DR. JOHN HARDIN
Executive Director
Office of Science, Technology & Innovation

June 3, 2019

I am delighted to introduce this issue of Research North Carolina, a forum for sharing information from North Carolina institutions and companies about their research programs and achievements.

Research-based innovation is a force multiplier, providing a first-mover advantage in new products and services, expanding exports, and creating expansionary employment effects. It also helps power a virtuous cycle of expanding employment, which in turn leads to increased wages and lower prices, both of which expand domestic economic activity and create jobs.

In the words of Nobel Prize-winning economist Paul Romer (1993), "No amount of savings and investment, no policy of macroeconomic fine-tuning, no set of tax and spending can generate sustained economic growth unless it is accompanied by the countless large and small discoveries that are required to create more value from a fixed set of natural resources." For North Carolina, this means our ability to thrive in the increasingly dynamic, global economy depends, fundamentally, on how much we infuse research and innovation throughout our economic system.

As shown in the North Carolina Board of Science, Technology & Innovation's most recent Tracking Innovation report, one of our state's strongest sources of research and innovation is its universities. North Carolina's academic R&D expenditures relative to the size of its economy now rank the third highest in the nation. And over the last 15 years, North Carolina's academic R&D intensity has been growing at a rate more than three times faster than the U.S. rate overall.

Additionally, North Carolina's high-technology sectors are increasing in employment and have wages nearly twice as high as the U.S. average for all industries. Our high-tech business formation is outpacing the national average by more than 20 percentage points. And our manufacturing output as a function of total GDP ranks among the top five states in the country, performing at more than 150 percent of the U.S. average. These patterns are driving productivity and job gains in high-technology, high-skill industries.

This special section, Research North Carolina, is a great way to learn in more detail about the types of technology based activities that underlie these statistics and are helping to grow our economy in North Carolina. A high-productivity, high-employment, high-income, growing economy must be a high-technology economy driven by research and innovation.

I invite you to read Research North Carolina and to join in these efforts.

Sincerely,

John W. Hardin

North Carolina Department of Commerce | Office of Science, Technology & Innovation
301 North Wilmington Street | 1326 Mail Service Center | Raleigh, NC 27699-4300
919 814 4642 T

RESEARCH NORTH CAROLINA


Building
infrastructure
Empowering
human potential

As the premier, public undergraduate institution in the state of North Carolina, Appalachian State University prepares students to lead purposeful lives as global citizens who understand and engage their responsibilities in creating a sustainable future for all.

- Appalachian's largest and newest facility to date features state-of-the-art classrooms and laboratories, offering unprecendented opportunities for interprofessional collaboration, **preparing health care professionals for a changing and dynamic workforce**.

- A $191 million residence halls project underway will enhance students' living environment, **promoting their academic and personal success**.

- The Innovation Campus will have a **powerful impact on the region's economic development** by expanding and enhancing Appalachian's curriculum to produce a workforce of critical thinkers who are capable of developing economically, environmentally and equitably sound communities.

Appalachian
STATE UNIVERSITY
BOONE, NORTH CAROLINA

appstate.edu

Leon Levine Hall of Health Sciences

New Residence Halls

Innovation Campus

Next Generation Science Standards emphasize student engagement through hands-on activities and problem-solving techniques used by scientists and engineers.

Innovation serving education

Carolina Biological Supply Company's innovative products support students and educators at every level.

