemical and Biomolecular Engineering at NC State and Chancellor's Eminent Professor of Chemistry at UNC-CH,

DeSimone is known for his ability to apply insights in materials science to create advances in medicine, as well as other fields.

Currently, DeSimone is on sabbatical leave to lead his new company, Carbon3D, in Silicon Valley. Carbon3D is developing a new 3-D printing technology invented by DeSimone and colleagues, which can fabricate objects significantly faster than current state-of-the-art 3-D printers.

RHETORIC RESEARCH PIONEER HONORED

In 1984, Carolyn Miller spent months working on a journal article based on her dissertation in communication and rhetoric. Her article, titled "Genre as Social Action," was published in the *Quarterly Journal of Speech*. Thirty years



doesn't take long to read from start to finish would generally be called a *short story*, a book-length piece of fiction is a *novel*. For scholars, however, the difficulty with genres is how to define them. It's easy to rattle off a list of genres, but what really constitutes a genre?

The problem is particularly acute in the field of rhetoric, which is the study of how we influence each other through communication. Rhetoricians have come up with many schemes for defining genres, but they all overlap or contradict each other in some way.

Miller got the idea to write her groundbreaking article when she realized that none of the rhetoricians' definitions of genre were based on the communicative act itself. Her essential insight is that genres don't exist in some list or scheme; they're created through shared, repeated social actions. Genres are social actions, which means that old genres die, and new ones come into being, all the time. Miller's article was the first theoretically based statement of that principle within the field of rhetoric.

Since then the ideas in her article have spread throughout academia, to fields including linguistics, education, anthropology and sociology; and in popular culture, popping up in discussions about literature, music and even technology.

OTT CITES INNOVATOR AND ENTREPRENEUR

Paul Franzon, Distinguished Alumni Professor of Electrical and Computer Engineering, was named 2014 Innovator of the Year by NC State's Office of Technology Transfer (OTT). He has also worked at AT&T Bell Laboratories, DSTO Australia, Australia Telecom and

three companies he co-founded: Communica, LightSpin Technologies and Polymer Braille.

Franzon's current interests focus on the technology and design of complex microsystems incorporating very-large-scale integration, microelectromechanical systems, advanced packaging and nanoelectronics. He has published more than 300 papers in these areas. In 1993, he received a National Science Foundation Young Investigators Award; in 2001 he was selected to join the NC State Academy of Outstanding Teachers; in 2005 he received the Alcoa Research Award; and in 2014 he received the Board of Governors Teaching Award. Franzon is a Fellow of the IEEE.

OTT also named Kenneth B. Adler, a cell biology expert in the Department of Molecular Biomedical Sciences, as the 2014 Dr. John S. Risley Entrepreneur of the Year.

Adler has published more than 150 papers, mostly on airway inflammation and mucus secretion, and more lately on lung injury and lung cancer. In 1998, he was named Alumni Distinguished Graduate Professor at NC State.

He has received numerous awards, including an Established Investigator Award from the American Heart Association in 1987; NC State's Alexander Quarles Holladay Medal for Excellence, the highest award made by the university in recognition of faculty career accomplishments, in 2004; and the O. Max Gardner Award from the University of North Carolina Board of Governors in 2005.

continued

later, Miller's hard work has paid off handsomely. Her article has long been the journal's most frequently cited article, and it provided the catalyst for the development of a whole new academic field: rhetorical genre studies.

Miller is now the SAS Institute Distinguished Professor of Rhetoric and Technical Communication in NC

State's Department of English. In honor of the 30th anniversary of her article's publication, the journal *Composition Forum* dedicated its November 2014 issue to articles about rhetorical genre studies and the impact of Miller's work.

"Genre" refers to the categories that we slot communications into, based on the patterns they demonstrate. For instance, a fictional narrative that



• **LEFT:** Anita Brown-Graham is director of the Institute for Emerging Issues. • **RIGHT:** Terri Lomax has served as vice chancellor for research, innovation and economic development.

TWO HONORED AS 'WOMEN IN BUSINESS'

NC State is well represented among the 2014 winners of the Women in Business Award, announced by the *Triangle Business Journal*. Anita Brown-Graham, director of the Institute for Emerging Issues, and Terri L. Lomax, vice chancellor for research, innovation and economic development, are among 26 area women honored for their accomplishments in business and community service.

"These winners are putting accomplished leadership to work in their professions, challenging any lingering gender gap," says publisher Bryan Hamilton.

