NC STATE UNIVERSITY

results.

Winter 2015/2016 • Research, Innovation & Economic Development

ALSO IN THIS ISSUE:

- Tracing the Dream
- Self-Powered Sensors
- Investing in Innovation

HARNESSING THE GENE-EDITING POWERS OF BACTERIA: CRACKING THE CRISPR CODE

Change Brings Continued Success

• **ABOVE:** *Alan Rebar, NC State's new vice chancellor of research, innovation and economic development, has an office in the Springboard Innovation Hub on Centennial Campus.*

As NC State's new vice chancellor for research, innovation and economic development, I look forward to taking our successful research enterprise to a higher level. This issue of *Results* highlights our fiscal year 2015 accomplishments and recognizes just a few of our many celebrated faculty and the innovative research they lead.

We're pleased to report on Jason Miller's project, King's First Dream, that preserves a speech Martin Luther King Jr. delivered in Booker T. Washington High School's gymnasium in Rocky Mount in 1962. This discourse, a precursor to King's iconic "I have a dream" address, will be available online at kingsfirstdream.com.

We're also excited to share several stories on medical- and health-related research.

Rodolphe Barrangou, a food scientist and NC State alumnus, and Chase Beisel, a chemical engineer, were independently investigating CRISPR DNA segments when Beisel initiated a collaboration between them in 2012. Barrangou joined NC State a year later. Now, separately and together, they are advancing microbiological research that will increase food safety and enhance antibacterial product manufacturing, food production, and plant and animal breeding practices.

The Advanced Self-powered Systems of Integrated Sensors and Technologies (ASSIST) Center is improving human health though wearable monitoring systems that don't require batteries for power. As one of NC State's National Science Foundation Engineering Research Centers, ASSIST collaborates with experts in industry and across other institutions.

Also in this issue, we profile four examples of transformational researchers at NC State.

Zhen Gu is creating advanced drug-delivery systems, such as one targeting deadly cancer cells in patients' bloodstreams, and another reducing the number of insulin injections diabetic patients need.

Alper Bozkurt's research includes developing dog harnesses that can monitor the animals and communicate data through smartphones, as well as devices to remotely control insects for use in emergency-response situations. His work has earned him a place in *Popular Science*'s "Brilliant Ten" this year.

Lee-Ann Jaykus, one of the nation's top food safety experts, leads the NoroCORE Food Virology Collaborative, a team of scientists from 22 institutions working to reduce foodborne diseases.

Natasha Olby's holistic approach to spinal cord injury research and neurogenetics shows great promise for both animals and humans. Her research includes identifying canine gene mutations that cause hereditary ataxia, or incoordination, and developing therapies for neurodegenerative diseases.

Our update on the Chancellor's Innovation Fund highlights five new projects: converting simple radios into millimeter-wave imagers; identifying natural yeasts to optimize the beer-brewing process; creating conductive fabrics to monitor body functions; developing technology to create infrared images that don't require bulky cryogenic cooling systems; and growing therapeutic stem cells to repair the damaged lungs of patients with chronic obstructive pulmonary disease or idiopathic pulmonary fibrosis. This fund plays an important role in bringing NC State's innovations to market for societal benefit.

Finally, on a more personal note, I'd like to thank the NC State community for making my wife, Sue, and me feel welcome. I'd especially like to thank Mladen Vouk for his interim service in my role and his continued support as I settle into the job.

It feels great to be part of the Wolfpack family — and to call North Carolina home.

ALAN REBAR, Vice Chancellor,
Research, Innovation and Economic Development

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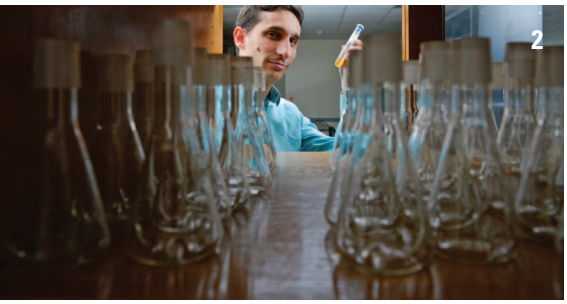

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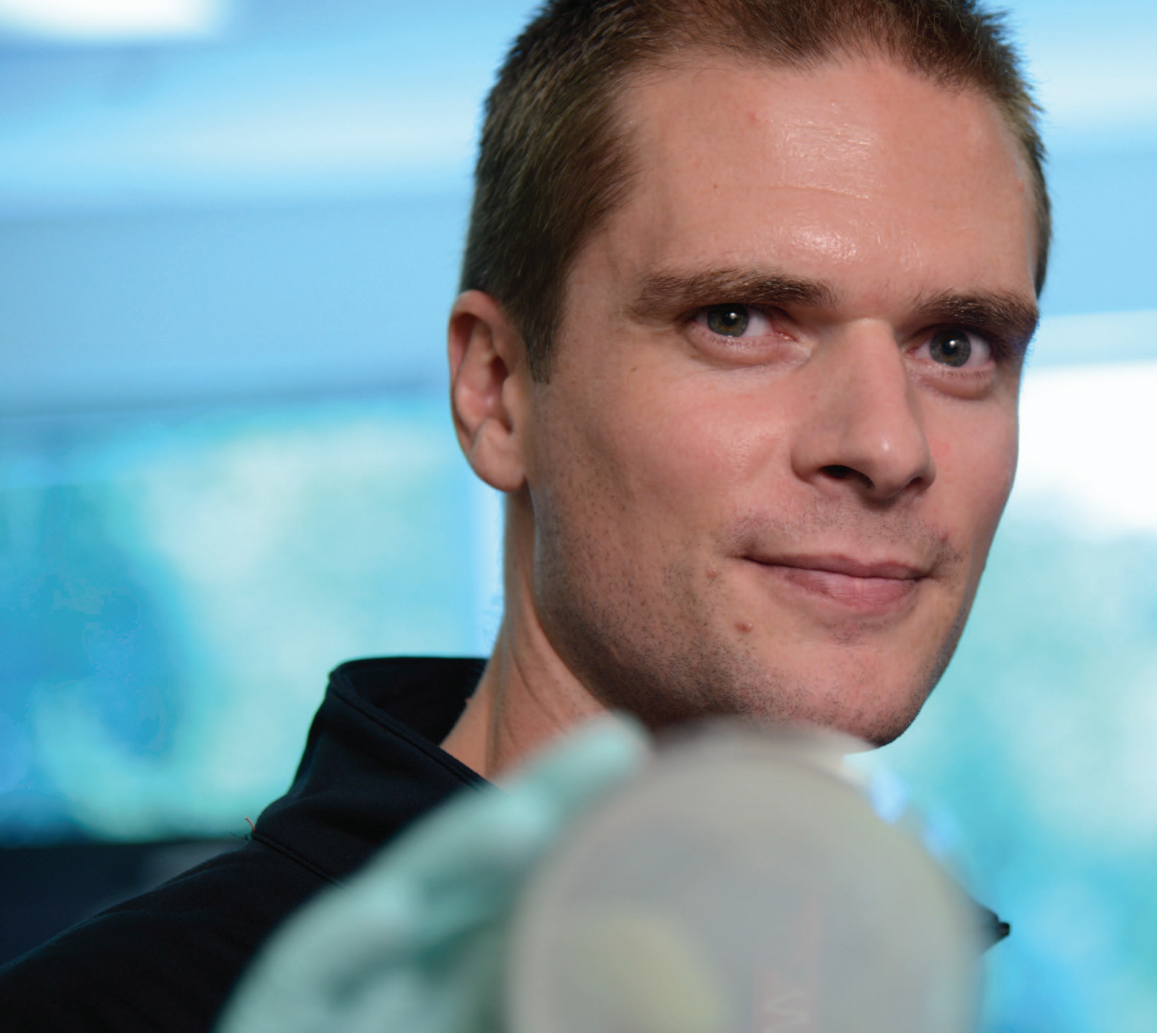
Front Cover: *Rodolphe Barrangou has spent the past decade pioneering a revolutionary gene-editing system. Photo by Marc Hall.*



Cracking the CRISPR Code

GENE-EDITING SYSTEM IS TAKING THE SCIENTIFIC WORLD BY STORM

By Mick Kulikowski

• OPPOSITE PAGE: *CRISPR pioneer Rodolphe Barrangou is seen as an international leader in research on the gene-editing system.* • THIS PAGE: *Barrangou's bustling CRISPR lab is located on Centennial Campus.*

Imagine you're a virus — but not just any virus. You're a bacteriophage, or a virus that specifically attacks bacteria.

You operate by invading a bacterium and hijacking its cellular machinery to overwhelm and devour it while producing more copies of yourself. You grow more powerful by moving on to an adjacent bacterium and devouring it too. Soon, you'll conquer the world!

Or you might, if not for one problem: Many bacteria have an adaptive defense system that can recognize foreign DNA and use a special molecular scalpel to cleave it from their cells and destroy it.

Moreover, this adaptive defense mechanism performs double duty as a sort of genetic tape recording that remembers previous phage attacks and how to respond to them, providing immunization against future phage attacks of a similar type.

You, virus, have been foiled by a tool known as CRISPR, a microbial adaptive immune system that has been co-opted into a cut-and-replace gene-editing system currently taking the scientific world by storm. CRISPR has potential applications for crop production, agricultural biotechnology and a myriad of other important processes and industries. It promises to be a Swiss army knife for genome editing in life forms ranging from bacteria to humans.

While researchers across the globe are

continued

You, virus, have been foiled by a tool known as CRISPR, a microbial adaptive immune system that has been co-opted into a cut-and-replace gene-editing system currently taking the scientific world by storm.

While researchers across the globe are quickly jumping on the bullet train that is the CRISPR bandwagon, a pioneering NC State professor has spent more than a decade helping move the bandwagon forward, authoring dozens of refereed journal articles and chalking up around 20 patents along the way.

• RIGHT: *Barrangou began his career sequencing dairy bacteria genomes to produce better starter cultures for cheese and yogurt.*

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BEYOND CHEESE AND YOGURT

Food scientist Rodolphe Barrangou clearly remembers his CRISPR "eureka" moments.

Shortly after earning his Ph.D. in functional engineering under Todd Klaenhammer in NC State's food science department in 2004, Barrangou worked to produce better bacterial starter cultures for cheese and yogurt at Danisco, a food ingredients company in Madison, Wisconsin.

Barrangou and his colleagues sequenced genomes — the complete set of genes — for dairy bacteria such as *Streptococcus thermophilus*. That particular bacterium breaks down lactose, a sugar in milk, and turns it into lactic acid, an important ingredient in cheese and yogurt as well as in pickled vegetables and fermented products.

But Barrangou's team had difficulty putting the dairy bacterium genome puzzle together. Think of assembling a multimillion-piece jigsaw puzzle without

• LEFT: *CRISPR sequences, highlighted in red, appear in non-random patterns in the alphabet soup of DNA.*

having a picture template to know exactly what it should look like. The reason? CRISPRs.

In the alphabet soup of cellular DNA sequences, which are represented by the letters A, T, G and C that correspond to the chemical building blocks of DNA — adenine, thiamine, guanine and cytosine — a CRISPR looks like a relatively short, repetitive DNA sequence, after which comes a sequence of two or three dozen letters known as "spacer" DNA, followed by another palindromic sequence just like the first.

"They weren't called CRISPRs a decade ago. We called them SPIDRs, for 'spacers interspersed direct repeats,'" Barrangou says. "They kept breaking down the assembly process as we sequenced these bacterial genomes. We knew they were part of the DNA repeat family, but we didn't know what they did or why they mattered so much."

At the same time, Barrangou and his Danisco colleagues also were sequencing genomes of important phages involved in cheese and yogurt manufacturing. While comparing and contrasting these phage DNA sequences with the bacterial DNA sequences, patterns emerged.

"Some of the spacer DNA sequences we found in bacteria were close matches to monkey pox, frog pox and ringworm virus sequences," Barrangou says. "One of the key moments was when we realized that those were actually real viral sequences. In hindsight we know now that these elements were a record of viruses that the bacterium had vaccinated itself against.

"The CRISPR content of those bacteria, the way they clustered together by similarity, is correlated with their profiles of resistance to the phage," Barrangou adds. "That was a key element showing that there was a link between the function of phage resistance and the genetic makeup of CRISPR content."

At the same time in summer 2005, three independent research groups published papers suggesting that CRISPRs and their spacer DNA were indeed important. The research found that bacterial spacer DNA matched foreign genetic elements, which provided clues that it could be involved in bacterial immunity.

Armed with the knowledge from these papers and their own lab work, Barrangou and his Danisco colleagues published a seminal paper in the journal *Science* in 2007, showing that the *S. thermophilus* bacterium could be engineered to either resist or succumb to attack from phages by altering the spacer DNA that matched the phage DNA.

"That paper showed CRISPR is indeed an adaptive immune system with the functional ability to acquire genetic snapshots of phage attacks," Barrangou says.

CUTTING WITH CRISPR

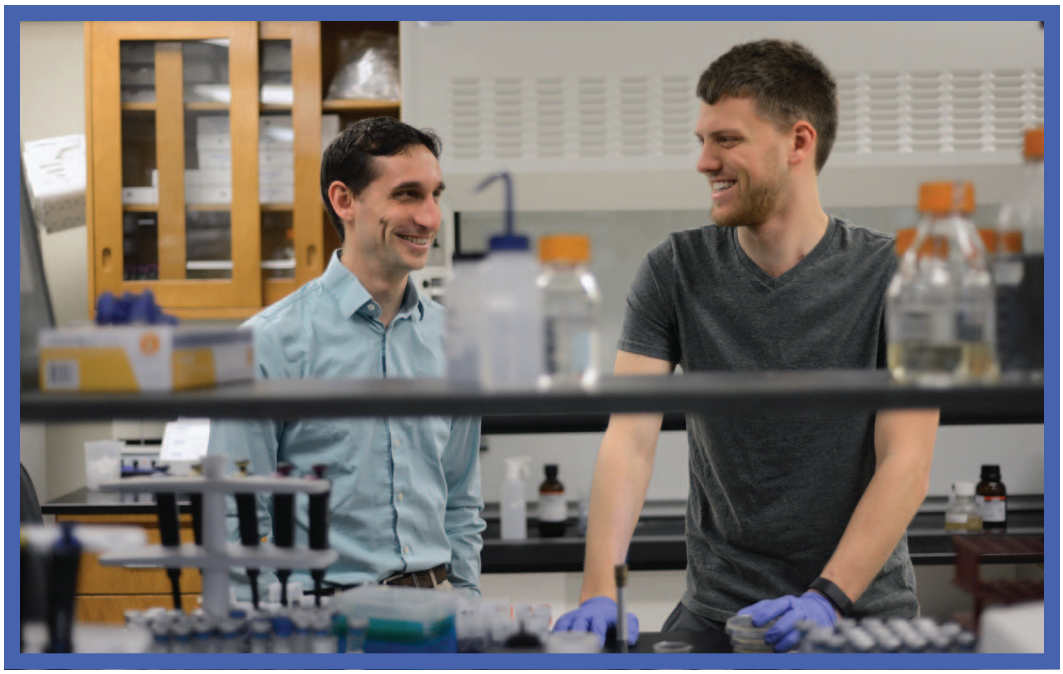
If you've ever used a word processing program, you're probably familiar with highlighting a block of text and using the Control-X (or Command-X) keystroke combination to delete that text. CRISPR uses the same principle to defend bacteria against the DNA of attacking viruses.

CRISPR stands for "clustered regularly interspaced short palindromic repeats" that appear in non-random patterns. CRISPR systems exist in prokaryotes — single-celled bacteria and archaea — and within the last two years have been put to work by scientists in eukaryotes, or plants and animals.

There are several different types of CRISPR

continued

The CRISPR-Cas system has lots of advantages over other gene-editing systems, Barrangou says. It's quick, efficient, precise, relatively inexpensive and, as the scientific community has shown over the past two years, transferable to many types of living things.



• RIGHT: *Chase Beisel, at left, an NC State chemical and biomolecular engineer, works on CRISPR systems.*

systems. Barrangou is concerned mostly with CRISPR-Cas systems that use Cas9 proteins as scalpels to cleave away unwanted foreign DNA.

Simply put, the CRISPR system recognizes invasive foreign DNA and creates CRISPR RNAs that look for and mimic the DNA letter sequences of the invaders. When the CRISPR RNAs find a matching sequence, they guide the scalpels — in this case, Cas9 proteins — to cut the exact sequence of invading DNA from the cell.

The CRISPR-Cas system has lots of advantages over other gene-editing systems, Barrangou says. It's quick, efficient, precise, relatively inexpensive and, as the scientific community has shown over the past two years, transferable to many types of living things.

Barrangou ticks off the list of possible applications: genome editing, antibacterial and antimicrobial production, food safety, food production, plant breeding and perhaps even animal breeding.

"Some of these things sound like science fiction, but there is real science behind it," Barrangou says.

There are still a few gaps to overcome before CRISPR-Cas becomes a ubiquitous tool, however. Cas9 proteins are rather large and cumbersome to work with, Barrangou says. In addition, all guides — the CRISPR RNAs that guide the Cas9 scalpels to their target — are not created equally; some do a better job than others of homing in on an invasive target.

One way of bridging these gaps, Barrangou said, is to collaborate with others, across campus and across the globe. One of his collaborators, NC State chemical and biomolecular engineer Chase Beisel, brings specializations in bacteria, systems biology and regulatory RNAs to bear on the issue.

A BETTER BACTERIUM

Beisel first learned about CRISPR systems as a postdoctoral researcher in 2009 at the National Institutes of Health in Bethesda, Maryland. He was working in a microbiology lab that focused on regulatory RNAs in bacteria — how they function and what they do.

"What got me excited was how these CRISPR RNAs can direct proteins," he says. "CRISPR is a naturally occurring system for which you can design an RNA and direct it to a specific DNA sequence. As an engineer, you think, 'How can we use this?'"

Beisel began his CRISPR research when he started his career at NC State in fall 2011.

"I was not only launching a new lab here at the university but also entering an entirely new field from my projects at NIH, so it was challenging," Beisel says.

He met Barrangou in October 2012, when they ran into each other at an NC State biotechnology symposium on CRISPR led by Barrangou, who was the guest speaker.