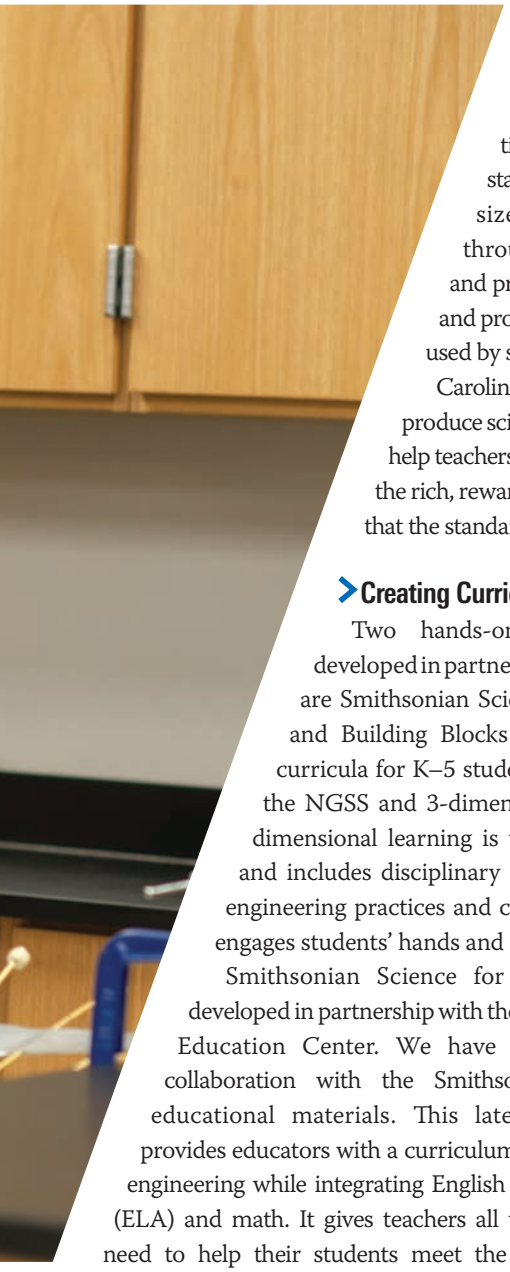
In 1927, Dr. Thomas E. Powell, Jr., a young professor of geology and biology at Elon College – now Elon University – began collecting specimens in the field and selling the surplus to his colleagues. From that unpretentious start, Carolina Biological Supply Company has grown to an enterprise with over 400 employees and sales to customers across the world.

Dr. Powell believed that innovation, quality and service were the key elements to his educational materials supply company's growth and success. Indeed, innovations in kit design and manufacturing, curriculum development and distance education propelled Carolina to the top tier of educational suppliers, serving institutions ranging from elementary schools to research universities.

Rethinking the Basics

Designing and manufacturing science kits are some of the core functions of our company. These kits are essential to teaching science at every level. Bringing innovation to them begins with rethinking how they are used in the classroom and laboratory. Computers and new science education standards are the key drivers in this innovation.

Since computers are nearly ubiquitous in today's classrooms and students are digital natives, many of our kits now include digital resources such as videos, teacher's manuals and interactive lessons that enhance the learning experience. Our website, Carolina.com, provides a wealth of free information on organism care, laboratory techniques, lessons and activities.



The Next Generation Science Standards (NGSS) are the latest national science education standards. These emphasize student engagement through hands-on activities and practicing the investigative and problem-solving techniques used by scientists and engineers.

Carolina has been working to produce science kits and curricula to help teachers and students experience the rich, rewarding learning experience that the standard developers intended.

Creating Curricula

Two hands-on curricula that we developed in partnership and independently are Smithsonian Science for the Classroom and Building Blocks of Science 3D. These curricula for K–5 students specifically address the NGSS and 3-dimensional learning. Three-dimensional learning is the heart of the NGSS and includes disciplinary core ideas, science and engineering practices and crosscutting concepts. It engages students' hands and minds.

Smithsonian Science for the Classroom was developed in partnership with the Smithsonian Science Education Center. We have a long history of collaboration with the Smithsonian in creating educational materials. This latest collaboration provides educators with a curriculum that focuses on engineering while integrating English Language Arts (ELA) and math. It gives teachers all the tools they need to help their students meet the NGSS, and students the tools they need for real, hands-on engineering activities.

Building Blocks of Science 3D was developed in house and enables teachers to give an effective science lesson in as little as 30 minutes a day. Centered on the NGSS and 3-dimensional learning, it is flexible and provides robust teacher support for efficient lesson planning. Each unit includes hands-on materials, digital media and printed resources. The journaling and reading help students develop ELA and math skills.

Going the Distance

Distance learning, or providing online courses to off campus students, is one of the fastest growing segments of higher education. The challenge for institutions has been how to conduct laboratory science courses online. Carolina Distance Learning was created to help institutions meet that challenge by providing kits and materials that enable students to safely and successfully complete a laboratory science class in their own homes.

Each Distance Learning kit we offer has been thoroughly tested in a home setting for safety and reliability and includes the necessary personal protective equipment for the student. Students are guided through the kit activities with easy-to-follow digital manuals containing embedded videos. Feedback from students and faculty on these kits and materials has been positive and encouraging.

These kits bring campus quality courses to students who may have no other way of receiving them. They are also cost effective — customization allows faculty to include in the kit only the activities they specify. Sales have exceeded our forecasts, and we believe the future of distance education, and Carolina Distance Learning, is bright.