Brown-Graham joined IEI as director in January 2007. She previously worked at UNC-Chapel Hill's Institute of Government, training communities in strategic planning to revitalize distressed rural economies. She is a William C. Friday Fellow, an American Marshall Fellow and an Eisenhower Fellow.

Lomax joined NC State in 2006 as dean of the Graduate School and associate vice chancellor for research. She was named vice chancellor after serving as interim vice chancellor from 2008 to 2009. Before arriving at NC State, Lomax was on assignment from Oregon State University to

NASA Headquarters in Washington, D.C., where she served as division director of the Fundamental Space Biology programs, acting deputy associate administrator for research in the Exploration Systems Mission Directorate, senior policy analyst for the NASA Office of Program Analysis and Evaluation and senior education advisor to NASA's Office of Education. She was on faculty at Oregon State from 1987 to 2006.

Among her honors and accomplishments, Lomax has been named a Fulbright Fellow, Carnegie Fellow, National Science Foundation Postdoctoral Fellow and Monsanto Research Fellow.

MBA TEAM BEST IN BRANDING

A team of MBA students from NC State took first place in a contest to rebrand the state of North Carolina. The competition, sponsored by the state's Department of Commerce and the Frank Hawkins Kenan Institute of Private Enterprise, challenged college students to "capture and document what makes North Carolina, North Carolina."

NC State's winning team, the Cardinal Marketing Group, included Annie Bishop, Christie Montague, Meagan Sams and Lauren Wright. They beat more than 100 other teams to nab the contest's \$5,000 prize.

The team's full-scale marketing campaign proposed that the state adopt the slogan "Chart Your Own Course." It recommended the use of digital channels, including a mobile app, to drive messaging.

"Our brand campaign shines a light on what North Carolina stands for: opportunity, innovation, excellence, variety, beauty and fun," Wright says.

Cardinal Marketing Group was one of three NC State teams competing in the finals. Most students competing on behalf of NC State were veterans of the Consumer Innovation Practicum, a hands-on graduate marketing course taught through the Consumer Innovation Consortium in the Poole College of Management. They work with faculty advisers and partner companies on custom-designed research projects aimed at answering marketing and consumer behavior question posed by client companies AmerisourceBergen, Bayer CropScience, Burt's Bees and Cotton Incorporated.

ALLIANCE HONORS DANCE DIRECTOR

When Robin Harris opened the email notifying her that she was being honored for her lifetime contributions to North Carolina dance, her first thought was, "Wow; have I lived a lifetime already? I've got so much more to do!"

Director of the NC State Dance Program, Harris was selected to receive the 2014 Annual Award from the North Carolina Dance Alliance, one of the most prestigious arts awards in the state.

In addition to directing the dance program, Harris is artistic director of the NCSU Dance Company. She has choreographed more than 30 major works and has received two North Carolina Arts Council fellowships, the Raleigh Medal of Arts and an Indy Award from *Indy Week*, among other honors and awards.

The NC State Dance Program occupies an unusual place within the university because NC State has no dance major.

"Our students are getting degrees in everything that NC State has to offer," Harris says. "A lot of them could have gone into dance, but they also happen to be engineers or mathematicians or textiles majors."

So why would an engineer take a dance class or join a dance company? "Because, for them, dance supports who they are in the world," she says.

"They're engineers, but they're also dance artists, and they need their art form to express themselves fully, to organize their perspectives on the world around them and be a whole human being."

The university may not have a dance major, but that doesn't stop the dance program from emphasizing the centrality of art in everything it does.

"The art is the core of what we teach," Harris says. "And the value of that method has been proven time and time again in terms of regional and national recognition."

ANNUAL REPORT

FY14 KEY ACCOMPLISHMENTS in Research, Innovation and Economic Development

SUCCESS ABOUNDS AT NC STATE

NC State launched 10 new startups in FY2014. More than 400 products have been commercialized based on NC State inventions. An Office of Technology Transfer survey indicates that our startups have created more than 3,500 jobs in North Carolina and more than 8,100 worldwide, and raised more than \$1.6 billion in investments. The majority of NC State's startups are headquartered in North Carolina, contributing to the economic development of our state.

In the first three years of the Chancellor's Innovation Fund, 17 projects received funding. From these projects, five startups have launched, five commercial licenses have been executed and \$3.9 million awarded in additional development funds. Six additional projects have been selected for funding in FY2015: "cut and replace" gene editing; extreme biofuels; identifying "vulnerable" arterial plaque; a low-cost, aseptic food-processing system; thermoelectric textiles; and variable fuel injectors.