"I knew of Rodolphe as a name on papers I had read in the CRISPR literature," Beisel says. "At that point, my lab had some initial results of using CRISPR systems as antimicrobials. In a conversation with Rodolphe at the symposium, we realized we had a number of

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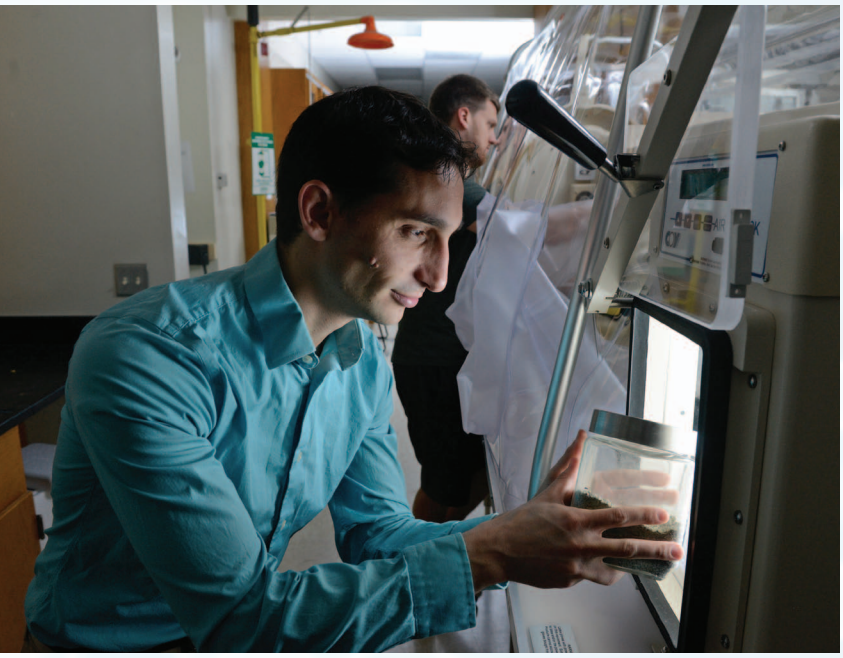

• LEFT: *Beisel began his CRISPR research when he started at NC State in fall 2011. He frequently collaborates with Barrangou on CRISPR research projects.*

overlapping interests and began thinking of ways we could collaborate."

Barrangou joined the NC State faculty a year later, in 2013.

'A RIDICULOUS RECORD OF COLLABORATION'

That collaborative spirit has yielded a number of important results for the two NC State professors in the past few years. Beisel calls Barrangou's capacity to work with various groups "a ridiculous record of collaboration."

"I'm an engineer by training, so I understand engineers — not all of them, obviously," Barrangou says with a smile. "But when you bring different and complementary skills together, you get more than the sum of your ingredients."

Beisel's academic pedigree is in chemical engineering but with a biological focus. "As an engineer, you say, 'We have a problem, how do we solve it?' A biologist says, 'Nature created this solution. We just need to figure out what it is and how it works.'"

Their work, together and apart, has made great advances in CRISPR-related science.

In 2014, Barrangou and Beisel co-authored a paper in *mBio* that showed CRISPR can be used as a "smart bomb" in bacteria. They also co-authored a 2014 paper in *Molecular Cell* that delved into the mechanisms of how the CRISPR RNAs guide the Cas9 scalpels to the targeted foreign DNA.

Working separately from Barrangou, Beisel and NC State colleagues this summer published findings in the journal *Angewandte Chemie* on a new way to get CRISPR-Cas9 into a cell by using so-called "nanoclews," or tiny single-bound strands of DNA.

And Barrangou, working apart from Beisel, published with NC State colleagues a paper in *Proceedings of the National Academy of Sciences* on using CRISPR to identify key bacterial genomic regions and whether these regions are expendable or required for bacterial survival.

CRISPR'S FUTURE

Business attention — and the attendant venture capital — flows to CRISPR research, technologies and applications. The academic literature crackles with CRISPR-related findings.

As new studies have shown, CRISPR systems can be utilized to not only delete DNA sequences from a cell, but also to add sequences. Since the CRISPR system is essentially an immune system, it can also be turned against itself to cause cell death. You read that right: A bacteria's defensive machinery can be directed against itself to make it commit cellular suicide. Think of the antibacterial potential of unleashing that power.

"Resistant bacteria can be targeted by CRISPR systems," Barrangou says. "The literature has already shown staph being knocked out in mice. Basically it can work on any sequence in any cell in any way."

When asked about CRISPR's future, Barrangou says the past is prologue.

"I think it's back to the basics — back to bacteria," he says. "That means using CRISPR machinery to kill cells. There's lots of promise here and less engineering needed because CRISPR comes from bacteria. In the short term, I would look for applications in antimicrobials and antibiotics."

The biggest technical challenge now, Barrangou says, is how to efficiently deliver the CRISPR payload into specific cells.

"Chase and I think using phages is the way to go," he says. "You can inject phage DNA containing CRISPR like a syringe; the CRISPR will selectively target the exact DNA sequence to kill whatever it is you want to kill. And it won't target the good bacteria, unlike antibiotics, which kill everything.

"I think this system is astonishingly cool on so many levels — its practicality, its technological promise, its power. We're only limited by our imagination."

As new studies have shown, CRISPR systems can be utilized to not only delete DNA sequences from a cell, but also to add sequences. Since the CRISPR system is essentially an immune system, it can also be turned against itself to cause cell death. You read that right: A bacteria's defensive machinery can be directed against itself to make it commit cellular suicide. Think of the antibacterial potential of unleashing that power.

Tracing the Dream

The discovery of a 1962 recording of Martin Luther King Jr. in Rocky Mount, North Carolina, establishes the small town as a key site in the civil rights movement

By David Hunt

Hold fast to dreams
For if dreams die
Life is a broken-winged bird
That cannot fly.

Hold fast to dreams
For when dreams go
Life is a barren field
Frozen with snow.

— Langston Hughes

• TOP: *A statue of Martin Luther King Jr. stands in a Rocky Mount park to commemorate King's visit to the town in 1962.* • BOTTOM: *King and other civil rights leaders hold a news conference at the White House following the March on Washington in 1963. Courtesy: Library of Congress.*

On Nov. 27, 1962, in the small town of Rocky Mount, North Carolina, civil rights leader Martin Luther King Jr. delivered a phrase that ultimately would inspire millions.

"I have a dream," he intoned from the stage of a gymnasium at a segregated high school where 1,800 African-American residents stood elbow to elbow, eager for a message of hope in troubled times.

Again and again in the 55-minute speech, King touched on themes that would resonate nine months later before a vastly larger audience gathered on the national mall in Washington, D.C., for the historic 1963 March on Washington for Jobs and Freedom.

The latter speech, delivered on the steps of the Lincoln Memorial, is one of the most recognized and revered orations in American history. The Rocky Mount speech, on the other hand, has lived on only in memory — until now.

Earlier this year Jason Miller, an English professor at NC State, unveiled a long-lost audio recording of the address at a news conference on campus. As he played portions of the speech, Miller recounted how he arranged to have the fragile audiotape digitally preserved after it was discovered at a Rocky Mount public library.

A librarian told Miller she found the reel of old-

• LEFT: *NC State English professor Jason Miller's book reveals Langston Hughes' influence on King's rhetoric.*

Earlier this year Jason Miller, an English professor at NC State, unveiled a long-lost audio recording of the address at a news conference on campus. As he played portions of the speech, Miller recounted how he arranged to have the fragile audiotape digitally preserved after it was discovered at a Rocky Mount public library.

fashioned acetate tape sitting on her desk when she returned from vacation. Inside a box holding the priceless tape someone had penned a note in elegant handwriting: "Dr. Martin Luther King speech — please do not erase."

In January 2016, the audio and a full transcript will be posted on a website Miller created: kingsfirstdream.com. Miller created 89 annotations, accessible through hyperlinks on the site, to help explain the historical and literary context of the speech. He hopes the site will draw researchers and students of English, rhetoric, history, politics and social sciences.

The discovery of a rare King recording set off a media firestorm in August, generating worldwide coverage as Miller spent a week fielding calls from journalists. The news was reported by *USA Today*, CNN, the BBC, the Associated Press, the *Miami Herald*, the *Boston Globe*, the *New York Times* and hundreds of other media outlets.

But for Miller, the recording was more than a historical curiosity. The Rocky Mount speech is, he asserts, "incredibly unique," marking a high point in King's development of the "dream" motif as a rhetorical device.

Miller should know. He's spent much of the past decade charting the evolution of the civil rights leader's speeches and writings about King's dream of a more just society. In a 2015 book, *Origins of the Dream: Hughes's Poetry and King's Rhetoric*, Miller documents how King's vision was inspired by the poetry of Langston Hughes.

I DREAM A WORLD

Hughes was a leading figure in the Harlem Renaissance, the cultural and artistic revolution that took place in New York City's Harlem neighborhood — a predominantly African-American section of the city — from the end of World War I to the mid-1930s. Hughes and King exchanged letters in the 1950s, at a time when King was beginning his civil rights activism.

"Hughes sparked King's own poetic self," Miller says.

The influence was evident from the start, the professor explains, noting that King concluded his first published speech with a Hughes poem. But as King's renown grew, he found it necessary to distance himself from the poet, who was gaining a reputation as a Communist sympathizer — a major political liability during the Cold War era.

continued

• TOP: *Rocky Mount resident Herbert Tillman returns to the high school gymnasium where he heard King speak more than 50 years ago.*
• BOTTOM: *King's dramatic speech at the 1963 March on Washington had echoes of the earlier speech in Rocky Mount. Courtesy: Library of Congress.*

King knew his enemies would try to use his personal and professional associations to discredit the civil rights movement. A Senate investigation later revealed that the FBI organized a disinformation campaign against the movement, falsely asserting that Communists and "outside agitators" were behind the efforts to secure social justice and economic opportunity for black Americans in the 1950s and 1960s.

Between 1960 and 1965 Hughes' influence on King is hard to trace, unless you know what to look for, Miller says. He doggedly pursued the trail as he pored over Hughes' poetry and King's speeches from the early 1960s, looking for connections.

"The ideas from Hughes' poetry are still there, but they're submerged," Miller says.

To make the effort easier, Miller bought a piece of butcher's paper, three feet tall and 14 feet long, and began charting every known connection between Hughes and King, documenting "letters exchanged, poems sent, times they met."

Miller anchored the right-hand end of the timeline at Aug. 28, 1963, the date of the March on Washington and King's famous "I Have a Dream" speech. Working backward, he made a notation for every time King uttered the word "dream" in a speech, publication or correspondence.

Hughes was a leading figure in the Harlem Renaissance, the cultural and artistic revolution that took place in New York City's Harlem neighborhood — a predominantly African-American section of the city — from the end of World War I to the mid-1930s.

The exercise eventually brought Miller back to a speech King delivered on Aug. 11, 1956 — the first time the civil rights leader publicly spoke of the dream. In this speech, titled "Facing the Challenge of a New Age," King paraphrased Hughes' 1926 poem "I Dream a World."

The 16-line poem is a lyrical call to create the kind of "beloved community" envisioned by the philosopher Josiah Royce, where peace, tolerance and justice prevail:

I dream a world where man
No other man will scorn,
Where love will bless the earth
And peace its paths adorn.
I dream a world where all
Will know sweet freedom's way,
Where greed no longer saps the soul
Nor avarice blights our day.
A world I dream where black or white,
Whatever race you be,
Will share the bounties of the earth
And every man is free,
Where wretchedness will hang its head
And joy, like a pearl,
Attends the needs of all mankind —
Of such I dream, my world!

"That's the first real iteration of 'I have a dream.' You can see it," Miller says. "It has the same ideas. But King takes those ideas and changes and develops them in the coming years."

Tracing the evolution of King's dream along the timeline, Miller comes to the Rocky Mount speech, six years later. Like the speech in 1956, this one is titled "Facing the Challenge of a New Age." But unlike the first speech, which lightly touched on the dream theme, the Rocky Mount speech is a deeply personal statement.

"So my friends in Rocky Mount, I have a dream tonight," King declared. "It is a dream rooted firmly in the American dream. I have a dream that one day down in Sasser County, Georgia, where they burned two churches down a few days ago because Negroes wanted to register to vote, one day right down there little black boys and little black girls will be able to join hands with little white boys and little white girls and walk the streets as brothers and sisters. I have a dream."

The dream King spoke of in Rocky Mount is far more than a paraphrased version of Hughes' ideals. This is King's own dream, fully developed and articulated.

"This is the turning point," Miller says, the place where Hughes' utopian vision is transformed into King's bold vision for a just society.

Miller smiles as he recalls the journey he took, in the North and the South, searching for this piece of the puzzle.

"I'd been to Atlanta twice, I'd been to Boston for over a week, I studied everything they had on Hughes at Yale, and the most amazing piece of evidence I found was an hour and a half away from my office," he says.

THE POWER OF POETRY

Although researchers have studied King's philosophy and rhetoric for decades, Miller is one of the first to focus on how the civil rights leader incorporated poetry and poetic devices into his speeches and writings.

"Poetry is compelling and important because it's the most imaginative form of expression, and it connects that imaginative aspect with memory," Miller

continued

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— Martin Luther King

• TOP: *Tillman was inspired by the 1962 speech.* • BOTTOM: *Rocky Mount resident Helen Gay recalls preparing dinner for King during his 1962 visit. Courtesy:* The News & Observer.

• ABOVE: *The fragile 1.5 mm acetate tape recording of King's 1962 speech was found at a public library in Rocky Mount.*

School in Rocky Mount as King stepped forward to address the African-American community.

Rocky Mount, like cities throughout the South, enforced the segregation laws of the Jim Crow era.

"We weren't getting beaten by police or attacked by dogs because we weren't marching and protesting," Tillman says. "But we were part of the struggle."

King's words sent a wave of excitement through the crowd in the gymnasium.

"I was sitting there listening to him. Everybody knows the hardships that we as blacks were going through at the time," Tillman says. "He came with a message of hope. He said, 'I have a dream about tomorrow.' He said, 'These are the things we need to do, but we need to do them in a peaceful way.'"

The words stayed with Tillman. A few years later, when he was passed over for a promotion at Burlington Mills because whites wouldn't work for a black supervisor, Tillman left the plant for a job at Abbott Laboratories.

"I told the folks at Abbott my story. I said, 'If you all are going to hold me back because of my skin color, I don't want to work for you either.'"

The hiring manager, who respected Tillman's reputation as a mechanic, assured him he would get fair treatment.

Today Tillman is heartened by the changes he's seen in the past five decades since King visited his hometown.

"I think Martin Luther King would be proud," he says. "To be honest with you, I'm proud of Rocky Mount."

Listening to the recording of King's 1962 speech brings back a flood of memories for Tillman.

"I praise the Lord that I was able to be there and witness that event," he says. "Not just to hear the speech but to be in that atmosphere.

"If you were back there then you would realize how far we've come. We've come a long way. Not just as black people but as people of the United States. We have all come a long way."

says. "Poetry has the capacity on many levels to give people breakthrough insights that they just can't forget. It doesn't just inspire; it actually motivates people to act."

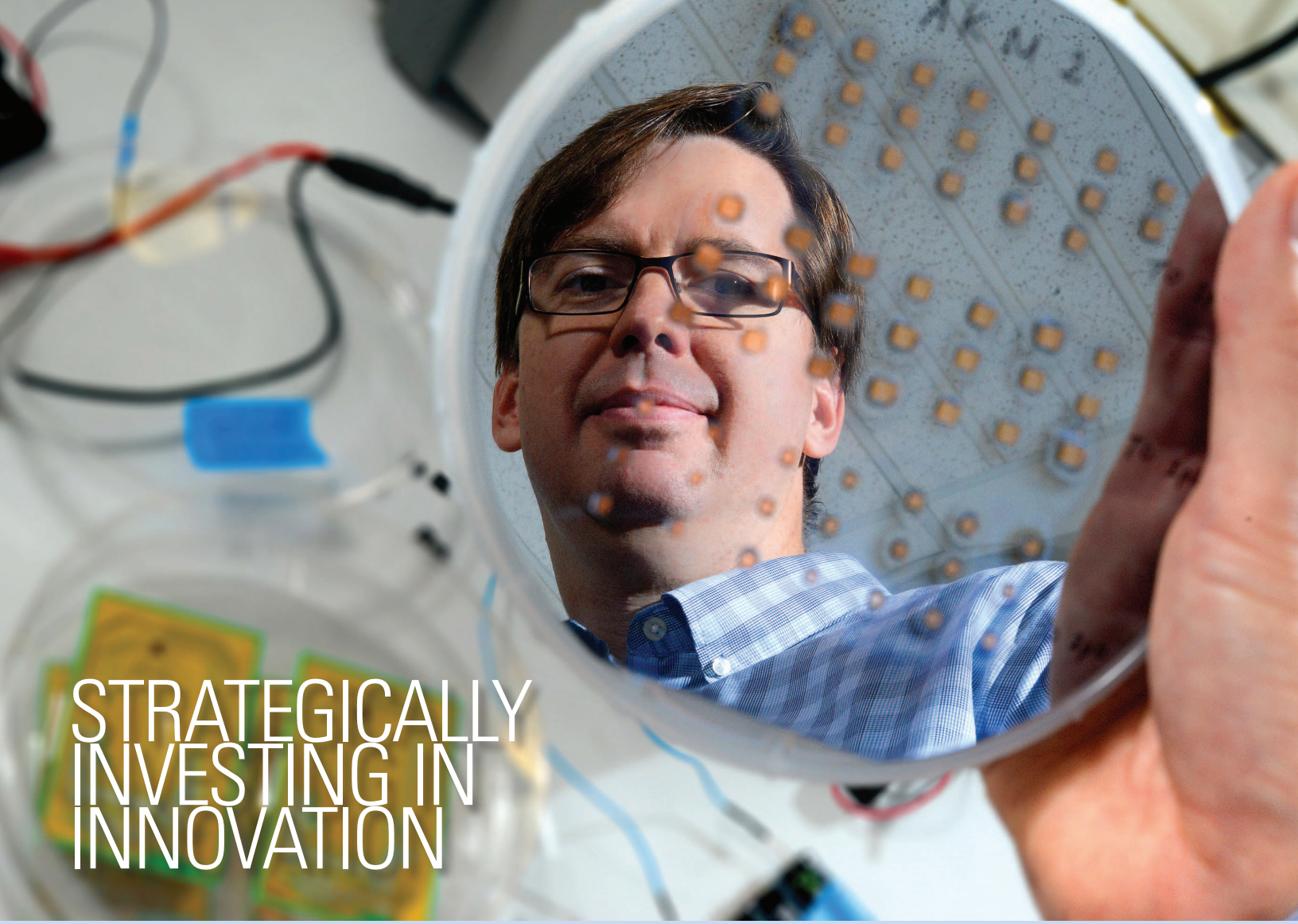
King's use of poetry is a case in point.