Over 90 years ago, Dr. Powell planted the seed for an educational supply company rooted in innovation, quality and service. Today, it is flourishing and eager to face the challenges ahead.

Carolina Distance Learning provides kits and materials that enable students to safely and successfully complete a laboratory science class in their own home.

CAROLINA®

Carolina Biological Supply Company
2700 York Road, Burlington, N.C. 27215
800-334-5551 • carolina.com

East Carolina University is exploring opportunities for the industrial hemp market in agriculture-rich eastern North Carolina.

Exhemplary Innovation

ECU plans for the future of industrial hemp manufacturing.

East Carolina University is planting its roots in North Carolina's emerging hemp industry.

When the U.S. Congress passed the Farm Bill last December, the industrial hemp market experienced a boom as the plant shifted from a crop outlawed across much of the nation to a multiuse, jack-of-all-trades product.

While the industry remains regulated – growers must apply for a license and are held to strict standards for plant THC content – hemp could find a home in agriculture-rich eastern North Carolina.

Innovators and entrepreneurs at ECU are using university resources to explore the hemp industry and its potential future in the region.

"Eastern North Carolina has historic agricultural and textile knowledge that makes growing hemp an exciting and real possibility," Jay Golden, ECU vice chancellor for research, economic development and engagement and a professor of engineering and supply chain management, says. "We have the right climate, soil composition and farming background to turn hemp production into a valuable industrial manufacturing raw material."

However, as with any new industry, the knowledge and infrastructure behind the production of the crop has yet to be built. That's where ECU's students, researchers and community partners come in.

Investigating Hemp's Potential

ECU's research leadership sees hemp as a compelling crop that can create new job opportunities and sustain existing companies in the state. So far the market has been fixated on consumable hemp products, but ECU is looking at a different role for hemp – as a manufactured good that can create jobs and economic value in rural North Carolina.

During spring 2019, ECU put research students to work as part of its Rural Prosperity Initiative to investigate hemp's promise as an agricultural commodity and industrial feedstock.

"There's so much more to learn about hemp," Madeline Fleishman, a student member of ECU's RPI hemp research team, says. "We feel like we're working on the next big, cutting-edge crop to come to agriculture. There are so many everyday products that can incorporate hemp into their production."

What the faculty-supervised student team found were extensive uses for industrial hemp, ranging from cosmetics, fabrics, textiles and construction and insulation materials. It also discovered a growing hemp market in the U.S. The industry was valued at $820 million in 2017 – a 16% increase from the previous year.

Additionally, a rising number of consumers are making purchasing decisions based on product sustainability, according to the 2019 CGS Retail and Sustainability Survey, and are

demanding eco-friendly products and processes.

Hemp Uses

Armed with the knowledge that hemp is part of a growing U.S. market and that consumers are more cognizant of the impact their purchases have on the environment, ECU set to work on a plan for the future of hemp in North Carolina.

Nationally, CBD sales make up 23% of the overall hemp market. However, industrial applications and consumer textiles combine for more than 31% of the overall share, creating golden opportunities for eastern North Carolinians.

These industrial applications include the possibilities of apparel, denim, canvas, rope, paper, packaging, surfboards, paddleboards and construction materials. Hemp packaging may also play a crucial role in helping solve the looming plastics problems around the globe.

Wilmington-based entrepreneur Kyle Trivisonno and his company, ecoTEKindustries, have been early adopters of hemp, using the fiber cloth to create medical prosthetics that could offer a low-cost alternative to traditional carbon fiber products.

"All of us – entrepreneurs, researchers, farmers, creators and distributors – have to come together and empower one another in order to succeed," Trivisonno says. "This is for the community; it's not just for one single person. Moving forward, I'd like to see more innovation spaces available for startups to test their ideas and prototypes. We need the space and high-end manufacturing equipment to build hemp's next great ideas."

Future of Hemp

The possibilities of a bright future are real. Think about this: in 2000, North Carolina produced fewer than 4 million pounds of sweet potatoes. Today, it leads the nation with 1.7 billion pounds grown each year. As the hemp industry in North Carolina takes shape, ECU has dreams of replicating the state's success with sweet potatoes.

To do that, ECU is establishing long-term goals. As part of its Hemp 2040 Plan, the university is committing resources – including its recently launched Economic Growth Collaboratory – to study what the hemp market requires to thrive.