NC State exceeded \$300 million in sponsored-research funding for the first time, spurred by success capturing federal awards along with record-setting funding from industry partners. See details on page 32. The total does not include several major projects recently announced to begin in FY2015.

The U.S. Department of Energy selected NC State to lead PowerAmerica, the Next Generation Power Electronics National Manufacturing Innovation Institute, which will work with industry,

government and academic partners to develop processes to manufacture wide bandgap power electronics. This \$140 million effort could lead to dramatic energy savings for industries and consumers.

NC State entered into a new partnership with the National Security Agency to create the Laboratory for Analytic Sciences, bringing together experts from government, academia and industry to address the most challenging big-data problems.

The Eastman Chemical Company donated its Max A. Weaver Dye Library — more than 100,000 dye and fabric samples — to NC State. After decades as a tool for Eastman scientists and engineers, it is now available to researchers worldwide.

The National Nuclear Security Administration's Office of Defense Nuclear Nonproliferation Research and Development awarded NC State a five-year, \$25 million federal grant to develop the next generation of leaders with practical experience in technical fields relevant to preventing the spread of nuclear weapons around the globe.

The U.S. Department of Agriculture selected NC State to lead coordination efforts of more than two dozen agencies and organizations to help farmers, ranchers and forest landowners adapt to impacts of climate change. The Southeast Regional Climate Hub is one of seven regional hubs converting basic research into applied practices.

NC State combined research, education and outreach efforts in the physical, chemical, mathematical,

statistical, biological and earth system sciences to launch the College of Sciences. With six departments, 4,000 students and 575 faculty, staff and postdoctoral researchers, it is NC State's third-largest college.

With help from NC State's marching band, mascots and cheerleaders, Centennial Campus welcomed a new partner in fall 2013. LexisNexis joins other new partners on Centennial Campus: ProteoVec and ShowOps.

The university's Economic Development Partnership played an integral role in recruiting or retaining companies to North Carolina: Argos Therapeutics, Brooks Brothers, Tyton Bioenergy, Shandong Tranlin Limited, HCL America, 3 Phoenix, Sunstone Water Group, RCF Technologies, 3-C Institute, Immuno Reagents, VX Aerospace and Nutkao.

NC STATE RESEARCHERS HONORED

Dr. Ruben Carbonell was elected to the National Academy of Engineering. He joins 12 faculty members previously elected to this prestigious group: Drs. B. Jayant Baliga, Donald L. Bitzer, Jerome J. Cuomo, Joseph M. DeSimone, Keith E. Gubbins, Carol K. Hall, Thom Joel Hodgson, Carl C. Koch, Frances S. Ligler, R. Wayne Skaggs, James A. Trainham III and Paul Zia. Dr. Baliga received the Medal of Honor from the Institute of Electrical and Electronics Engineers and is also a recipient of the President's National Medal of Technology and Innovation. Dr. Cuomo is also a recipient of the previously named President's National Medal of Technology.

NC State has 10 members of the National Academy of Sciences: Drs. David E. Aspnes, Ellis B. Cowling, Joseph M. DeSimone, Major M. Goodman, Fred Gould, Todd R. Klaenhammer, C.S. Levings III, Thomas F. Malone, Trudy Mackay and Ronald R. Sederoff.

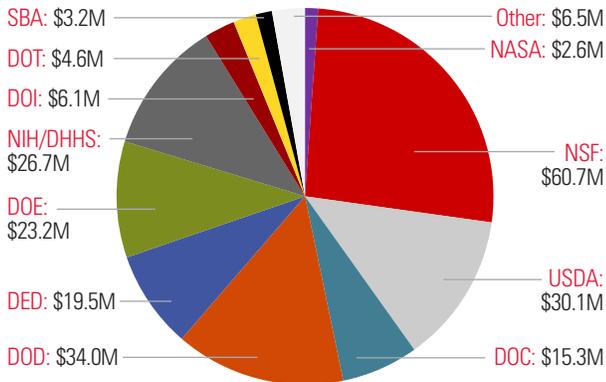
Dr. Frances S. Ligler was elected as a new Fellow of the American Association for the Advancement of Science. There are now 55 NC State faculty members who hold this honor.

Dr. Reade Roberts was one of only seven recipients this year of the Beckman Young Investigators Award. Dr. Michael Kudenov received a Young Investigator Award from the Office of Naval Research. Drs. Linyou Cao, Owen Duckworth, Andrew Grieshop, James LeBeau and Binil Starly are recent recipients of the National Science Foundation's Faculty Early Career Development program. Dozens of NC State faculty have received this recognition.