"He thought of himself in artistic terms, not simply as an orator," Miller says. "When he got up to deliver a speech, he thought of it as his chance to perform. It wasn't just rhetoric. It wasn't just a speech. It was a way of bringing poetry into the world of public speaking and communication."

The results changed many lives.

In the kitchen of his home in Rocky Mount, Herbert Tillman recounts how King's poetic oration changed the story of his life, from his childhood in a public housing project to his retirement at age 54 after a career as a mechanic and engineer in a textile mill. The rags-to-riches story is inspirational, demonstrating a classically American ability to overcome poverty, disadvantage and discrimination.

Tillman traces the source of his inspiration to that night in 1962 when he stood with friends, relatives and neighbors in the gymnasium at Booker T. Washington High



STRATEGICALLY INVESTING IN INNOVATION

• ABOVE: *Brian Floyd is constructing millimeter-wave cameras for body scanners, biomedical imaging devices and surveillance systems.*

NC State researchers fueled by support from the Chancellor's Innovation Fund are developing technologies that are changing the world.

From brewing beer with insect yeast to curing lung disease using stem cells, groundbreaking research doesn't always have the easiest path from the lab to the marketplace.

"Testing, validation and further refinement often are necessary to ensure innovations reach a point where they can benefit society," notes Kelly B. Sexton, director of NC State's Office of Technology Transfer.

With its blend of funding, entrepreneurial mentors and other support, the CIF program plays an essential role in bringing discoveries to the marketplace.

As the CIF enters its sixth year, the program's overall $1.9 million commitment to 28 projects has already has resulted in:

- $5.4 million in follow-on funding;
- $926,000 in licensing revenue;
- 10 commercialization agreements; and
- 8 startup companies formed.

That success translates to a 3-to-1 return on investment — a big reason why innovators keep coming back every year.

"It's great to see our investment paying off in terms of licenses executed, startups formed, and licensing revenue coming back to the university, " Sexton adds. "This shows that the CIF provides our inventors with the resources and support needed to commercialize their research."

She anticipates similar success for the five research teams selected for CIF funding for the 2015-16 fiscal year.

CATCHING LITTLE WAVES

Millimeter-wave cameras are used in full-body scanners, biomedical imaging devices, aircraft navigation and surveillance systems. Existing cameras, however, are not cheap — some cost up to $180,000 — and are large and heavy. Now electrical and computer engineer Brian Floyd has developed a technique to allow off-the-shelf radios to be reconfigured as millimeter-wave cameras.

His approach takes advantage of multi-antenna systems, or "phased arrays." These low-cost components provide the main sensors needed for a millimeter-wave imager, allowing the construction of exponentially lower-cost cameras — think $100 to $1,000.

This innovation combines imaging approaches from radio astronomy with coding approaches from wireless communications. The end result is a kind of "miniaturized

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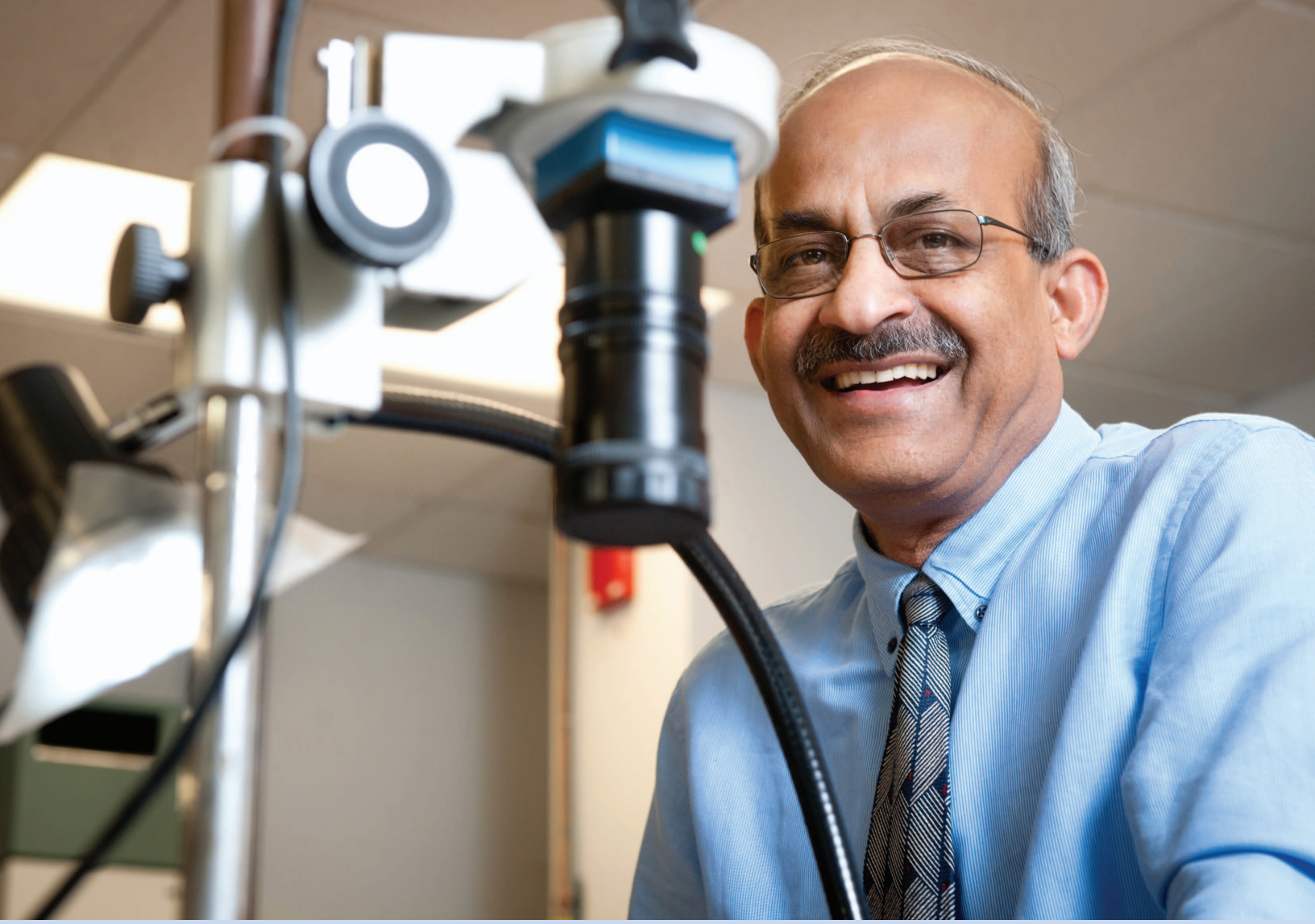


• ABOVE: *Tushar Ghosh is working with Alper Bozkurt to create durable, washable textiles containing sensors that monitor a person's health.*

radio telescope" that is drastically less expensive than the existing technology.

BIG NEWS FOR BREWS

Ecologist and evolutionary biologist Rob Dunn has teamed up with John Sheppard, a brewing expert and professor of bioprocessing, and Anne Madden, an ecologist with deep interests in yeasts and wasps, to do what comes naturally to such a group: Search for new beer yeasts, using nature as a guide.

They have identified strains of wild yeast that produce new tastes in beer — honey flavors without adding honey, fruit flavors without fruit — as well as easier ways to make well-known custom brews.

For example, the yeasts can produce sour beers in days rather than years while adhering to the German purity law and without the need for special techniques or facilities, a significant advantage for brewers. CIF funds will allow the scientists to characterize the yeasts they already have, develop new beer recipes and optimize the brewing process to make their technology attractive to potential licensees.

The team is also moving ahead with the search for more wild yeasts. On the horizon, they expect the new, nature-inspired approach they have used to yield many more new yeasts, leading to other unique beers.

FIBER-BASED BIOMEDICAL SENSORS

Keeping tabs on your health may soon be as simple as slipping on a shirt and picking up a smartphone. Fabrics with conductive textiles have a wide range of biomedical applications, from monitoring the health of expectant moms to providing real-time data for athletes.

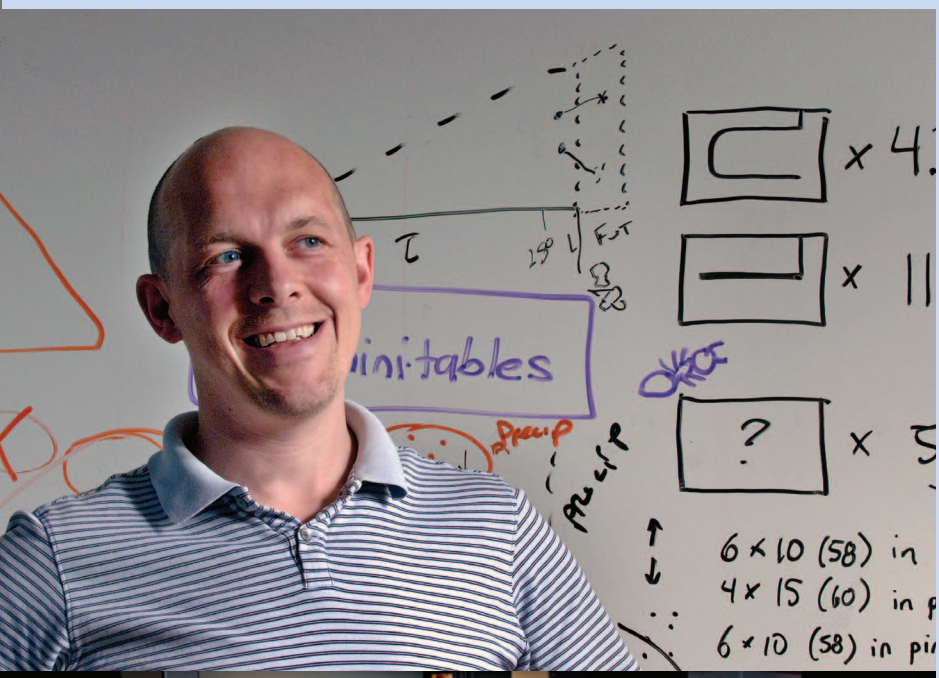
Researchers Tushar Ghosh and Alper Bozkurt are working on a second-generation prototype of their Fabric-Based Integrated Sensing Technology.

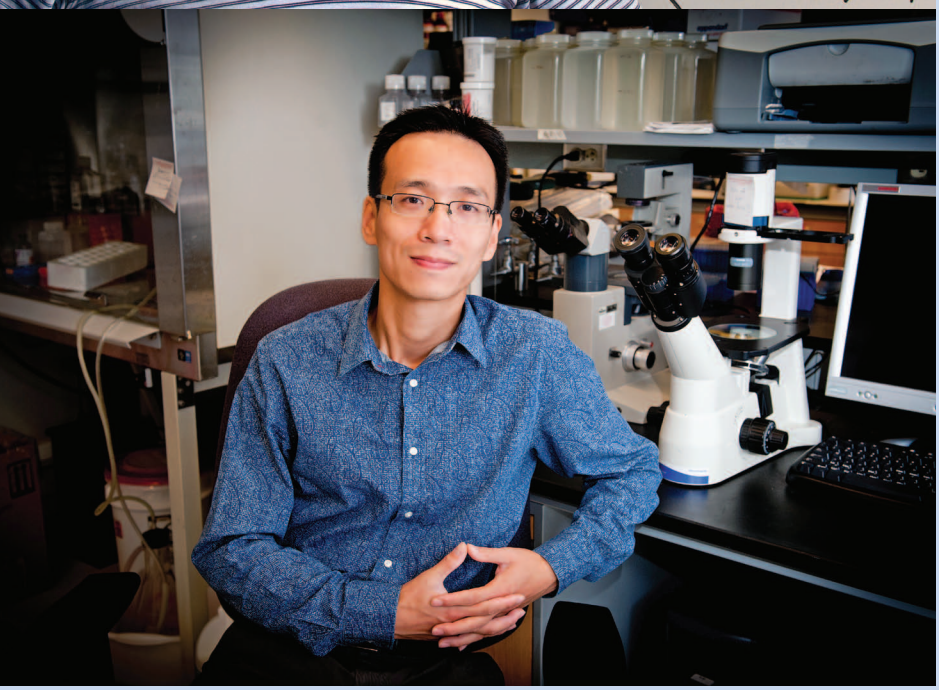
They've designed a textile structure that enables sensors to form at intersections in durable, washable synthetic fabric. Conductive threads in the fabric allow the sensors to form networks. The team is focusing on the user interface, the next step in moving the technology to market.

INNOVATIVE INFRARED IMAGING

Currently, infrared imaging technology that can "see" the heat emitted by warm objects, such as machinery or living things, has to be cryogenically cooled in order to operate effectively. But materials science and engineering researcher Jon-Paul Maria plans to develop technology that can create infrared images without relying on bulky and expensive cooling equipment.

"We have the core research





• ABOVE: *Rob Dunn is part of a team using wild yeast to produce new flavors of beer.* • BOTTOM: *Ke Cheng is using lung tissue to grow stem cells that can cure lung diseases such as chronic obstructive pulmonary disease and pulmonary fibrosis.*

done, and we have a technology goal," Maria says. "The CIF's support will allow us to create the demonstration prototype we need to move forward either with a startup or to license the technology to the private sector."

BREATHING EASIER

Regenerative medicine researcher Ke Cheng is working to make breathing easier for patients with chronic obstructive pulmonary disease and idiopathic pulmonary fibrosis (IPF). Cheng uses a patient's biopsied lung tissue to grow therapeutic lung stem cells that can then be returned to the patient to repair the damage done by disease.

The process is less time-consuming for patients because the cells can be harvested at the time of the initial biopsy. Cheng's innovation is also likely to be more effective because, unlike stem cells derived from bone marrow or cord blood, the therapeutic cells come from the organ they will be repairing.

"By utilizing a cell's 'memory,' we increase the potential for those stem cells to actually become lung cells, rather than other types of cells that cannot be used by the organ to repair itself," Cheng says. "The Chancellor's Innovation Fund gives me the means to move forward with preclinical testing, which I can present to the FDA. It gets us one step closer to human clinical trials for IPF treatment."

CIF STRATEGIES

Each year NC State researchers submit approximately 40 funding proposals to CIF. Following review by external subject-matter experts, eight inventors are invited to pitch their projects to a selection committee of university innovation partners.

These partners, representing a spectrum of industry sectors, provide valuable insight on potential markets, challenges and opportunities for each proposal. NC State Chancellor Randy Woodson reviews the recommendations from the selection committee and makes the final selections, with input from the university's research leadership.

The winning innovators receive up to $75,000 for their projects. They also have support from technology licensing professionals within the Office of Technology Transfer, along with members of the selection committee who are interested in the research.

"The ultimate goal is to ensure that these innovations make it further down the path toward the marketplace," Sexton says.

She is pleased with progress made by CIF projects to date, and she sees even more progress ahead. "We will continue to utilize these funds and the guidance of our selection committee to put our innovative faculty in the best position to succeed," she says.

This story was prepared by University Communications and the Office of Technology Transfer.

Honoring the Past, Defining the Future

BIOMEDICAL ENGINEER ZHEN GU'S INNOVATIVE DRUG-DELIVERY SYSTEMS FIGHT CANCER AND DIABETES AT THE CELLULAR LEVEL

By Tim Peeler

Four months after Zhen Gu was born, his father died of leukemia. The only photo of Gu and his father documents the moment when Gu's mother took the child with her to drop his father's body off at a Chinese medical morgue. His father had made the difficult — and, in China, rare — decision to donate his body for scientific research.

"He was a pioneer," Gu says proudly.

After Gu's father was diagnosed with leukemia, friends of Gu's pregnant mother had suggested gently, yet insistently, that it might be best if she didn't carry the baby to full term. She was young; if Gu's father succumbed to the disease, she could remarry — maybe to someone who didn't have a family history of cancer. She could offer a better future to a different child if she started her family later.

She steadfastly refused.

"What if," she told her family, "this child grows up to find a cure for cancer?"

That's exactly what Gu is trying to do in his pharmacoengineering lab on NC State's Centennial Campus, now that he's an assistant professor in the joint biomedical engineering program at NC State and the University of North Carolina at Chapel Hill.

"He remains the most creative and courageous Ph.D. student I've ever had. He produced the most professional presentations and lab reports, and he immediately struck me as someone who pays attention to details and has a very creative side."

— Yi Tang

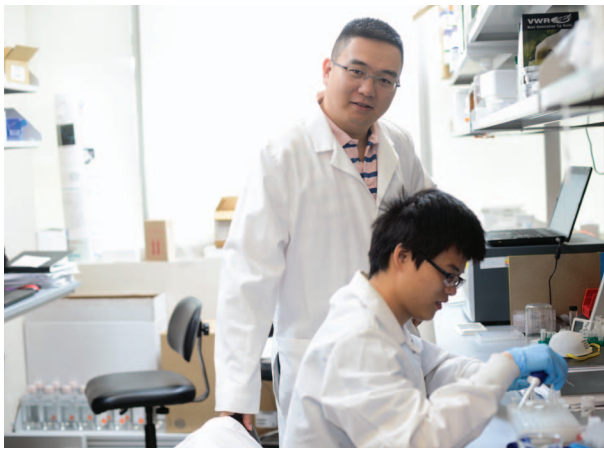
BRILLIANCE AMONG US

Gu's work in developing innovative drug-delivery systems for treating cancer and diabetes recently earned him recognition as one of *MIT Technology Review's* 35 Innovators Under 35.

He's created dozens of new technologies and techniques for delivering an exact drug dosage to an exact place at an exact time to maximize the effectiveness of therapeutic medications. His groundbreaking interdisciplinary work draws from the expertise that surrounds him on North Carolina's biggest research campuses, in fields including biomolecular engineering, materials chemistry and nanotechnology.

He's received grants from the American Diabetes Association to help develop a "smart insulin patch" and injectable nanoscale systems that can regulate insulin delivery, and he's currently working to move these inventions to market.