Already the researchers are pinpointing industrial needs, from innovation hubs and maker spaces with advanced manufacturing equipment to stimulating development of dedicated hemp fiber processing facilities.

"There are certainly challenges to face when you're building new agricultural and industrial supply chains," Golden says. "We're sensitive to those concerns, but the benefits we see hemp production providing the state are numerous. The country stands at a turning point in its agricultural history. We believe ECU and eastern North Carolina can lead that change, not merely be a part of it."

Interested in partnering with ECU? Let us know how we can help you.

Keith Wheeler
Executive Director of Industry Initiatives
Email: wheelerch18@ecu.edu
Online: go.ecu.edu/industry

Twine is one of many industrial products that can be created from hemp. Potential industrial products include cosmetics, fabrics, textiles and construction and insulation.

East Carolina University
Division of Research, Economic Development and Engagement
2200 S. Charles Blvd., Suite 1500
Greenville, N.C. 27858
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Fayetteville Technical Community College provides basic construction trades training programs for United States Army Special Operations Command Engineers

Schooling soldiers

Fayetteville Technical Community College offers a new construction trades course for local soldiers.

North Carolina's soldiers now have an opportunity to learn basic construction trades through Fayetteville Technical Community College.

The 252-hour pilot course provided the 249th Engineers Battalion of Fort Bragg with lectures and lab exercises in the technical aspects of building construction, material selection, welding, basic electrical welding, masonry and wood roof frame construction this past spring.

The success of this level-one training course has prompted consideration of a second course to be offered in the fall, says Adam Nowiski, department chair of Corporate and Continuing Education. Classes were held at the Fayetteville campus of Fayetteville Technical Community College inside the Center for Business and Industry.

"The customized training course provides soldiers with a broad range of training in different skills areas within the construction trades area," Nowiski says. "We provided training to nineteen soldiers during the spring course and look forward to continued opportunities to serve our military neighbors with specialized training to help them meet their training objectives. A second offering of the Construction Trades training program may be available as early as the fall."

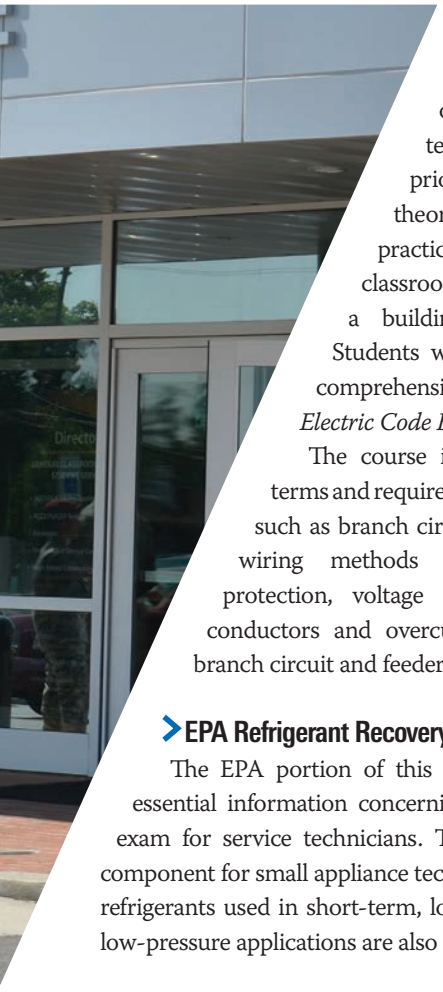
Concrete and Masonry Training Foundations

The masonry portion of the course covers all aspects of foundation building basics, including block pillars, brick and block wall construction and facades. Having had no prior experience, students are able to learn masonry construction basics. The training includes hands-on activities, class lectures and discussion on topics including mixing mortar, laying block, brick and building foundations and block pillars for structural support.

Carpentry and Renovation

The carpentry and renovation portion provides soldiers with a general knowledge of tool and safety practices. They learn the basics of carpentry skills such as material analysis, measuring, cutting, squaring and angle cut layout for gable roof stick-built trusses.

During this course, there's a hands-on interaction involving a building project including framing, sheeting floors, wall construction, roof construction, window and door framing and mounting, drywall hanging and finishing and electrical with a focus on wiring buildings for plugs and lights. The wood framing phase focuses on wood construction techniques, building structure assessments techniques and selection of material.



Basic Electrical Wiring

The course also provides an overview of electrical wiring techniques for students with no prior knowledge of electrical theory or installation. Students practice the skills they learn in the classroom in a hands-on setting within a building that students assemble. Students will receive training through a comprehensive study of the *National Electric Code Book*.