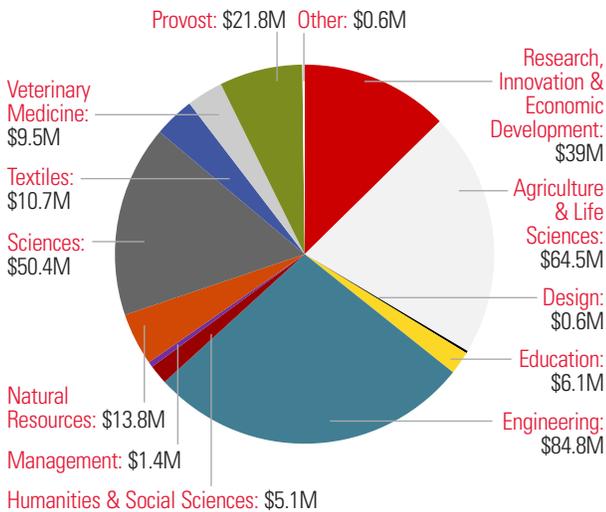
Drs. Michael Escuti, Jason Haugh, Jacob Jones, Carla Mattos and Veena Misra have received the Presidential Early Career Award for Scientists and Engineers. NC State has three individual winners of the Presidential Awards for Excellence in Science, Mathematics and Engineering Mentoring: Drs. Laura Bottomley, Christine Grant and Winser E. Alexander.

NC State is represented in the American Academy of Arts and Sciences by Drs. William R. Atchley, Joseph M. DeSimone and Trudy Mackay. Dr. Mackay is also a member of the Royal Society of the United Kingdom.

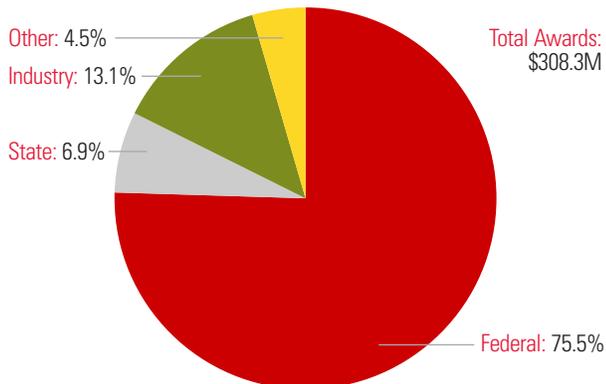
AWARDS BY FEDERAL AGENCIES, FY14



AWARDS BY NC STATE UNIT, FY14



AWARDS BY SOURCE, FY14



NC STATE STARTUPS, FY14

- 410 Medical Innovation LLC
- AirGlow Inc.
- Benanova Inc.
- Clave Biodesign Inc.
- CompletErgo LLC
- Harrison Analytic Technologies LLC
- Mlinzi Vaccines LLC
- Platinix LLC
- RJL Interactive LLC
- Scientific Organizational Solutions LLC

TECHNOLOGY TRANSFER & INNOVATION IMPACTS

	FY2014	FY2010-14 TOTAL
Invention Disclosures	258	1,059
Patents Issued	82	435
New Patents Filed	186	755
Commercialization Agreements	145	479
Startups	10	26
Licensing Revenue	\$7.5M	\$31.0M

CENTENNIAL CAMPUS: AN INNOVATION DESTINATION

University leaders unveil VISION 2034, a blueprint for developing Centennial Campus into North America's premier Innovation Destination. The plan calls for the campus to be a proving ground for new technologies and creative ideas.

apartment complexes — one for students and another for working professionals. The Wolf Ridge student complex also houses the Albright Entrepreneurs Living and Learning Village, and the Entrepreneurship Initiative Garage, a prototyping space for students.

The Laboratory for Analytic Sciences opens to help the National Security Agency find creative solutions to big data problems.

Centennial Campus announces the development of a 155-room hotel and conference center, to be located across from the Lonnie Poole Golf Course. The campus also begins construction of a 145,000-square-foot office building.

German filter manufacturer Mann+Hummel opens an innovation center on campus to tap into NC State research expertise in textiles and engineering.

Claude McKinney, former dean of the College of Design and the visionary behind Centennial Campus, is named to the Raleigh Hall of Fame.

Centennial Campus opens two



Turning the Classroom Inside Out

By David Hunt

• ABOVE: Muntazar Monsur's research brings the outdoors into classrooms.