His anti-cancer drug cocktails come with whimsical names like nanoscale "daisies," graphene "flying carpets" and "nano-cocoons," all of which describe ways to attack cancer on a cellular level. He has just launched a startup company in Research Triangle Park and plans to launch another to commercialize these technologies that are sure to revolutionize treatments for cancer and diabetes.



"He remains the most creative and courageous Ph.D. student I've ever had," says Yi Tang, Gu's Ph.D. advisor at UCLA and a respected innovator in natural product biosynthesis and biocatalysis. "He produced the most professional presentations and lab reports, and he immediately struck me as someone who pays attention to details and has a very creative side."

FOR HIS GRANDMOTHER

Gu grew up in China's Jiangsu province, in the East China Sea port city of Nantong City. He often spent the holidays with his maternal grandmother, allowing his mother and stepfather the time they needed to work in the family grocery store.

Through the years, he watched his grandmother's health deteriorate because of her diabetes.

For this reason, Gu wanted to be a medical doctor, as his grandfather and several of his uncles and aunts had been. He was confident he could discover something that could alleviate — perhaps even cure — the disease afflicting his grandmother.

"Try to do it as soon as possible," she told him. "I will use your cure."

• LEFT: *Zhen Gu is earning national recognition for his development of innovative drug delivery systems.* • FAR LEFT: *Gu's lab is on NC State's Centennial Campus.*

Eventually, however, she died of complications from diabetes — another loss that shaped Gu's future.

CHEMISTRY, NOT MEDICINE

Gu's academic proficiency as a young student was in chemistry; it's the subject at which he excelled and for which he achieved his best grade in China's rigorous collegiate qualifying tests. Once he was on the path to a future in chemistry, his dream of working as a medical researcher seemed impossible.

"Sometimes when you have a dream, you still pursue it, even if you can't do it immediately," Gu says. "It's always affected by other stuff."

He received his bachelor's degree in chemistry and a master's degree in polymer science and engineering at Nanjing University. He then applied for doctorate programs in China and the United States, eventually enrolling in a program at UCLA.

His first adviser there worked with electronic polymers, specifically LED materials — something that didn't particularly interest Gu. But he soldiered on. He eventually switched to Yi Tang's lab, even though it didn't exactly put him on the path to medical research.

After taking a class from Tang called Molecular Biotechnology: From Genes to Products, Gu had asked to switch labs. Tang immediately accepted him and set aside some discretionary funds that allowed Gu to work on protein delivery systems that were tangential to the lab's actual research.

"Knowing that he was so creative with what he did, I knew he could teach me more about it," Tang says.

After two years, Gu received his doctorate in engineering and applied science and applied for a postdoctoral position at Robert S. Langer's research lab at the Massachusetts Institute of Technology. Langer is perhaps the world's foremost biomedical engineering researcher. He sent Gu a welcoming email within six hours of receiving Gu's application.

"He supported everything I did," Gu says. "He encouraged me to follow my dream. He promoted my career."

A JOINT VENTURE

Gu set up his lab as part of NC State and UNC's joint biomedical engineering department, through grants from the ADA's Pathway to Stop Diabetes Fund. It was the perfect fit for his unique ideas in the field of drug delivery.

"NC State is really strong for engineering, and UNC is really strong in medicine and pharmacy," he says. "It's perfect for what we're doing. It's really exciting."

One of his earliest inventions was an insulin "nano-network" that used just one injection to control the blood-sugar levels in diabetes patients for more than a week. The network is made up of tiny insulin particles, along with dextran and glucose oxidase enzymes, that are all held together with electrostatic coatings found in shrimp shells and seaweed.

Gu and his colleagues also created an infinitesimal daisy-shaped drug carrier that can directly target cancer cells in the bloodstream, releasing a deadly cocktail of drugs that destroy the cells from within. The controlled and coordinated doses reduce the famously nauseating side effects of traditional chemotherapy.

His most recent work is a painless insulin patch — about the size of a penny and covered with microneedles — that could end the need for injections, making diabetes management far less risky.

In just four years at NC State, Gu has earned a reputation for quickly finding solutions to difficult problems that has caught the attention of his mentors, his colleagues and medical researchers around the world.

"He starts a project fast and makes rapid progress," Tang says of his former protégé. "If that's portrayed as being a 'scientist in a hurry,' then these are all good things. He's off to a flying start and I am not surprised by that at all."

In just four years at NC State, Gu has earned a reputation for quickly finding solutions to difficult problems that has caught the attention of his mentors, his colleagues and medical researchers around the world.

Bionic Realities

ALPER BOZKURT IS DEVELOPING INTEGRATED MICROSYSTEMS TO IMPROVE LIVES

By Tim Peeler

When young Alper Bozkurt trekked to the local bakery in his native Turkey, he usually wore what he liked to call his "old-man sweater" with argyle patterns and his old-school large-framed glasses.

"Ah, it's the Professor," the man behind the counter frequently said.

It was a nickname that stuck with Bozkurt through middle school, high school and college. On his first day of engineering classes at Istanbul's Bogazici University, the MIT-trained chair of Bozkurt's electrical engineering department asked his class of first-year students who was interested in pursuing a career in academia.

Bozkurt's arm shot up. Then he looked around and saw everyone else sitting still, staring at him. He couldn't understand why the others weren't raising their hands.

Now the lauded researcher and assistant professor of electrical engineering at NC State is finally on the verge of earning the lofty title he's answered to since he was a child.

Scientific research is "what I was destined for, I believe," he says.

Bozkurt was recently named one of *Popular Science's* "Brilliant 10" for his work on building the foundations of what he calls the "Internet of bionic things," from remote-controlled cockroaches used by first responders to smart diapers that can monitor the vital signs of infants and toddlers.

Independent Thinker

Bozkurt used to think he might follow in his father's footsteps and become a physician. In high school, his light reading consisted of his father's biomedical textbooks and journals. "I've always been fascinated with how the body works," he says.

In talking with his father's medical colleagues, however, Bozkurt learned a disturbing truth: Doctors deal with things that fail. He wanted to create things that work.

In talking with his father's medical colleagues, however, Bozkurt learned a disturbing truth: Doctors deal with things that fail. He wanted to create things that work.

"The thing I discovered was that instead of appreciating how the body worked, you tried to solve problems," he says. "Instead of focusing on the beauty, you spend more time on all the reckless work of the body — all the diseases, all the problems, all the suffering.

"There are all sorts of algorithms you follow: If the patient's body temperature is high, if there is coughing, if there are white sores in the throat, you give these antibiotics or vitamins or medicines. While helping people is very satisfying and important, there's not much space for creativity."

Bozkurt's highest dream was to help people by expressing his creativity. He eventually discovered that electrical engineering gave him that opportunity.

He discovered biomedical engineering as a graduate student at Philadelphia's Drexel University, and he made use of facilities at nearby research hospitals. He also developed an interest in microsystems and began studying in the electrical engineering doctoral program at Cornell University.

Soon after Bozkurt started his doctoral program, his advisor left for the Pentagon's Defense Advanced Research Projects Agency in Washington, D.C. As they maintained their academic relationship from afar, Bozkurt appreciated the experience of being trained in microsystems without being micromanaged.

"My advisor was gone for four of my six years at Cornell," Bozkurt says. "Although it was difficult at the beginning to work alone, it gave me independence. It helped me grow tremendously as a researcher by learning how to define problems and offer solutions all by myself."

OUT-OF-THE-BOX RESEARCH

When Bozkurt set up his Integrated Bionics Microsystems lab at NC State in 2010, he had ideas he wanted to explore — such as his groundbreaking work with insect cyborgs, which he helped start as a graduate student — but to do so, he needed to tap the expertise of researchers in other fields. He reached across departmental boundaries to collaborate with researchers in computer science, entomology, the College of Veterinary Medicine, the College of Textiles and even the medical schools at Duke and UNC-Chapel Hill.

On his first day of faculty orientation at NC State,

• LEFT: *Alper Bozkurt works on improving the electronic interfaces on wearable sensors.* • FAR LEFT: *Bozkurt developed a technique to remotely control, or steer, cockroaches.*

Bozkurt and computer scientist David L. Roberts fell into conversation about the possibility of expanding Bozkurt's cyborg insect research to rescue dogs. The idea came to Bozkurt after seeing the Disney movie *Up*, and Roberts also had the same idea based on earlier work on the topic. The two freshly minted Ph.D.s became fast friends and began looking for ways to work together.

Working with Barbara Sherman of CVM's Department of Clinical Sciences, they developed a comfortable harness that allows trainers to observe dogs' behavior and body language remotely. Using an array of sensors that measure heart and respiration rates, the harness can communicate the information wirelessly to a smartphone, track the physical and emotional well-being of the dogs and, they believe, help reduce the stress service dogs often experience.

"Dr. Bozkurt is a true innovator who sees beyond the present and into the future," Sherman says. "He is able to think outside the box to envision future applications and invent working devices that will make his vision a reality."

His work has caught the eye of scientists across the country, and his unique solutions have often been mentioned in pop culture and mass media. His cockroach backpacks even were an answer on the TV game show *Jeopardy!*

He also was an advisor for Disney's 2009 animated film *G-Force*, adapting his remote-controlled cockroach research into the character Agent Mooch, a robotic housefly. He talked about the possibility of a zombie apocalypse on the Science network documentary series *Through the Wormhole*, narrated by Morgan Freeman.

He and his students take their work to school kids at events such as BugFest at the North Carolina Museum of Natural Sciences, reaching a variety of audiences that aren't often exposed to scientific research.

"There's no doubt he's had significant impact on various research communities, and on the general public through outreach and the media," Roberts says. "His recognition is well-deserved."

IMPROVING INTERFACES

Working with animals has been enlightening, Bozkurt says, but he now wants to return to his original goal of using microsystems to improve the lives of human beings.

He's doing that with help from Tushar Ghosh, a professor in the College of Textiles. The two are working together to develop durable, washable fabrics that can collect data from built-in biomedical sensors. They recently received Bozkurt's second award from the NC State Chancellor's Innovation Fund to help move a prototype to market.

Bozkurt is particularly interested in developing improved electronic interfaces that allow communication between patients and synthetic fabrics.

Soon, keeping an eye on personal health, monitoring pregnancies, improving athletic performance or even reading newborns' vital signs could be as simple as putting on a shirt.

Bozkurt's first award from the Chancellor's Innovation Fund was for a wearable bandage that monitors sleep more accurately. SleepiBand is currently under clinical testing in Duke's Sleep Lab.

He also contributes as a testbed leader to one of NC State's two National Science Foundation Engineering Research Centers: Advanced Self-Powered Systems of Integrated Sensors and Technologies, known among business partners as ASSIST. He combines the research products of more than 20 researchers to develop prototypes of body-powered wearable sensors that monitor health and environment simultaneously. One application is managing the wellness of asthma patients.

"This is the kind of high-impact research I believe I was destined to do," Bozkurt says. "Here at NC State and in the Triangle, I've found great collaborators, amazing students, a supportive department and a fertile ecosystem to keep growing in this direction."

"This is the kind of high-impact research I believe I was destined to do. Here at NC State and in the Triangle, I've found great collaborators, amazing students, a supportive department and a fertile ecosystem to keep growing in this direction."

— Alper Bozkurt

Fighting Viruses for Food Safety

FOOD VIROLOGIST LEE-ANN JAYKUS LEADS A TEAM TAKING AIM AT THE VIRUSES THAT CAUSE FOODBORNE DISEASE

By Brent Winter

Every life has its crucial decision points — those moments when a choice one way will result in one life story, and a choice the other way will result in a radically different story. Lee-Ann Jaykus faced one of those decisions in high school.

"Initially, what I liked most was music," Jaykus recalls. "I played the flute. But then I took my first biology class, and I realized that I liked studying science more than I liked practicing the flute," she says with a laugh. "So here I am. That was probably a really good choice."

It probably was. Jaykus is now a food virologist and one of the nation's leading experts on food safety, and she's a William Neal Reynolds Distinguished Professor in NC State's Department of Food, Bioprocessing and Nutrition Sciences. She's also directing the U.S. Department of Agriculture's Food Virology Collaborative (called NoroCORE), a five-year, $25 million project to reduce the burden of foodborne disease associated with viruses.

When Jaykus entered college, she continued to follow what interested her most and made her happiest.

"In my first microbiology class, in sophomore year, we worked with culture plates," Jaykus says. "Things on the plates turned colors, and I really liked that — although microbiology has certainly changed a lot over the last 30 years!"

Jaykus knew she liked microbiology, but it's a vast field, and she was mindful of her mother's advice: "It's better to be a big fish in a little pond than a little fish in a big pond." Jaykus eventually chose the little pond of food microbiology, where she earned both her bachelor's and master's degrees.

Before going into academia, Jaykus worked in industry, first as a quality assurance manager and then running a microbiology lab for a testing firm.

In the late 1980s and early 1990s, food safety began to emerge as a discipline in its own right. Jaykus understood that she wanted to push her career in that direction, which would require her to get a Ph.D. She was willing to go back to school and earn the degree, "but I didn't want to get a Ph.D. in food science, because I'd already done that," she explains.

To chart the next stage of her journey, Jaykus went to food-safety conferences, attended the lectures, and talked with participants to determine where the discipline was headed. That's how she identified four main emergent areas of activity in food safety: epidemiology, risk assessment, molecular biology and food virology.

Jaykus looked for doctoral programs that would allow her to work in all four areas. The only one she found was in the School of Public Health at UNC-Chapel Hill, so that's where she earned her doctorate.

When her degree was almost complete, one of her dissertation committee members — a food microbiologist from NC State — mentioned that NC State had a position open in Jaykus' field.

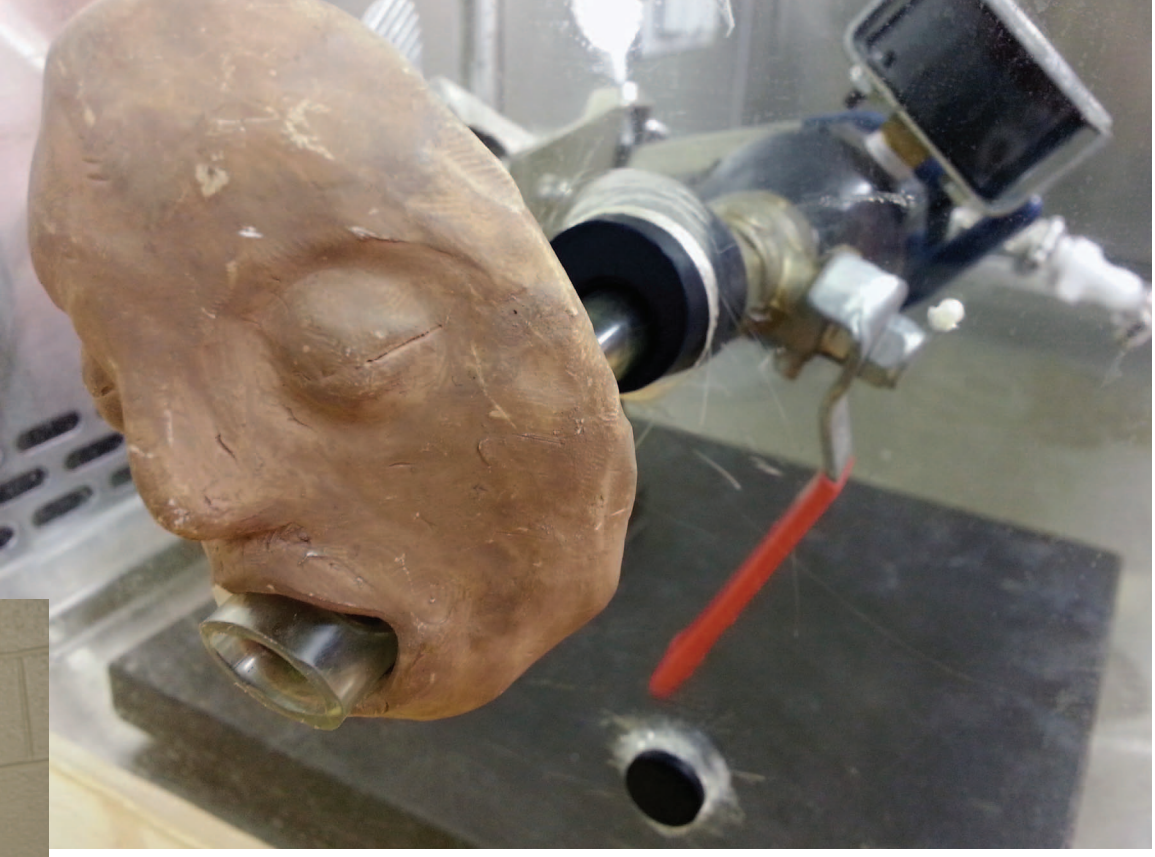
"I said, 'That's great, but I'm very nontraditional. I've had a very different trajectory,'" Jaykus recalls. "My committee member said, 'Well, I still think people would like what you're doing.' So I applied for the position. The rest is history."

Jaykus joined NC State's faculty in 1994. She soon found that she was very well positioned in her field because of her unique educational and professional preparation covering the four emerging domains of food-safety research. She immediately began developing a research program based on those areas.

"When I started at NC State, nobody knew or cared about viruses in food," Jaykus notes. "There was a lot of work addressing viruses in water, but not in food." That began to change in 1999, when the Centers for Disease Control and Prevention released an estimate stating that viruses were the leading cause of foodborne disease in the U.S.

"This news blew the minds of food microbiologists

> "When I started at NC State, nobody knew or cared about viruses in food. There was a lot of work addressing viruses in water, but not in food. ...There were very few scientists with the unique combination of expertise in both viruses and foods. I was one of maybe two or three people in the whole country who fit that description. So my life got very crazy very quickly."
>
> — Lee-Ann Jaykus



• LEFT: *Researchers designed and built a "vomiting machine" that provided the first laboratory evidence that vomiting causes norovirus to be aerosolized at levels high enough to transmit the virus to another person.* • FAR LEFT: *Food virologist Lee-Ann Jaykus leads NoroCORE, a five-year, $25 million project to reduce the burden of foodborne disease associated with viruses.*

and food-safety experts," Jaykus says. "There were very few scientists with the unique combination of expertise in both viruses and foods. I was one of maybe two or three people in the whole country who fit that description. So my life got very crazy very quickly."