The course includes a study of electrical terms and requirements for electrical installation, such as branch circuits, grounding and bonding, wiring methods and materials, overcurrent protection, voltage drop calculations, sizing of conductors and overcurrent protection devices for branch circuit and feeder circuits.

EPA Refrigerant Recovery / Recycling

The EPA portion of this course provides soldiers with essential information concerning the EPA/CFC certification exam for service technicians. This includes a core materials component for small appliance technicians. The characteristics of refrigerants used in short-term, long-term, high-, medium- and low-pressure applications are also covered.

Heat Pump Technology

This course is designed to provide a working knowledge and understanding of heat pump technology for those desiring technical positions in heating, ventilation and air conditioning. It addresses laws of refrigeration, air properties, refrigerants and recovery techniques, pressure-temperature relationships, heat transfer, types of systems, basic controls, components and troubleshooting techniques specifically focused toward heat pump technology.

Basic Welding

This is designed to teach the apprentice welding techniques and manipulative skills required for each welding process. Special focus is placed on oxy/acetylene cutting, SMAW, and GMAW processes in a workshop environment for application purposes. Welding techniques are stressed above welding theory to ensure the students meet welding performance demands.

OSHA 30 Construction

This segment of the training, taught by an authorized OSHA Construction Safety instructor, provides soldiers with a foundational knowledge policies, procedures, health standards and standards for safe practices in the construction trades industry. Soldiers who pass the written examination receive certification of completion from federal OSHA.

This course is appropriate for construction workers, site foremen, safety managers and any professional who has a need for a deeper understanding of current OSHA standards for their agency or company.

In addition to the Fayetteville campus, Fayetteville Tech has campus locations in Spring Lake and at Fort Bragg. The FTCC office located at the Bragg Training and Education Center provides one-on-one educational counseling and assistance to soldiers and their family members.

The All American Veterans Center located at the Fayetteville campus is staffed by veterans who provide personal assistance to other veterans seeking educational opportunities at the college. As the top ranked school in the Top 10 Gold Category College Award for 2019-20 by Military Friendly Schools and Viqtory Media, Fayetteville Tech is proud to serve our military service members and their family members.

A second offering of the Construction Trades training program may be available as early as the fall.

Fayetteville Technical Community College
Corporate & Continuing Education
Dr. Jolee Marsh, Associate Vice President
FTCC Corporate & Continuing Education
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BioWork, a flexible three-month training program offered through several community colleges, provides students with a process technician certification and a direct path to employment.

Three months to a new career

BioWork's flexible training program prepares students for employment.

By Vernon Shoaf

North Carolina is home to a thriving life science industry with numerous opportunities to jump-start a new career. BioWork, a three-month training program offered through several community colleges, provides students with a process technician certification and a direct path to employment.

Camir Ayuso was pursuing a nursing degree at Wake Technical Community College when she discovered BioWork.

"At that point, I had to decide whether to commit to two years of nursing school or go a different direction," Ayuso says. "I enrolled in BioWork."

Created with direct input from industry experts, the 136-hour program provides students like Ayuso with a crucial foundation for employment in the biomanufacturing industry.

A new version being offered this fall includes topics such as:

- Quality & Current Good Manufacturing Practices (CGMP)
- Working Safely
- Measuring Process Variables
- Equipment & Materials
- Controlling the Process
- Aseptic Processing
- Biomanufacturing Production

Ayuso discovered that the rapidly growing biotechnology industry typically hired contractors through placement agencies as the primary entry point for technician positions.

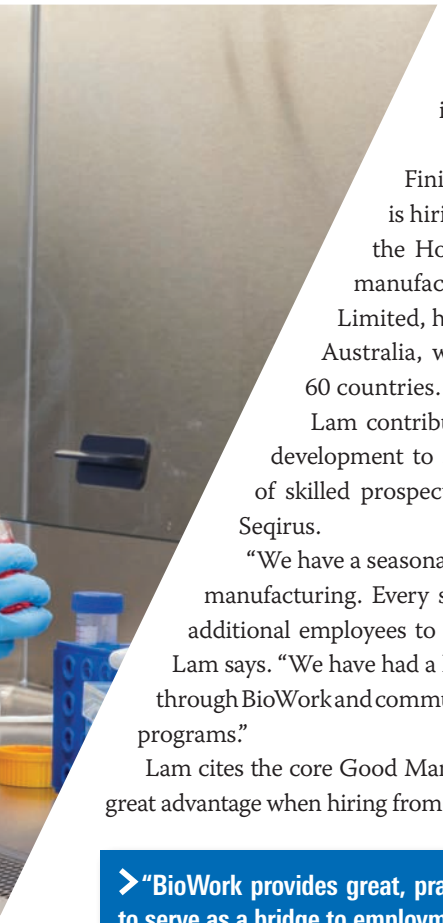
"I went on several interviews and was turned down. But BioWork taught me about the whole process. After I was hired as a contractor within a local life science company, I continued taking classes offered by BioNetwork," Ayuso says.