An architecture student designs a model classroom that strengthens the connection between indoor and outdoor spaces.

It's not unusual to find NC State students working on research breakthroughs in fields as diverse as computational astrophysics and plant biology. Now, a doctoral student in the College of Design is pushing the boundaries of architecture with award-winning research revealing how the interplay of light and space influences early childhood learning.

If you want to take a break from reading this story to look out the window — or, better yet, take a quick walk around campus — you'll soon understand the basis for Muntazar Monsur's research.

The Bangladesh native, who has a passion for designing child-centric

environments, came to NC State three years ago to work with the pioneering designers in the Natural Learning Initiative. It's a good fit. Faculty with the program have written the book on how child care centers and schools can use natural outdoor environments to engage children and combat problems such as childhood obesity.

Inspired by the work of faculty mentor Robin Moore, an international authority on the design of children's play and learning environments, Monsur decided to chart new paths in the field by exploring how the relationship between indoor and outdoor spaces affects teaching and learning.

Let There Be Light

After extensive data collection involving 22 classrooms, 31 teachers and more than 300 students, Monsur identified a variety of factors that strengthen the bond between indoor and outdoor spaces and ultimately

lead to improvements in both student engagement and teacher motivation.

Simply put, to encourage learning, there be light — especially natural light.

Of course, there's more to it than that. Designers seeking to create a more effective learning environment should pay attention to the naturalness of views, the number and location of windows and doors, the amount of seating and shade available and even the orientation of the building. Classrooms also need transitional spaces, such as patios, that allow for messy learning activities such as art and science projects.

"It's all about a zoning system," Monsur explains, rolling out a giant poster that illustrates his ideas.

Monsur has developed a system that enables designers and teachers to strengthen the bond between a classroom's indoor and outdoor spaces.

In the case of an existing classroom, for example, a teacher could simply move a writing table closer to a window to take advantage of natural light, which has been shown to promote creative thinking.

Monsur plans to deliver two tools with his dissertation: a model classroom that illustrates the optimal indoor-outdoor relationship, and an app for a smartphone or tablet that can be used to rate an existing classroom in terms of how beneficial its indoor-outdoor relationship is.

After graduation, he hopes to design the classrooms of the future, "where technology and nature will equally contribute to the richness of the learning environment for young children."

Monsur's research won the student design award at the prestigious Environmental Design Research Association conference in New Orleans this summer.



• ABOVE: *The Max A. Weaver Dye Library includes more than 100,000 samples.*

A Research Treasure Trove

The next generation of cutting-edge NC State solutions in forensic science, cancer treatment, solar energy and more may come from a decidedly old-school source: dye.

The Eastman Chemical Company has donated its Max A. Weaver Dye Library — more than 100,000 dye and fabric samples in all — to NC State.

“This priceless collection could contain the dyes for the next generation of solar panels, the next generation of photodynamic cancer therapies, the next generation of environmentally responsible textile dyes,” explains David Hinks, interim dean of the College of Textiles. The dye collection will be a “treasure trove” for NC State’s innovative, interdisciplinary research in a range of fields, he adds.

Medical researchers and dye chemists such as Ciba Professor of Dyestuff Chemistry Harold Freeman use dyes to develop targeted cancer treatments. “The dyes are designed to dye cancer cells and not healthy cells,” Hinks says. “That allows doctors to identify the cancer but also, by focusing a tunable laser onto that area, the dye will absorb the energy of the laser and ultimately kill the cancer cell. So this is a form of targeted chemotherapy.”

David Muddiman’s research group in chemistry is developing state-of-the-art analytical techniques for forensic analysis of dyed fibers. Frank Hunte’s group in materials science and engineering is interested in developing new dye applications with improved infrared absorption signatures that can prevent military personnel from being detected by night-vision scopes.

The next generation of analytical chemists and forensic scientists will build skills as student researchers who contribute to the forensic science database, Hinks notes. Textiles scientists and engineers will study it for ways to create environmentally responsible dyes that can be applied to textiles, paper, packaging, cosmetics, hair coloring and a host of other products and applications.

Chemists around the world will be able to use data such as 3-D crystallographic models of the chemical structures that the late Max Weaver, longtime dye research leader for Eastman, drew by hand on glass vials. NC State will digitize and post the structures along with key cheminformatics data using ChemSpider, a free online resource maintained by partners at the Royal Society of Chemistry.

The donation builds on NC State’s existing partnership with Eastman. Under a 2012 agreement, NC State became an Eastman Chemical Center of Excellence and the recipient of \$10 million over six years.

results.

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