Soon the federal government started asking Jaykus to serve on national food-safety panels to advise policymakers. Then she was elected to the executive board of the International Association for Food Protection, the world's leading food-safety association. Jaykus served as president of the organization in 2010-2011.

Around the same time, the U.S. Department of Agriculture issued a call for proposals to establish a national food virology initiative. Jaykus took the lead in developing a proposal and assembling a team to work on the initiative. The USDA funded her proposal, and that's how NoroCORE (Norovirus Collaborative for Outreach, Research and Education) came into being.

NoroCORE focuses on combating noroviruses, which cause the illness variously known as "stomach flu," "24-hour bug" or "cruise-ship virus." The primary symptom of norovirus infection is vomiting, often accompanied by diarrhea and abdominal cramps — a miserable way to spend the 12 to 72 hours of a normal course of infection in a healthy adult.

But if you're a member of a high-risk group, such as the elderly, the disease can last far longer and become much more severe — occasionally even fatal. It's now believed that noroviruses cause perhaps 50 percent of all foodborne illness, and they're easily transmitted between people via fecal matter and vomit. That's why it's estimated that around 20 million norovirus cases occur each year in the U.S.

NoroCORE is trying to change that. The NC State-led initiative brings together more than 30 lead scientists and their teams from 22 partner organizations.

"We're taking a wide, multidisciplinary approach," says Jaykus, NoroCORE's scientific director. The team is working on several focus areas at once, including sanitation and hygiene, education and outreach, epidemiology and virus detection. "NoroCORE is a great example of team science, which is my favorite way of approaching science," she says.

Among NoroCORE's recent breakthroughs is the discovery that vomiting can cause norovirus to be aerosolized at levels high enough to transmit the virus to another person. Epidemiological evidence has long suggested such a mechanism for norovirus transmission, but no one had verified it in a laboratory until Jaykus and her team designed and built a "vomiting machine" that allowed them to test that thesis under controlled conditions.

Jaykus talks optimistically about putting even more irons in the fire in the future: working more with the federal government and with industry, and getting back into the classroom to teach. Yet she still decides what to do based on what matters most to her — and that includes her family.

"I didn't accomplish any of this without considering my family all along the way," Jaykus says. "All my career choices took them into account. For instance, I purposely didn't travel much for work until my daughters were in college."

When asked how those decisions affected her career, Jaykus gives an unequivocal reply: "Not at all. Saying no to an opportunity now doesn't mean another opportunity won't come along later. If you work hard and earn a good reputation, there will always be opportunities for you."

"We're taking a wide, multidisciplinary approach. NoroCORE is a great example of team science, which is my favorite way of approaching science."

— Lee-Ann Jaykus

On the Move

NATASHA OLBY'S RESEARCH BRINGS NEW HOPE TO DOGS — AND PEOPLE — WITH NEUROLOGICAL DISORDERS

By David Hunt

Veterinary neurologist Natasha Olby carries Reagan, a plush golden dachshund, into a treatment room in NC State's cutting-edge veterinary hospital. The dog shyly eyes a visitor while Olby sets the animal on an exam table and carefully manipulates his back legs.

Reagan seems perfectly content throughout the exam, and his instincts aren't wrong. He couldn't be in better hands.

"The most common condition we neurologists see is dogs with spinal cord injuries," Olby says as she checks Reagan's posture. "That's why I just love my spinal cord injury research."

Advances in veterinary neurology are coming quickly now after years of research —and Olby is delighted to be at the forefront of discovery.

Although spinal injuries can be painful and debilitating, they often respond well to surgery and rehabilitation. But in some cases, a dog with a spinal injury may suffer permanent paralysis, especially if the nerves in the spinal column are severely damaged.

"There's a lot of energy and attention focused on the acute phase right after an injury," she explains. "But after a couple of weeks, guess what? If they haven't gotten better, they're going into a chronic phase, and we don't have great options for treatment then."

Olby focuses much of her research on expanding those treatment options, giving her canine patients better odds of living rewarding, active lives. She ticks off some of the more promising areas of research, including epidural stimulation of the spinal cord, Schwann cell transplantation to regenerate nerve fibers and use of the drug 4-Aminopyridine to restore the conduction of impulses across regions of nerve fibers that have lost their myelin, a natural insulating material.

All of these research areas are important because, as Olby demonstrated in a recent clinical trial, dogs with the same type of injury often respond very differently to the same treatment.

"If we take a group of dogs with acute spinal cord injuries due to a herniated disc and look at their spines using an MRI, some of them have what looks like fibrous scar tissue in there, and some of them have a big fluid-filled hole," she says. "Some of them may even have demyelination that we can't see with a regular MRI. It's complicated."

Olby takes a holistic approach, targeting virtually everything related to her patients' paralysis — even conditions that have nothing to do with neurology.

"We look at secondary health problems, such as urinary tract infections, that paralyzed dogs tend to get," she says. "For example, we've just done a clinical trial of cranberry extract to see if it reduces those infections."

Olby's work is the essence of personalized medicine,

caring for individual patients with medical strategies tailored to their physical characteristics and genetic predisposition to respond to treatment.

If you're wondering why you can't get this level of care from your family doctor, don't worry. It's only a matter of time. Dogs like Reagan are excellent models for people, she explains.

"There's a lot of energy and attention focused on the acute phase right after an injury. But after a couple of weeks, guess what? If they haven't gotten better, they're going into a chronic phase, and we don't have great options for treatment then."

— Natasha Olby

• LEFT: *Neurologist Natasha Olby examines a patient in the veterinary hospital at NC State.* • FAR LEFT: *Olby helps dogs like Reagan live rewarding, active lives.*

That brings us to another of Olby's research areas: neurogenetics, a field at the intersection of neuroscience and genetics that explores how an animal's genetic code affects its physical traits. The connection to human health is striking. Olby studies hereditary ataxias, a group of diseases found in some breeds of dogs, which are also among the most common neurodegenerative disorders in humans.

Ataxia occurs when a gene makes abnormal proteins that impede the function of nerve cells, primarily in the cerebellum and spinal cord, causing them to degenerate. Over time, sufferers have trouble walking and may experience a wide range of symptoms, such as slurred speech, fatigue, involuntary eye movements, curvature of the spine, hearing loss and even heart disease.

While you probably haven't heard of ataxias, these diseases are almost as prevalent as better-known neurological disorders such as Huntington's and Parkinson's. They're also extremely difficult to treat. Just finding the genetic mutations linked to each type of ataxia is like finding the proverbial needle in a haystack.

However, because dogs have been narrowly bred over millennia, ataxia mutations in their genes are easier to spot. That's exactly what happened last February when Olby and a team of researchers identified a mutation related to a type of hereditary ataxia in the genes of Old English sheepdogs and Gordon setters.

It was a groundbreaking moment.

"Identifying the mutation helps us understand what is killing neurons and may enable us to develop a therapy that is going to be pertinent to people with neurodegenerative diseases," she says. "Once you understand what causes the disease, then you can start to look at new ways to treat it. That's the potential."

Olby recognized her own potential as a veterinarian at an early age. Raised in the Yorkshire region of England, she was inspired by the semi-autobiographical books chronicling the day-to-day struggles and triumphs of Yorkshire veterinary surgeon James Herriot, starting with the 1972 bestseller *All Creatures Great and Small*.

"There's a whole generation of people who wanted to be vets because of James Herriot," she says. "I was one of them."

Years later, Olby's dream took shape at the University of Cambridge, where she pursued a degree in veterinary medicine and a Ph.D. in neurosciences. Her decision to pursue neurosurgery as a specialty came in a roundabout way.

"I joined a rowing team," she explains. "I spent many hours every day rowing and decided that I wanted to further my rowing career."

But the team's schedule threatened to interfere with her schoolwork. Luckily, Olby stumbled upon a lab at the university that offered to accommodate her passion for rowing.

"The professor said, 'If you want to row, I'll let you row and work in my lab.' It happened to be a neurology lab that focused on spinal cord injuries," Olby says. "It turned out to be perfect for me."

Why was the professor so eager to help the young student? "He was the treasurer of the local rowing club," Olby explains with a grin.

Now that she's midway through a rewarding and successful career as a veterinary neurologist, Olby knows she picked the right specialty, even if by happenstance.

"This is a really exciting time in the field," she says. "Here in my lab we have a lot of clinical trials under our belt, so we know how to do them well, and we can get funding to do them. Best of all, we're starting to turn out some really useful data."

For dogs like Reagan — and thousands of people with spinal cord injuries — Olby hopes to translate those research findings into new knowledge leading to better medical care.

As for her passion for rowing?

"I never did become a rowing superstar," Olby deadpans. "I got trapped into neurology instead."

"This is a really exciting time in the field. Here in my lab we have a lot of clinical trials under our belt, so we know how to do them well, and we can get funding to do them. Best of all, we're starting to turn out some really useful data."

— Natasha Olby

Self-Powered Vision

NC STATE'S ASSIST CENTER AIMS TO IMPROVE GLOBAL HEALTH OUTCOMES BY ELIMINATING SENSOR BATTERIES

By Gene Pinder

• BELOW: *Tim Shay, a graduate student in chemical engineering in Michael Dickey and Orlin Velev's research group, works with illuminated hydrogels.*

"Our mission is to improve global health outcomes by creating battery-free, self-powered, wearable systems for continuous health monitoring and long-term use. The idea is for a wearable unit to collect continuous health data from sensors. At the same time, it's being powered by the patient or user. It's really breakthrough technology — and a lot of it is being developed at NC State."

— Veena Misra

Health monitors harvesting energy from body heat. Stretchable nanowire electrodes embedded in garments. Wearable ozone sensors alerting asthma sufferers to adverse conditions.

These are some of the exciting research breakthroughs made by a National Science Foundation Engineering Research Center located on NC State's Centennial Campus.

The Advanced Self-Powered Systems of Integrated Sensors and Technologies Center — better known as ASSIST — was launched in fall 2012 with a $20 million grant from NSF. Since then, the NC State-led consortium of academic institutions and private companies has worked to revolutionize health monitoring by giving sensors a whole new power source: the patient's own body.

"Our mission is to improve global health outcomes by creating battery-free, self-powered, wearable systems for continuous health monitoring and long-term use," explains Veena Misra, director of ASSIST. "The idea is for a wearable unit to collect continuous health data from sensors. At the same time, it's being powered by the patient or user. It's really breakthrough technology — and a lot of it is being developed at NC State."

Freeing health monitors from relying on batteries sounds like a good idea, but it's no easy feat. There are good reasons why health monitors use batteries: the power batteries generate is generally reliable and strong enough to drive the associated electronics, such as a pacemaker.

But batteries eventually die — even rechargeables. In a health care context, that makes battery-powered sensors poorly suited for long-term use and continuous monitoring.

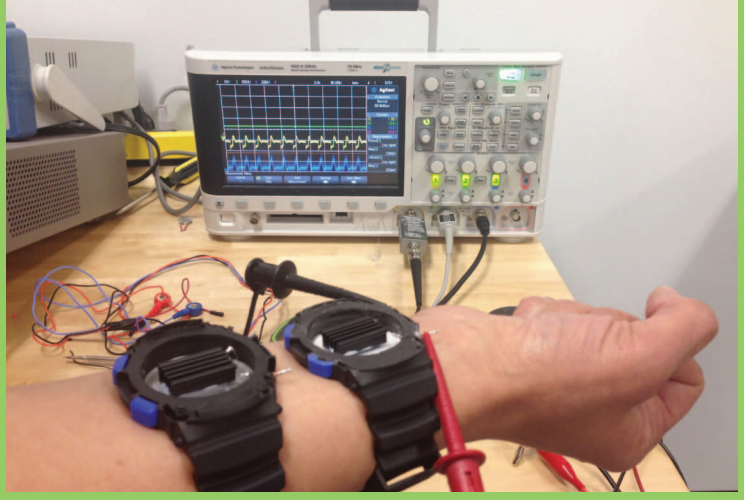
Some research suggests that battery use may be one of the primary obstacles to patient compliance. In other words, patients may not use their monitors if they have to keep messing with batteries.

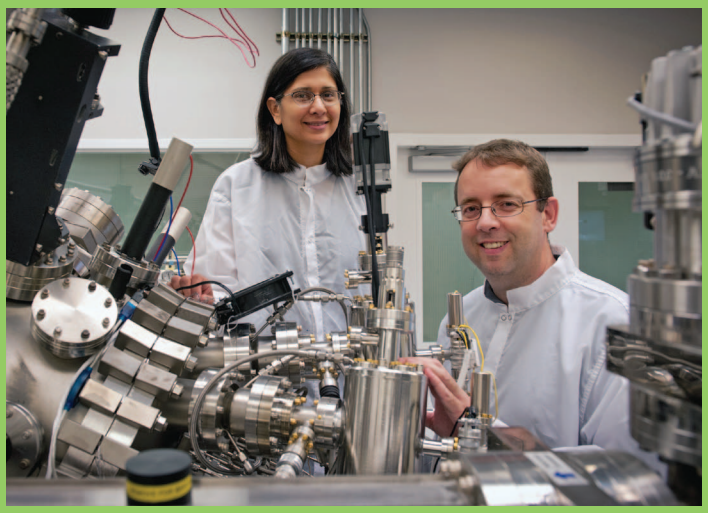
POWERED BY YOU

ASSIST researchers intend to change that paradigm by eliminating the battery completely.

"Humans have two ways to generate power using the body," Misra notes. "One is heat, and the other is motion. But in order to harness that power efficiently, you have to have very advanced materials, and you need systems in place to capture that power."

Take body heat, for instance. Small thermoelectric energy generators (TEGs) can be placed on the body to convert the temperature differential between the skin and the air into energy. But achieving maximum power and efficiency can be challenging, especially when a





• TOP LEFT: *ASSIST-created thermometric generators (TEGs) are tested against off-the-shelf TEGs.* • TOP RIGHT: *Early-stage development of ASSIST vital-sign monitoring included units for use on the chest.* • MIDDLE LEFT: *Visiting middle school students play ASSIST senior design thermometric and kinetic energy harvesting game at NanoDays 2015.* • MIDDLE RIGHT: *Elena Veety, ASSIST education director, judges visiting middle school students' marshmallow and spaghetti towers.* • BOTTOM LEFT: *Jesse Jur, at right, of the College of Textiles, is an expert in nanosystems.* • BOTTOM RIGHT: *Veena Misra, ASSIST director, and John Muth, deputy director, work with partners in multiple universities and private companies.*

rigid TEG doesn't conform to the contours of the skin.

In addition, a single TEG can't deliver the desired power levels for the sensors and electronics of the future. As a result, ASSIST researchers have been working on stringing several TEGs together to achieve sufficient power, as well as making them more flexible.

The team is exploring new "nanocomposites" of bismuth telluride that deliver higher power performance. NC State researchers have been particularly effective at developing these nanocomposites in grain form, further optimizing the material's thermoelectric properties.

SAVING POWER

While some researchers are focusing on significantly improving the effectiveness of harvesting power from the body, other ASSIST teams are lowering the power demands of health sensors.

Wearable systems consume power in a number of ways, such as sending and receiving radio signals or by using the microchip embedded in a system. Researchers at the University of Virginia, an ASSIST partner institution, and the University of Michigan are developing high-functioning chips that use very little power — a critical requirement for a

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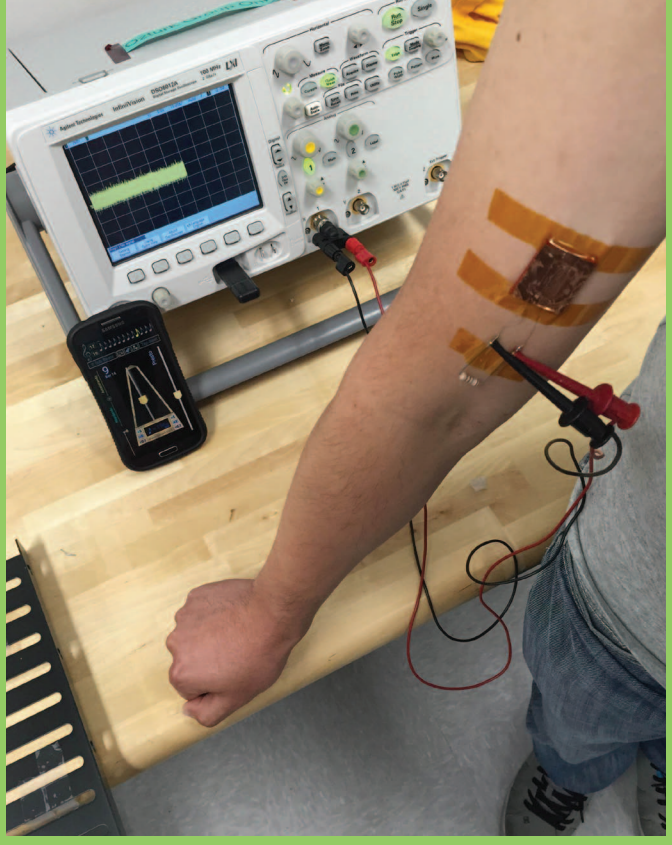


• LEFT: *ASSIST facilities include a cleanroom for development of high-tech sensors.* • RIGHT: *The public and private partnership resulted in the development of prototypes like this.*

self-powered wearable sensor.

Sensors, in fact, play a key role in the development of current and future health monitors. NC State researchers and others are developing more effective biochemical and organic compound sensors, such as ozone detectors, which could have significant applications in asthma treatment.

Imagine monitors that could use sensor data to detect environmental risk factors for an asthma attack and could warn a person, especially a young child, that an impending episode is likely.

BIG DATA

Misra says big data is at the core of the entire health-monitoring system.

"For all of these systems to have value, the data needs to be obtained from different sensors, then correlated and mined for trends," she says. "That's why we're so focused on a systems approach. It all has to work together."

That systems approach is multidisciplinary at its core. For example, a new wireless, wrist-worn platform of sensors optically measures movement of the blood in the body. The monitoring platform is solar-powered and contains supercapacitors — devices that can store energy in the form of an electrostatic field..

Another focus at ASSIST involves clothing. The center incorporates research from NC State's College of Engineering and College of Textiles because ASSIST's corporate members are particularly interested in integrating wearable platforms into apparel.