> Ayuso's experience as a contractor with Biogen paid off when she was hired full-time in November 2018 as a Bioprocess Manufacturing Associate II in Upstream Cell Culture.

Biogen Inc.

Biogen Inc.'s Research Triangle Park location is one of many for this American multinational biotech company, specializing in innovative therapies for neurological and neurodegenerative diseases. The Raleigh-Durham area has consistently been ranked in the top five life science clusters in the nation, and a skilled workforce is a key reason why.

North Carolina hosts over 700 bioscience companies that employ over 64,500 people. BioNetwork's company directory includes these organizations as well as 2,400 additional North



Carolina companies that support the thriving biotech industry.

Rodney Lam, Director of Fill-Finish Manufacturing at Seqirus, is hiring manager for his division of the Holly Springs influenza vaccine manufacturer. Seqirus is part of CSL Limited, headquartered in Melbourne, Australia, with operations in more than 60 countries.

Lam contributed to BioWork's curriculum development to support a continuing pipeline of skilled prospects for entry-level positions at Seqirus.

"We have a seasonal workforce for our flu vaccine manufacturing. Every summer we bring in 20 to 30 additional employees to increase production capacity," Lam says. "We have had a high level of success recruiting through BioWork and community college biomanufacturing programs."

Lam cites the core Good Manufacturing Practices skills as a great advantage when hiring from BioWork for Seqirus positions.

> **"BioWork provides great, practical, hands-on experience to serve as a bridge to employment in the industry."**
> **— Rodney Lam, Director of Fill-Finish Manufacturing at Seqirus**

"The vast majority coming out of BioWork understand good technique, documentation processes, safety practices and perspective on quality," Lam says.

Lam emphasizes that Seqirus, as part of an international corporation, also looks for employees with leadership and soft skills. "We look for capable problem-solvers, being on time, behavioral traits," Lam says. "There is a very distinct learning curve for those who have not had BioWork."

BioWork underscores these qualities, giving job applicants a higher probability of consideration for Seqirus's contract-to-hire openings. Seqirus, like many bioscience companies, views the entry-level positions as a 90-to-120-day job interview.

"If they are good and perform well, this can lead to a permanent, full-time role," Lam says.

Ayuso says that her BioWork training gave her the skills and confidence to enter and prosper in her new career.

"Everything I learned in BioWork prepared me for what I'm learning on my job," Ayuso says. "Working in upstream processing is a completely different language than in research and development. It's really exciting knowing I am part of a team working on various neurological therapies."

Ayuso plans to finish her undergraduate degree, supported by Biogen, which is a common industry practice.

"I encourage people to sign up for BioWork," Ayuso says. "The professors have a lot of industry or academic experience. And the probability of getting a biotech job increases with the BioWork certification. Even with a high school diploma, and a lot of extra work, BioWork is a great opportunity. You can take your career as far as you want to go."

> **To learn more about a BioWork class near you, visit ncbionetwork.org/BioWork.**

Questions? Contact Len Amico, Industry Liaison and Curriculum Coordinator for BioNetwork at lamico@ncbionetwork.org or visit ncbionetwork.org/BioWork.

North Carolina hosts over 700 bioscience companies that employ over 64,500 people.