Instead of a wristwatch monitoring your heartbeat or body heat during a workout, imagine self-powered sensors embedded in your workout clothes that continuously monitor your activities. Or envision a hospital gown that has sensors in its fabric to continuously monitor a person's vital signs as they recover from a devastating illness.

What does this research mean for the average person?

Misra expects people will make better decisions about their health because they'll have access to more and better data. That, in turn, will make health care more effective and will eventually help drive down costs.

ASSIST member UNC REX Healthcare is acutely aware of the potential benefits of the center's critical research.

Anita Watkins, director of Rex Strategic Innovations and chair of the ASSIST Industry Advisory Board, notes that technology developed by ASSIST will provide constant monitoring for hospital patients once they are discharged — a direction the health care system is already moving in.

In addition, the millennial generation expects health care to be digitized, with wearables as integral parts of overall health care. "They expect their visits will involve data from devices and that they will be active in their care decisions," Watkins says. "They will be collecting data for their health care providers and transmitting that data back to improve health outcomes and overall wellness."

Watkins is pleased that Rex Strategic Innovations became an ASSIST corporate partner. "ASSIST was one of our first partners when we started our initiative, and it's been a great partnership," she says. "We were looking for people and institutions that were forward thinking, and ASSIST matched our needs perfectly. We can look internally to generate innovative ideas for how to improve health care, but we also wanted to reach outside health care as well."

Commercialization of the center's research is a key outcome. It's not enough that ASSIST will create new and exciting self-powered health monitors; the innovative technology also must stimulate the development and distribution of new commercial products and programs.

"Because our technologies are so advanced, we want industry to be able to pick them up and translate them into products that create jobs, stimulate the economy and create new market directions," Misra adds. "That's a critically important part of our work, and we're very focused on it."

While researchers work behind the scenes to bring new technology to light, the center also conducts an active educational outreach program, including preparing NC State students for careers in this burgeoning field.

ASSIST also holds summer programs for high school teachers to help strengthen interest in science, technology, engineering and mathematics by introducing students to a cross-disciplinary scientific environment.

"I think it's really fulfilling to see how we've all come together," Misra says. "We have really gelled as a center, and we're all focused on achieving this self-powered vision."

QUICK TAKES

RETHINKING TEAM DYNAMICS

An international group of researchers has found that business team performance is impaired when leaders treat some team members much better than others — and when leaders treat all team members the same way.

"Existing research has generally shown that leaders treating team members differently, depending on factors such as how competent they believe each member is, can result in productive teams," says NC State researcher Bradley Kirkman, co-author of a paper on the work. "However, we found that leaders can go too far. If a leader treats team members too differently from each other, performance suffers."

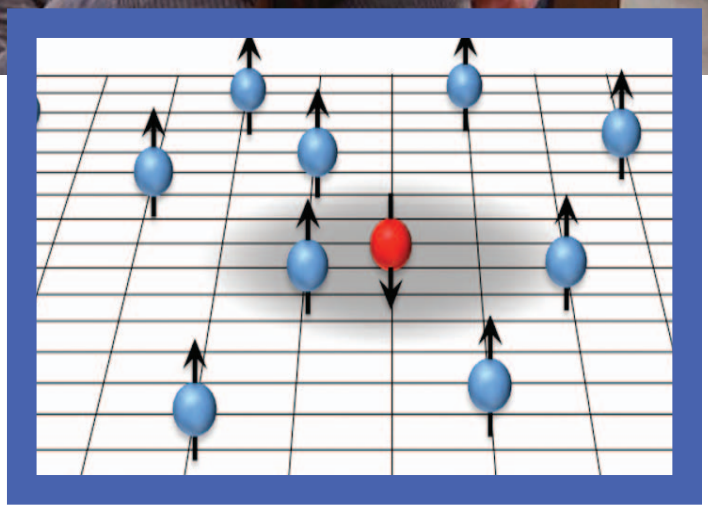
The researchers evaluated 145 teams in three Chinese companies. They assessed team performance via a survey of the team leaders, and they measured differential treatment using the "LMX7" scale, which assesses the relationship quality between team leaders and team members.

"We found an upper limit to how far leaders should go in treating their team members differently," Kirkman says.

"If leaders go too far with this behavior, leaders will end up with teams composed of basically two subgroups: the ingroup and the outgroup. And we know that the outgroup will not be happy about this and will start to slack off, withdraw from participating and even go so far as to be disruptive to the ingroup team members. But treating all team members the same also hurts performance. Leaders need to find a middle ground, or moderate level of differentiation."

ALGORITHM MODELS PARTICLE BEHAVIORS

Physicists have created a better algorithm for simulating particle interactions when an impurity enters a Fermi sea — a collection of weakly interacting identical fermions, such as supercooled electrons. The algorithm shows that when an impurity enters a Fermi sea, the impurity's transition from quasiparticle to bound molecule is smooth. The algorithm may aid in understanding the behavior of impurities in a variety of systems.



• TOP: *A new study sheds light on team dynamics in the workplace.* • BOTTOM: *A single down-spin impurity surrounded by a Fermi sea of up-spin particles in two dimensions.*

"Let's say that all the particles in a Fermi sea are up-spin particles, and we introduce one down-spin particle," says NC State physicist Dean Lee, co-author of a paper describing the work. "Does this new particle form a molecular bond with one of the up-spin particles? How does the system react?"

Lee and his colleagues developed a lattice algorithm that samples the possible paths of the impurity in the Fermi sea by treating the impurity particle explicitly, in a completely different manner from the other particles in the system.

The researchers found that when the impurity is introduced, "there's an interesting ambiguous state where the particles are interacting but may or may not be a bound molecule," Lee says. "And when the transition does happen, it occurs smoothly as a function of interaction strength.

"We want to take the lattice into three-dimensional simulations

continued

and introduce an impurity to a paired superfluid to see what effects that has on the system. We hope our method can be used to address questions about cold atoms, solid-state systems and neutron stars."

CONTROLLING PLANTS' STRESS RESPONSES

Researchers have developed an algorithm that identifies genes associated with biological functions in plants. The tool will help biologists target genes that control how plants respond to drought and other environmental stressors.

"By narrowing the field from thousands of possible genes to less than 10, it will be much easier for biologists to develop drought-resistant crops or plants that can thrive in nutrient-poor environments," says NC State engineer Cranos Williams, co-author of a paper describing the work. "It's a key that could unlock a great deal of plant biology research with real-world applications."

The researchers exposed a group of Arabidopsis thaliana plants to stress by placing them in iron-deficient growing media, and they took samples to learn how the plants' gene activity responded to stress.

The researchers found stress-response activity in 2,700 different genes — far too many to test in the lab. They then plugged the gene activity data into the algorithm, which predicted that seven genes were involved in initiating the plants' stress response.

They also found that the 2,700 initially active genes could have stimulated responses in 931 possible target genes; again, too many to test. But the algorithm narrowed it down to 32 predicted relationships between initially active genes and target genes. This was a small enough number to test.

"We went from thousands of genes to seven, and from 931 possible relationships to 32, making it possible to identify the relevant genes and interactions in weeks rather than decades," Williams says.

$5 MILLION GRANT TARGETS AFRICAN CROP DISEASE

NC State will receive National Science Foundation Partnerships in International Research and Education funding to study cassava mosaic disease, which severely limits production of one of Africa's most important food crops.

The five-year, $5 million project will be led by Linda Hanley-Bowdoin, William Neal Reynolds Distinguished Professor of Plant and Microbial Biology at NC State. She specializes in plant DNA viruses like the ones infecting the cassava plant. Cassava is a tuber grown in Africa that can thrive despite poor soil conditions and drought.

The study will establish a partnership with researchers in East Africa to examine how plant DNA viruses change over time.

"Agriculture is increasingly a global enterprise, and finding solutions to food security problems will depend on research partnerships such as this one that explore the basic science of how plant DNA viruses evolve and what limits their ability to adapt over time," Hanley-Bowdoin said. "Such fundamental knowledge can be used to develop rational, durable strategies to control these important plant pathogens."

Hanley-Bowdoin is joined by co-principal investigator George Kennedy, William Neal Reynolds Distinguished Professor of Entomology at NC State, and co-principal investigator Siobain Duffy, an assistant professor at Rutgers University.

NC State faculty members, including plant pathologist Ignacio Carbone, biochemist Jose Ascencio-Ibanez and education professor Timothy Goodale, will participate in the study, with researchers from Auburn University, NC A&T State University, Biosciences Eastern and Central Africa — International Livestock Research Institute Hub in Nairobi, Kenya, and Mikocheni Agricultural Research Institute in Tanzania.

WHITE HOUSE ADDS BEHAVIORAL SCIENCE FOCUS

When President Obama signed an executive order directing federal agencies to use behavioral science insights to better serve the American people, NC State psychology professor Lori Foster was proudly standing by. As a member of the White House's Social and Behavioral Sciences Team (SBST), Foster contributed to work that formed the basis for the order.

As an expert in industrial and organizational psychology, Foster studies how organizations and their employees function. She's worked with large organizations for more than 15 years, from the military and the United Nations to power utilities and international nongovernmental organizations.

The White House tapped Foster last year to serve on the newly created SBST to help federal agencies increase the efficiency and efficacy of their programs and policies by harnessing research methods and findings from the social and behavioral sciences.

The small interdisciplinary team of experts has been working with federal agencies over the last year, thinking creatively about how to translate social and behavioral science

• THIS PAGE ABOVE: *William Ditto is an expert in nonlinear dynamics and chaotic systems.* • BOTTOM: *Lori Foster was part of a White House panel.* • OPPOSITE PAGE ABOVE: *James Tuck, Joel Ducoste, Terri Long, and Cranos Williams pause in a phytotron greenhouse.* • BOTTOM: *Cassava is a tuber grown in Africa that can thrive despite poor soil conditions and drought.*

insights into concrete interventions that are likely to help agencies reach their institutional goals, and designing rigorous field trials to test the impact of these recommendations.

A recently released report features the team's first year of projects, which have made government programs easier to access and more user friendly, and have boosted program efficiency and integrity.

"As a result of these projects, more service members are saving for retirement, more students are going to college, more veterans are accessing their benefits, more farmers are obtaining credit, and more families are gaining healthcare coverage," said Maya Shankar, senior adviser for the social and behavioral sciences at the White House Office of Science and Technology Policy.

DITTO NAMED DEAN OF COLLEGE OF SCIENCES

William Ditto was named dean of NC State's College of Sciences on Sept. 1. Ditto came to NC State from the University of Hawaii at Manoa, where he was dean of the College of Natural Sciences.

"Dr. Ditto is a highly cited physicist and over the course of his career has been a leader in discovery and innovation," said Warwick Arden, provost of NC State. "We are looking forward to his leadership of the College of Sciences as it continues on a trajectory toward worldwide prominence."

At the University of Hawaii, Ditto led the Applied Chaos Laboratory, which has generated recent discoveries in reconfigurable computing, chaotic computing and astrophysics.

"Bringing order out of complexity has been the guiding principle in both my research and administrative endeavors throughout my career," Ditto said. "I'm excited to bring a spirit of entrepreneurship and innovation to a university that embraces — and celebrates — its think-and-do spirit to provide a world-class education for its students and life-changing research and service for its stakeholders."

Ditto has authored or co-authored 190 refereed publications and more than 20 patents in his field, and he has made more than 70 invited presentations at workshops and conferences in the United States and around the globe.

In recognition of his research achievements, Ditto has been elected a fellow of the American Physical Society and the American Institute for Medical and Biological Engineering, among numerous other awards.

PUSHING PLAY FOR EDUCATIONAL GAMES

Are computer games for learning or just for fun? That's the question Hiller Spires, NC State professor of literacy and technology, tackles in a commentary for the Journal of Adolescent and Adult Literacy.

While we may not think of them as texts, computer games use multiple modes of communication — writing, speech, sound, music, and still and moving images, Spires says. Game players may be motivated to read while playing, which helps build literacy.

"In order to become a good reader, you have to read," adds Spires, senior research fellow at NC State's Friday Institute. But interest in reading can flag in middle school, at least when it comes to traditional books.

However, Spires notes, a 2011 study found that teen boys could read above their grade level while playing a game, but scored about two years below grade level on standardized reading tests.

To learn more about games and literacy, Spires collaborates with computer science professor James Lester on the Crystal Island project, game-based research at NC State funded by the National Science Foundation. Researchers in computer science, literacy, science and design have created games for fifth- and eighth-grade students, incorporating science content from state standards for each grade level.

"In Crystal Island, students read, write and think in the role of a scientist," Spires says. "There's a feeling of connecting with the information, an understanding of how that information is helping them succeed in the game."

When it works, the role-playing helps participants become immersed

continued

in the game. Results so far show that playing Crystal Island increases students' knowledge of science content.

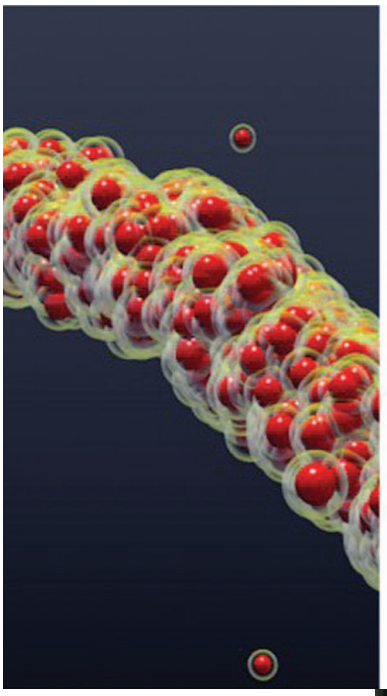
NSF-FUNDED NETWORK BOOST NANO INNOVATION

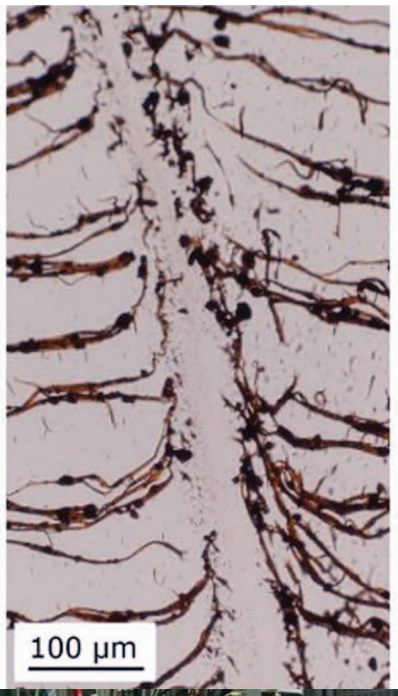
NC State, Duke University and UNC-Chapel Hill are launching a partnership to give businesses and educators access to expertise and facilities that will speed the development of new nanotechnology-based products and educational opportunities. The partnership, called the Research Triangle Nanotechnology Network (RTNN), is led by NC State and is supported by a five-year, $5.5 million grant from the National Science Foundation.

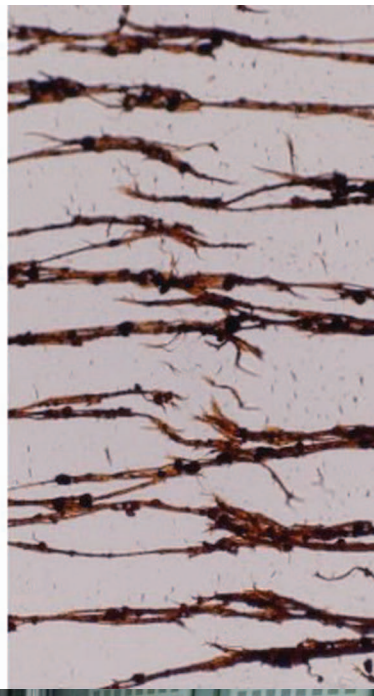
"The grant will fund efforts to open our doors and work more effectively with the public, from major corporations and start-ups to community colleges and K-12 educators," says Jacob Jones, a professor of materials science and engineering at NC State and principal investigator of the grant.

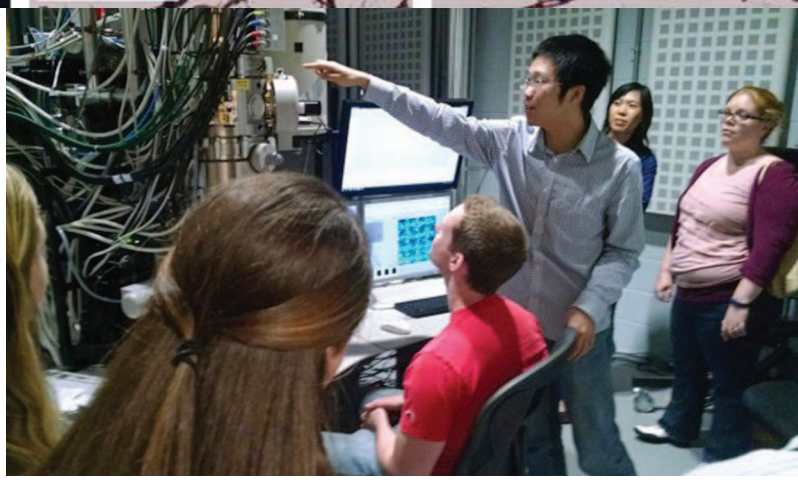
The bulk of the funding will be used to hire staff to reach out to potential industry and educational partners to identify ways that RTNN can address their needs.

"For businesses, our goal is to help them develop new products, improve existing ones and move discoveries to market," Jones says. "For educators, we want to introduce them to nanotechnology and give them resources they can use in the classroom." The RTNN will also make laboratories and entrepreneurs better at what they do. David Berube, a professor of communication at NC State and lead of the social science component of the grant says, "We hope that this will allow us to develop best practices that can be used to ensure that future partnerships for innovation will be successful."









• THIS PAGE ABOVE: *NC State researchers developed a technique to assemble nanoparticles into filaments (left) in liquid. The filaments can be broken (middle) and then re-assembled (right).* • BOTTOM: *Students and researchers collaborate at NC State's Analytical Instrumentation Facility.* • OPPOSITE PAGE ABOVE: *This illustration shows protein MutS inspecting newly replicated DNA for errors.*

SANDCASTLES INSPIRE NANOPARTICLE BINDING

If you want to form very flexible chains of nanoparticles in liquid in order to build tiny robots with flexible joints or make magnetically self-healing gels, you need to revert to childhood and think about sandcastles.