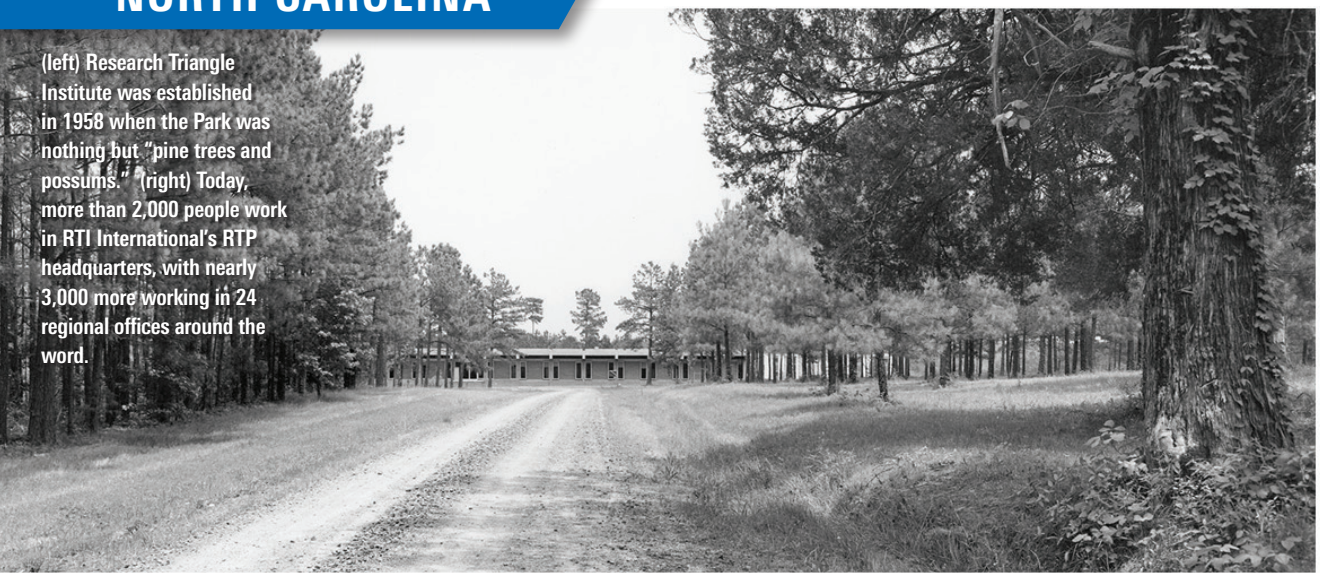
NC COMMUNITY COLLEGES BIONETWORK ncbionetwork.org

BIOWORK

Biogen

Seqirus™ A CSL COMPANY

BioNetwork
AB Tech
Gaston College
Pitt Community College
Wake Tech



(left) Research Triangle Institute was established in 1958 when the Park was nothing but "pine trees and possums." (right) Today, more than 2,000 people work in RTI International's RTP headquarters, with nearly 3,000 more working in 24 regional offices around the word.

Results in research

RTI International celebrates 60 years of living its mission.

For 60 years, RTI International's commitment to improving the human condition has positively impacted lives around the world. Since its beginning as a small nonprofit research institute nestled in the longleaf pines of Research Triangle Park, RTI has sought to address the world's most critical problems with science-based solutions in pursuit of a better future.

In its early years, RTI's projects honed in on areas of importance to North Carolina, including applied statistics and environmental research. Today, RTI's domestic work spans the country, informing health policy to improve all aspects of human health, addressing the opioid crisis using comprehensive, coordinated strategies and employing multi-method approaches to reform areas of criminal justice and more.

In 1961, RTI became international with its first project overseas in Nigeria. Today, as an organization of nearly 5,000 people, RTI implements and conducts research on hundreds of diverse projects in countries ranging from Guatemala and Indonesia to Nepal and Uganda.

Much of this international work has been funded by the United States Agency for International Development and is predicated on helping governments in developing nations build infrastructures – water quality, energy efficiency, agricultural production, sanitation, pollution, literacy and health care – and optimize the allocation of resources. RTI also works closely with private-sector clients, such as the Bill & Melinda Gates Foundation, on issues including HIV/AIDS prevention, air pollution exposure and neglected tropical diseases.

This type of work would not be possible without RTI's mindset of developing close client relationships to execute ideas that better people's lives. Last year, RTI experts in fields as varied as maternal and child health, unmanned aerial vehicles and food security implemented nearly 4,000 projects around the world, satisfying 1,200 public- and private-sector clients.

RTI seeks to continuously learn from its clients. The relationships developed across various sectors serve as catalysts that broaden RTI scientists' perspectives and understanding of major challenges, which opens doors for new ideas, technologies and multidisciplinary solutions. Today, our researchers develop innovation frameworks to help organizations achieve peak performance and work with others to advance early-stage technologies into the marketplace.