In a paper published in Nature Materials, researchers from NC State and UNC-Chapel Hill showed that magnetic nanoparticles encased in oily liquid shells can bind together in water, much like sand particles mixed with the right amount of water can form sandcastles.

"Because oil and water don't mix, the oil wets the particles and creates capillary bridges between them so that the particles stick together on contact," said Orlin Velev, INVISTA Professor of Chemical and Biomolecular Engineering at NC State and the corresponding author of the paper.

"We then add a magnetic field to arrange the nanoparticle chains and provide directionality," said Bhuvnesh Bharti, research assistant professor of chemical and biomolecular engineering at NC State and first author of the paper.

Chilling the oil is like drying the sandcastle. Reducing the temperature from 45 degrees Celsius to 15 degrees Celsius freezes the oil and makes the bridges fragile, leading to breaking and fragmentation of the nanoparticle chains. Yet the broken nanoparticles chains will re-form if the temperature is raised, the oil liquefies and an external magnetic field is applied to the particles.

"In other words, this material is temperature responsive, and these soft and flexible structures can be pulled apart and rearranged," Velev said. "And there are no other chemicals necessary."

DNA 'PROOFREADER' PROTEINS EDIT READING MATERIAL

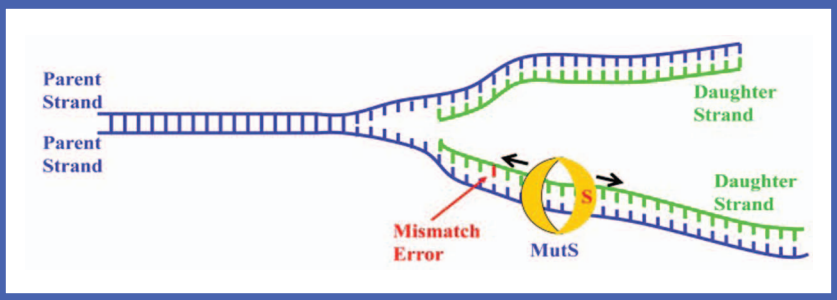
NC State researchers have discovered how two important proofreader proteins know where to look for errors during DNA replication and how they work together to signal

the body's repair mechanism.

When a cell prepares to divide, the DNA splits first, the double helix "unzipping" into two separate backbones. New nucleotides — adenine, cytosine, guanine or thymine — are filled into the gaps on the other side of the backbone, pairing with their counterparts (adenine with thymine and cytosine with guanine) and replicating the DNA to make a copy for both the old and the new cells. The nucleotides are a correct match most of the time, but occasionally — about one time in a million — there is a mismatch.

Fortunately, our bodies have a system for detecting and repairing these mismatches: a pair of proteins known as MutS and MutL. MutS slides along the newly created side of the DNA strand after it's replicated, proofreading it. When it finds a mismatch, it locks into place at the site of the error and recruits MutL to come and join it. MutL puts a nick in the newly synthesized DNA strand to mark it as defective and signals a different protein to gobble up the portion of the DNA containing the error. Then the nucleotide matching starts over, filling the gap again. The entire process reduces replication errors around a thousandfold, serving as our body's best defense against genetic mutations and the problems that can arise from them, like cancer.

"Every living thing uses this process for DNA replication and repair, and we know what the components are, but there are some key mechanisms that aren't well understood," says Keith Weninger, professor of physics at NC State and co-author of a paper describing the research. "For example, when the DNA is repaired, it only happens on the new portion of the DNA strand, and not the older template. And the proteins know which way to move along the strand in order to get rid of the defective portion. There's communication happening here, but disagreement about how it works."



Weninger, along with co-author Dorothy Erie from UNC-Chapel Hill, set out to determine how the proteins know where to find the defective DNA. Using single molecule fluorescence methods, which allowed the researchers to watch one protein moving on one piece of DNA at a time, they determined that when MutS finds an error, it changes shape in a way that allows MutL to bind with it, holding it in place at the site of the mismatch. MutL then changes its shape to "grab" another MutL, and so on, coating the defective part of the strand and nicking the area that needs repair.

"This system is essential to keeping the genome stable," Weninger says.

STUDY SHOWS LINKS: VIOLENCE, ALIENATION

New NC State research shows that the young black men and teens who are most likely to be victims or perpetrators of violence also feel that they have the least power to effect social change.

"We wanted to address stereotypes associating young black men with violence," says Elan Hope, an NC State psychologist and co-author of a paper on the work. "We wanted to explore both the extent to which black men are victims or perpetrators of violence and which factors are related to this behavior."

Using nationally representative survey data on 287 black males aged 15 to 25, the researchers divided survey respondents into four groups by exposure to violence.

The group with the most exposure to violence (12.9 percent of the sample) reported carrying weapons and threatening people with them weekly, fighting almost weekly, and being injured several times in the last year.

This group of participants also felt the most disenfranchised: They had experienced the most racial discrimination, were most aware of institutional discrimination, had the most experiences with the criminal justice system as both victims and suspects, and were the most cynical about politics.

"These are people who feel they do not have an equal opportunity in everything from education to the justice system, and they don't feel they have any power to change the status quo," says Hope. "This highlights the need to include young black men in policy development in a very real way."

$6.7M USDA GRANT WILL FIGHT FRUIT PEST

NC State has won a $6.7 million grant from the U.S. Department of Agriculture to undertake research and grower education efforts aimed at better managing a major new pest that causes hundreds of millions of dollars in annual agricultural losses.

NC State scientists will join with researchers and extension specialists from across the nation to conduct on-farm tests aimed at finding new ways of effectively dealing with spotted wing drosophila, a tiny fruit fly that's been causing big problems since it was first detected in North America in 2008.

They'll also develop tactics and tools for predicting risks from the pest, along with educational materials to help growers make the most economically and environmentally sound management decisions.

Guiding the initiative is Hannah Burrack, an associate professor of entomology. Others from NC State who are participating in the project are Max Scott of the Department of Entomology, Zack Brown of the Department of Agricultural and Resource Economics, Rhonda Conlon of Extension Information Technology and Jean-Jacques Debois of the Southern Integrated Pest Management Center.

Burrack wants to help growers reduce their reliance on insecticides for managing spotted wing drosophila.

"Our biggest goal is to have things return to a management program that is sustainable both economically and environmentally for our growers, where all the tools effective against spotted wing drosophila are being utilized, and pesticide use occurs only when absolutely necessary," she says.

KUDOS

CELEBRATING INNOVATION AND ENTREPRENEURSHIP

NC State's history of contributing to the state and national economies includes sending more than 500 products to market and launching more than 100 startups. That tradition continued in fiscal year 2015: In addition to executing 139 commercialization agreements during the year, the Office of Technology Transfer (OTT) created 12 startups and generated $7.6 million in revenue — both of which were all-time highs.

In November, OTT hosted its 26th annual Celebration of Innovation and Entrepreneurship to recognize outstanding NC State faculty innovators. The awardees included:

Innovators of the Year

- Sylvia Blankenship is an inventor of one of the most successful technologies ever developed at NC State. Along with co-inventor Edward Sisler, Blankenship discovered, developed and commercialized 1-methylcyclopropene, a material that blocks the activity of the naturally occurring plant hormone ethylene.

This technology extends the storage life of fruit and floral products and is used in dozens of countries around the world, leading to revolutionary changes in the way apples and other products are handled in the postharvest environment. Blankenship, a professor of horticultural science at NC State, has worked on postharvest problems in a number of crops including apples, peaches, pears, tomatoes, peppers, sweet potatoes, bananas and flowers.

Now associate dean for administration in the College of Agriculture and Life Sciences, Blankenship received her bachelor's and master's degrees from Texas A&M University in 1977 and 1979, respectively. She received her doctoral degree from Oregon State University in 1983, specializing in postharvest physiology. She joined the faculty at NC State in 1983.

• ABOVE: *Sylvia Blankenship*

- Todd R. Klaenhammer is a visionary in the area of food microbiology and biotechnology. Klaenhammer and his research team have a distinguished portfolio of intellectual property that has resulted in 36 issued patents and 22 licenses and executed options.

In 2009, the University of North Carolina Board of Governors awarded Klaenhammer's group the prestigious O. Max Gardner award for outstanding research contributing to the welfare of the human race. His group has published more than 280 articles on lactic acid bacteria and their bacteriophages, and on probiotic cultures and their genomic traits.

A William Neal Reynolds Professor of food, bioprocessing and nutrition sciences, he was elected to the U.S. National Academy of Sciences in 2001. He is a fellow in the American Association for the Advancement of Science, the American Academy of Microbiology, the Institute of Food Technologists and the American Dairy Science Association. He earned a bachelor's degree in microbiology, and master's and doctoral degrees in food science, from the University of Minnesota. He joined NC State in 1978.

• ABOVE: *Todd Klaenhammer*

Dr. John S. Risley Entrepreneur of the Year

- Lewis Sheats has an extensive background in new venture planning, concept consulting, logistics, opportunity identification and analysis, manufacturing organization, marketing and strategic planning. As a serial entrepreneur, he focused on opportunity identification, execution and education.

Sheats has leveraged his experience to develop and lead an undergraduate entrepreneurship curriculum in the Poole College of Management based on experiential learning and individual student development.

He also is the driving force and visionary behind the NC State Entrepreneurship Clinic, located at HQ Raleigh. Launched in January 2015, the E-Clinic enables NC State students to connect with startup companies to build the next generation of businesses in Raleigh. E-Clinic students already have logged more than 2,400 hours on projects for more than 60 local entrepreneurial ventures.

• ABOVE: *Lewis Sheats*

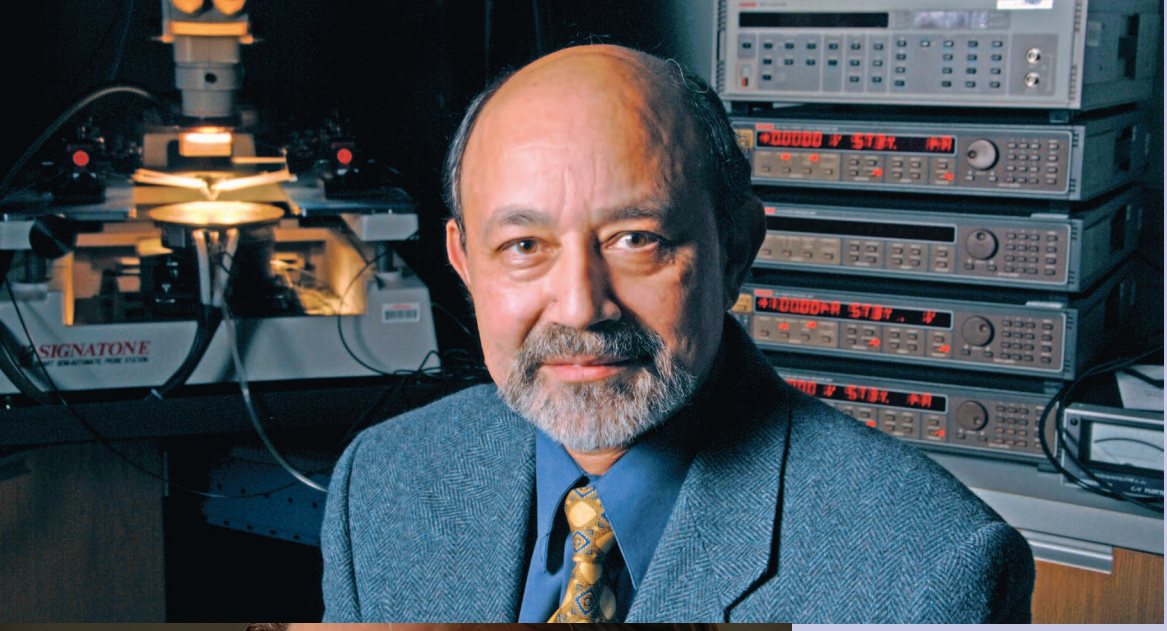
A member of Beta Gamma Sigma, an international honor society, Sheats has a bachelor's degree in finance from NC State and an MBA from the Lundy-Fetterman School of Business at Campbell University.

ELFENBEIN RECEIVES NIH AWARD

Johanna Elfenbein, an equine internal medicine specialist and assistant professor of equine medicine, was awarded first place in the Young Investigator Award competition at the 2015 Merial NIH Veterinary Scholars Symposium.

The competition, sponsored by the American Veterinary Medical Association and its charitable foundation, recognizes the scientific advancements made by veterinarians who are pursuing advanced research training through doctoral or postdoctoral programs. Elfenbein presented her work in a talk titled "Multicopy Single-Stranded DNA Directs Intestinal Colonization of Enteric Pathogens."

Elfenbein was selected as one of five finalists from 47 national and international submissions. Her work was honored for its innovation, experimental design, potential impact of results and outcomes, and



• TOP: *B. Jayant Baliga will be honored for his invention of the insulated-gate bipolar transistor.* • BOTTOM: *Robert Handfield is a Bank of America Distinguished Professor.*

relevance to comparative biomedicine.

For four of the past five years, this award has been given to an NC State researcher.

GORE LAUDED AS MENTOR, TEACHER

The Ethnic Minority Society of the National Recreation and Park Association selected Kathy Hamilton Gore of NC State's College of Natural Resources as the recipient of the 2015 Ernest T. Attwell Award, for contributions "to the development of new professionals through teaching, mentoring and programming for over 10 years and professional service activities for more than 20 years at the local, state and national levels."

Gore has been a member of the Department of Parks, Recreation and Tourism Management at NC State for more than 22 years, where she has taught courses on diversity, finance, administration, programming and management. Gore has earned numerous awards and has been a member of NC State's Academy of Outstanding Professors since 2002.

HANDFIELD HONORED FOR RESEARCH EXCELLENCE

A paper co-authored by Robert Handfield, Bank of America Distinguished Professor of Supply Chain Management in Poole College's Department of Business Management, was awarded the 2015 Emerald Literati Network Award for Excellence.

Winners are selected annually by Emerald Group Publishing's journal and book series editorial boards. Entrants are judged based on their research excellence, rigor and relevance. The awards recognize novel, interdisciplinary research that makes a difference within its academic field and is used more broadly by practitioners, policy makers and more.

"This is a great honor for me to be recognized, and it reflects the fact that research can be both relevant to practitioners and rigorous at the same time," Handfield said.

BALIGA TO JOIN NATIONAL INVENTORS HALL OF FAME

B. Jayant Baliga, Distinguished University Professor of Electrical Engineering at NC State, will be inducted into the National Inventors Hall of Fame in May 2016. He will be honored for his invention of the Insulated-Gate Bipolar Transistor, or IGBT – a power semiconductor device used as an electronic switch around the world in all sectors of the economy, ranging from transportation to consumer appliances to factory robots and medical devices in hospitals.

The improved efficiency gained by using the IGBT in a wide range of applications has resulted in saving more than 1.5 trillion gallons of gasoline and reducing electrical energy consumption by more than 75,000 terra-watt-hours (equivalent to not having to build 1,366 one-gigawatt coal-fired power plants). Since its invention, the IGBT has saved consumers $24 trillion while reducing carbon dioxide emission by more than 100 trillion pounds.

The National Inventors Hall of Fame was launched in 1973 to inspire the next generation of inventors by celebrating the achievements of visionary U.S. patent holders who, through their innovations, have changed the world. The 516 previous inductees include Thomas Edison and Nikola Tesla.

His past honors include: the 2015 Global Energy Prize, the 2014 IEEE Medal of Honor, the 2012 North Carolina Award for Science, the 2011 National Medal of Technology and Innovation from President Obama, the 1999 IEEE Lamme Medal, the 1998 O. Max Gardner Award, and the 1992 Pride of India Award.

A member of the National Academy of Engineering, he is an IEEE Life Fellow. He has been issued 120 U.S. patents, many of them commercialized via his four successful start-up companies in North Carolina.

POOLE PAIR EARNS GOLD LYBAND MEDAL

Two professors in the NC State Poole College of Management received the Institute of Management Accountants' 2015 Lybrand Gold Medal for their article on enterprise risk management and sustainability.

Recognized were Mark Beasley, Deloitte Professor of Enterprise Risk Management and director of the ERM Initiative at Poole College, and Scott Showalter, chair of the college's Sustainability Initiative leadership team.

Their article, "ERM and Sustainability: Together on the Road Ahead," was published in a March issue of IMA's Strategic Finance magazine. It was the highest-ranking manuscript in the Lybrand Competition, which included all manuscripts published during 2015 in the IMA's Strategic Finance and Management Accounting Quarterly journals, both of

continued

• RIGHT: *Juntos is an NC State program to empower Hispanic youth to succeed in high school.*

which are rated within the top five practitioner journals in their field.

Beasley and Showalter discussed benefits of integrating an organization's sustainability and ERM efforts into a single, coordinated process linked directly to the company's core strategies. They also provide a strategic process for doing so, along with examples of companies that have taken this approach.

6 FACULTY SELECTED AS FULBRIGHTS SCHOLARS

Several NC State faculty members have been selected to take part in the Fulbright scholars program in 2015-16.

A program of the United States Department of State's Bureau of Educational and Cultural Affairs, Fulbright scholars are awarded the opportunity to increase mutual understanding and support friendly and peaceful relationships between the United States and other countries.

NC State faculty members and their Fulbright country assignments and topics are:

- **Darrell Britt**, Israel, mathematics/numerical methods;
- **Michael Bustle**, Japan, international education;
- **Robert Kochersberger**, Slovak Republic, journalism
- **Lucian Lucia**, Brazil, polymer chemistry;
- **Patricia Marshall**, Ecuador, multicultural education; and
- **Michelle Schroeder-Moreno**, Croatia, agriculture.

KHATER EARNS STUDENT HISTORY HONOR

Micah Khater, who graduated in May from NC State with a bachelor's degree in history, won the 2015 Hugh T. Lefler Award from the North Carolina Literary and Historical Association for the best undergraduate history paper. "There Will Be Political Dirty Work: Gendered Expressions of Black Resistance in United States v. John Cashion (1936)," is Khater's senior honors thesis.

The paper documents how the white registrar of Wilkes County unlawfully denied about a dozen African-Americans the right to vote in 1934. Three of the disenfranchised citizens sued the registrar in federal court, and in a landmark decision, the judge ruled in the plaintiffs' favor.

"I became really interested in Southern history, particularly African-American history, after taking a class in Southern history my freshman year," Khater says. "I began to see that I really didn't understand the context of the society I had spent my whole life in. I grew up in North Carolina, but I didn't really understand where I lived."

Khater's thesis adviser, history professor Katherine Mellen Charron, praises the breadth and depth of her student's work.

"Her writing is clear, it's erudite and it makes a convincing argument about the importance of protecting black voting rights," she says.

WHITE HOUSE LAUDS 'JUNTOS' PROGRAM

A presidential initiative recently named an NC State program to empower Hispanic youth as a Bright Spot in Hispanic Education.

The White House Initiative on Educational Excellence for Hispanics, designed to address disparities faced by the Hispanic community in the United States, selected Juntos as one of the signature programs, models, organizations and initiatives helping to close the achievement gap.

Pronounced "hoon-tose," the word means "together" in Spanish. Fittingly, the program unites community partners, parents and schools in helping Latino youth, many of whom are struggling in school. The youth are encouraged to achieve high school success, graduate on time and pursue college education.

Developed in 2007 by the North Carolina Cooperative Extension, Juntos has since expanded to Iowa, Oklahoma, and Oregon. A $2 million grant awarded earlier this year by the National 4-H Council will launch the program in locations including New York City and San Antonio, Texas.

An online catalog listing the honored programs calls Juntos "an invaluable asset to the North Carolina Latino communities."

Juntos serves more than 600 Latino youth and parents across numerous N.C. counties. Andrew Behnke, Cintia Aguilar, Diana Urieta and Juana Hernandez, of NC State's Department of Youth, Family and Community Sciences, lead the program.

NC STATE COMPLETES HEALTH INITIATIVE

NC State, an inaugural partner in the national Healthier Campus Initiative, is the first to complete its commitment.

The initiative works with the private sector and the nonprofit Partnership for a Healthier America, a non-partisan effort supported by some of the nation's most respected health and childhood obesity advocates, including First Lady Michelle Obama. NC State was one of 38 colleges and universities selected for a three-year commitment to adopt guidelines around nutrition, physical activity and programming.

Building on existing efforts, NC State was the first to implement all 23 guidelines in the first year of its commitment. "Our commitment to providing a healthier campus and the strengths of our campus wide partnerships are reflected in this significant achievement," NC State Chancellor Randy Woodson notes.

Each of the 23 guidelines has been verified. NC State's accomplishments include:

- Offering a Dietitian's Dish wellness meal daily at breakfast, lunch and dinner.
- Designating healthier food and beverage options in vending machines, C-stores and dining facilities using the Wolf-Approved healthy icon program.
- Ensuring that free water is available at all dining, recreational and educational facilities.
- Providing more than 150 group fitness classes each week in addition to more than 25 intramural activities each year.
- Opening a Functional Training area on campus.
- Combatting food insecurity on campus and throughout the community via the Feed the Pack Pantry.

NC STATE UNIVERSITY

FY15 KEY ACCOMPLISHMENTS
Research, Innovation and Economic Development

• ABOVE: Sprouting a Sustainable Solution *Folks on NC State's Centennial Campus now may get a smile and a quick charge, courtesy of an effort led by the Park Scholars Class of 2015. The 16-foot-tall structure — including a 1,500-watt solar array — increases understanding of clean energy while providing a space to charge laptops, phones or other electronics.*

Fiscal year 2015 marked a change in leadership for NC State University's Office of Research, Innovation and Economic Development. Alan Rebar, former senior associate vice president for research at Purdue University, took over as NC State's new vice chancellor in fall 2015. His multiple titles at Purdue also included executive director of Discovery Park and professor of clinical pathology.

Another highlight was recognition of Centennial Campus as one of the nation's most innovative and productive economic engines. In November 2014 the Association of Public and Land-Grant Universities selected NC State as one of four winners of the second annual Innovation and Economic Prosperity University awards. NC State won in the "Place" category, 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.

RESEARCH MATTERS

Sponsored research represents more than 20 percent of NC State's annual income. Awards for all sponsored programs totaled $308 million for the year. More than 2,500 proposals seeking nearly $1 billion in research funding were submitted.

The latest National Science Foundation Higher Education Research and Development Survey, released in November 2015, indicates that NC State continues to increase research expenditures, consistently ranking in the 90th percentile nationwide. In the last decade NC State's research expenditures have increased more than 23 percent, placing the university seventh among land-grant institutions without a medical school.

Industry actively seeks out our expertise. We rank No. 2 among land-grant universities without a medical school in business-sponsored research. In FY15, industry sponsored more than 1,000 research projects for almost $40 million, making up 13 percent of the university's research awards.

FACULTY ACCOLADES

Joseph DeSimone, William R. Kenan Jr. Distinguished Professor of chemical and biomolecular engineering at NC State and Chancellor's Eminent Professor of Chemistry at the University of North Carolina at Chapel Hill, was elected to the Institute of Medicine, one of the highest honors in the fields of health and medicine a U.S. scientist can receive. It was the third time he has been named a member of a 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 National Academies.

B. Jayant Baliga, Distinguished University Professor of electrical and computer engineering and director of NC State's Power Semiconductor Research Center, received a 2015 Global Energy Prize.

Five NC State faculty members were elected as fellows of the American Association for the Advancement of Science: Nancy L. Allbritton, chair of biomedical engineering; David C. Dorman, toxicology; Justin Schwartz, head of materials science and engineering; Bruce A. Sherwood, physics; and Mohammed A. Zikry, mechanical and aerospace engineering.

Faculty members selected for the National Science Foundation Faculty Early Career Development Program in FY15 were: Xipeng Shen, computer science; James LeBeau, materials science and engineering; Daryoosh Vashaee, electrical and computer engineering; Chase Beisel, chemical and biomolecular engineering; Kristy Boyer, computer science; Rosangela Sozzani, plant and microbial biology; and Ana-Maria Staicu, statistics. In addition, Joshua Pierce, chemistry, received the award starting in FY16.

Jay Narayan, John C.C. Fan Family Distinguished Chair Professor of materials science and engineering, received the 2014 North Carolina Award for science.

Behnam Pourdeyhimi won the 2015 O. Max Gardner Award from the University of North Carolina Board of Governors for his contributions to health and human safety. He is director of the Nonwovens Institute and associate dean for industry research and extension in the College of Textiles.

Learn more about NC State's faculty honors at: go.ncsu.edu/facultyawards.

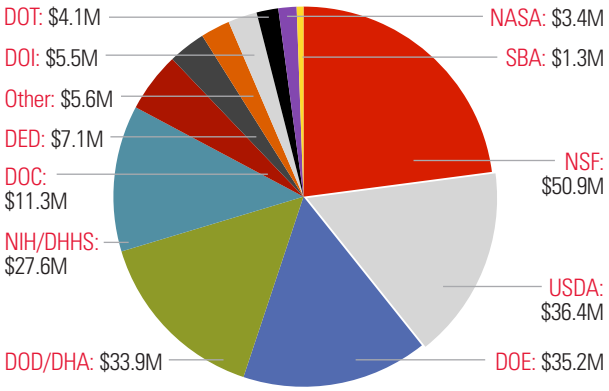
INNOVATION EXPLOSION

In FY15, NC State's Office of Technology Transfer launched a record-breaking 12 startup companies and brought in $7.6M in revenue. (See list of companies on next page.)

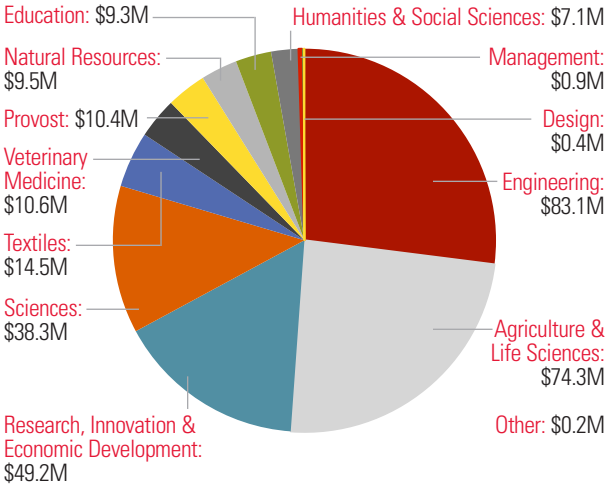
The new PackStart Program is now open to all newly created NC State startup companies. The program provides services including business-plan development support, strategic guidance, logo and website development, connections to strategic partners and funding opportunities, grant-writing support and coaching for pitch presentations.

To improve the process of bringing products to market, NC State's new Venture Innovation Partner Program matches entrepreneurial and investment communities, entrepreneurial talent and investors with the university's startup companies. Launched as a pilot in FY15 to a select group of leaders from the region, the portal is yet another step toward NC State's goals to become completely transparent about startup opportunities while also generating excitement and recruiting talent and investors early.

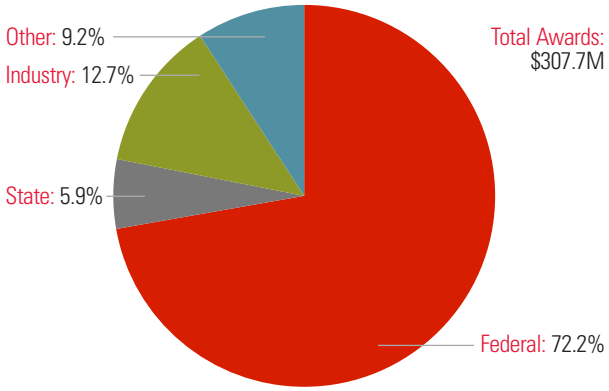
AWARDS BY FEDERAL AGENCIES, FY15



AWARDS BY NC STATE UNIT, FY15



AWARDS BY SOURCE, FY15



NC STATE STARTUPS, FY15

NC State had a record-breaking 12 startups — with five led by female entrepreneurs.

- Highly Tuned LLC
- Intelligent Campus Solutions Inc.
- International Technology Systems Transfer LLC
- Lumeova Inc.
- MAA Laboratories Inc.
- Nine Oak Media LLC
- People-First Tourism Inc.
- Permafuels Inc.
- Precision Diagnostics Inc.
- Sentinel Biomedical Inc.
- TextileScents Inc.
- Thermo-flex Technologies Inc.

TECHNOLOGY TRANSFER AND INNOVATION IMPACTS

	FY2015	FY2011-15 TOTAL
Invention Disclosures	291	1,226
Patents Issued	44	434
New Patents Filed	181	797
Commercialization Agreements	139	544
Startups	12	40
Licensing Revenue	$7.6M	$33.5M

CENTENNIAL COLLABORATIONS AND CELEBRATIONS

Amid the celebration of its 30th anniversary, NC State's Centennial Campus Partnership Office was a key partner in making PowerAmerica operational. A public-private partnership, PowerAmerica is the centerpiece of a $146 million grant from the U.S. Department of Energy, the largest grant NC State has received to date.

Fifteen new partners opened offices on Centennial Campus, including Undercover Colors and Audacity Factory. Also, nine partners graduated, moving elsewhere to create jobs in the region. This brings the current number of partners to 70.

The Richard L. and Marlene V. Daugherty Centennial Campus Endowment for Entrepreneurship awarded $3,500 each to promising new university spinoffs to assist with startup costs. The companies' technologies include "smart" bandages, Web-based tourism marketing, educational mobile apps for husbandry, extraction of impurities from combustion products, aromatherapy garments, improving wireless charging times, new imaging approaches for targeting cancer tumors, an app to improve collegiate student outcomes, Web-based office ergonomics data management and a nontoxic insect repellent.

CREATIVE STATE

• ABOVE LEFT: *People-First Tourism is the first tech-based, social-venture from NC State.* • RIGHT TOP: *A young girl holds a bunny at Crystal Willett's farm in Chatham County, N.C.* • RIGHT BOTTOM: *Wally Butler explaining the secrets behind his award-winning Chambourcin wine in Chatham County.* • BELOW: *Tim Stinson demonstrates BigDIVA's functional interface in the visualization lab at Hunt Library on NC State's campus.*

STARTUP FOCUSES ON LOCAL TOURISM

A multidisciplinary team from NC State created an online marketplace for those who seek genuine experiences with locals eager to share their communities. People-First Tourism also provides micro-entrepreneurial opportunities for small business owners to tap into varied tourist markets.

The university's Office of Technology Transfer cites it as the first tech-based, social-venture from NC State.

The company describes its mission to leverage technology innovation and the economic force of tourism to inspire a world where people develop deep connections with their hosts, experience genuine local cultures, and improve the lives of people they visit.

Travelers can visit www.peoplefirsttourism.com to explore opportunities such as a farm visit in a rustic corner of North Carolina, a cooking lesson with indigenous women in a Costa Rican village, or a fishing tour on the Outer Banks.

The founders — Duarte Morais and Gene Brothers, of the College of Natural Resources, John Bass of Institute for Next Generation IT Systems and Tim Wallace of the College of Humanities and Social Sciences — have set up a fund at NC State where individual royalties would go toward student scholarships and research on ways tourism can benefit people at the grassroots.

Located at 310 S. Harrington St., Raleigh, People-First Tourism celebrated its launch in October.

BIGDIVA IMPROVES SEARCHES

Digital humanities scholars from NC State University and Texas A&M University recently launched a powerful new system to help researchers more quickly and accurately sift through hundreds of thousands of archives and articles related to materials dating from 450 A.D. to the 20th century.

"Our goal in developing BigDIVA was to create a tool to help us explore our cultural heritage and facilitate scholarship in fields ranging from literature and religion to art and world history," says Tim Stinson, an associate professor of English at NC State and one of the project's creators.

BigDIVA, which stands for Big Data Infrastructure Visualization Application, offers a visual interface for navigating scholarly, peer-reviewed

humanities content, such as historical documents, images of art and artifacts, and any scholarship associated with those things.

The system displays results in an infographic format that is organized by category, such as journal articles or online digital collections. And color coding distinguishes those items you have immediate access to from items that a user doesn't have permission or a subscription to access.

Because BigDIVA's content is curated, search results aren't cluttered with irrelevant items. "Our plan is to market BigDIVA as a subscription-based service to libraries and the higher education community," Stinson says.

Based on an idea by Texas A&M's Laura Mandell, Stinson developed a proof-of-concept prototype with postdoctoral researcher Matt Davis and Markus Wust, a digital research and scholarship librarian at NC State. Mandell's team at Texas A&M then rebuilt BigDIVA from the ground up to make it more user friendly.

The collaborators began testing the beta version of BigDIVA with target audiences earlier this year. Currently, BigDIVA's strengths are topics from the medieval period and the 18th and 19th centuries — reflecting the research interests of Stinson and Mandell.

The team now is working closely with scholars of the Renaissance and the 20th century periods. BigDIVA was formally unveiled at the Hunt Library on NC State's Centennial Campus.

results.

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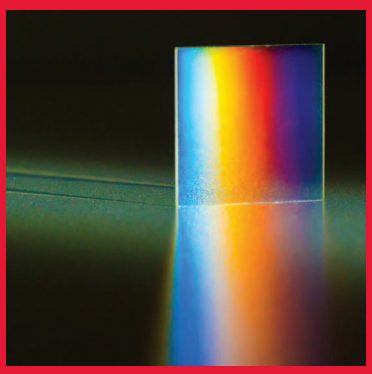

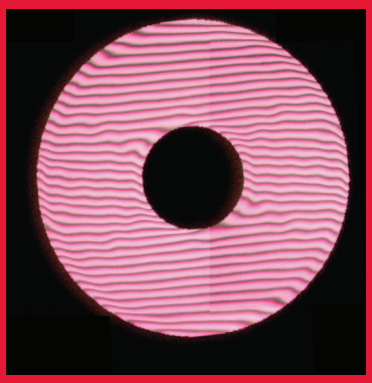

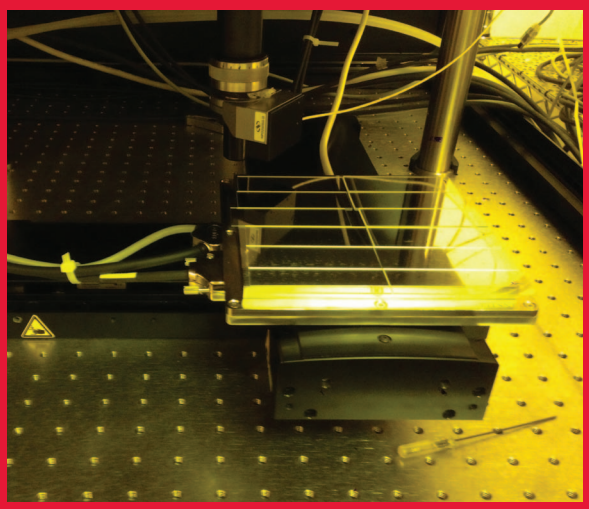

• ABOVE: *The DWLS has a moveable X-Y translation platform, on which substrates are placed.* • TOP LEFT: *A polarization grating patterned using the direct-write laser scanner.* • BOTTOM LEFT: *This composite image shows a geometric phase hologram called a vector apodizing phase plate (vAPP).*

4-D Lasers Offer New Tools

By Matt Shipman

IN 2010, MICHAEL ESCUTI RECEIVED FUNDING FROM THE NATIONAL SCIENCE FOUNDATION TO STUDY AND MAKE NOVEL HOLOGRAM TECHNOLOGIES.

He ended up creating a tool that opened the door to new ways to manipulate light — a tool with applications for everything from studying new worlds to making your cell phone more energy efficient.

"We were able to create something called a direct-write laser scanner (DWLS), which allows us to create nearly perfect geometric phase holograms," Escuti says. "They look like flat, semi-translucent plates, but they give us unprecedented control over the behavior of light. We can use them to make more efficient displays for mobile devices, sensors with greater resolution, and, we're still discovering potential applications for this technology."

One high-profile application of the DWLS was the visually impressive "Rainbow Station," an art installation conceived by Daan Roosegaarde for the International Year of Light.

Escuti is continuing to work on new applications with direct support from NSF and many others. But he also has taken steps to commercialize the technology. For example, Escuti's university startup company, ImagineOptix Corporation, has created technologies ranging from an ultra-efficient pocket projector to components for hardware supporting online traffic.

"As an entrepreneur, I'm excited by the range of projects and markets where we can have an impact," Escuti says.

"And as a researcher, I'm deeply satisfied by the capability of the DWLS to help people solve longstanding research challenges."

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