Although RTI's reach is global, its origins are local. They can be traced to North Carolina leaders in business, state government and academia, including its founding partners: The University of North Carolina at Chapel Hill, Duke University and North Carolina State University.

In the 1950s while other parts of the country boomed economically, North Carolina fell behind. The state lost people with advanced degrees from area universities who decided they had to go elsewhere to pursue their passions and earn a living. But area leaders saw the possibilities of the Piedmont region.

They envisioned the soon-to-be-named Research Triangle Park as an area that could rival technological and industrial

development in places like Boston's northern corridor and California's Silicon Valley. They set forth to cultivate the region's most promising minds and make the future research park a destination for scientists from around the country and world.

In 2019, on the main campus of its global headquarters in RTP, RTI continues to foster a collaborative environment and harness an innovative spirit to support scientific rigor, achieve technical proficiency and solve complex problems. Sixty years after its founding, science continues to be the vehicle through which RTI fulfills its mission.

With more than 2,000 people working in RTP – and nearly 3,000 more working in 24 offices around the world – RTI is an institute without walls. Its scientists seek to break down barriers and build on the achievements of its legacy, including the advancement of research in cancer therapeutics, biomedical addiction and substance use.

RTI leaders acknowledge that as the world rapidly changes, so will the role of the research institute. The one certainty is an ongoing and vital need for a research institute dedicated to tackling the most important problems confronting society. And that is a role RTI is uniquely positioned to fill.

To learn more about the compelling history of North Carolina's first groundbreaking research institute, visit RTI's

Improving early-grade reading, in the United States and around the world, has always been a top priority at RTI.

SBTDC Tech Team members with Summer Consultancy Program interns

Tech time

SBDTC links future business leaders with emerging tech companies.

Graduate student intern Josh Ritch summed up his time working with two technology-based companies as a part of the Small Business and Technology Development Center's Summer Consultancy Program simply: "It was quite an amazing experience."

Each year the SBTDC hires highly qualified graduate students from North Carolina universities to work with technology-based companies. This is the 18th year John Ujvari, SBTDC's SBIR Program Specialist and member of the Technology Commercialization Services team, or Tech Team, has run the summer internship program.

The SBTDC is a business and technology extension program of the UNC System, administered by North Carolina State University and operated in partnership with the U.S. Small Business Administration. SBTDC's business counselors assist small- and mid-size businesses throughout North Carolina from 16 offices across the state, each affiliated with a college or university.

The SBTDC's Tech Team focuses on providing counseling and resources to small business owners, university researchers and entrepreneurs looking to advance their innovations to the marketplace. These innovations typically involve intellectual property which has a strong competitive advantage in the marketplace and serves as a foundation for the business.

Growing technology firms often need access to hands-on business skills and expertise to help their ventures advance to the next level. The Summer Consultancy Program matches selected student interns with well-defined commercialization projects chosen by the businesses. Throughout the summer, the Tech Team provides in-depth mentorship to the students and monitor their projects to make sure the deliverables are achieved. Six group meetings are held with all the interns to discuss their projects, encourage knowledge sharing, hold practice pitch sessions and present final project deliverables.

This summer, 12 graduate student interns from across the state are working with 24 small businesses. Projects include primary market research, financial analysis, commercialization plan development, market assessments, competitive analysis and others. Participating schools have included North Carolina State University, UNC-Chapel Hill, Duke, Western Carolina University, UNC-Charlotte and Appalachian State. The students receive a stipend that is paid by the SBTDC and the universities the students are enrolled in.

Josh Ritch worked with two technology-based companies in western North Carolina and was able to gain networking skills and add to his resume. "I'd never written an NSF [National Science Foundation] grant before and hadn't really done a lot of accounting outside my class, so I had a chance to work in those areas," Josh says.

The SBTDC has offered the Summer Consultancy Program for 18 years, during which 165 students have worked with over

sbtdc
Your business. Better.

Small Business and Technology Development Center
5 West Hargett Street, Suite 600
Raleigh, N.C. 27601
919-715-7272 • sbtdc.org

Josh Ritch from Western Carolina University during his final presentation

300 clients for a total of 65,000 hours. Economic development impacts associated with their consulting work include well over $200 million in funding from both private equity and Small Business Innovation Research (SBIR) grant infusions.

Past interns have gone on to land full-time positions at companies of all sizes in a multitude of industries around the world. A handful have taken on the challenge of starting their own businesses, some of which have grown significantly and achieved successful financial exits for their founders.

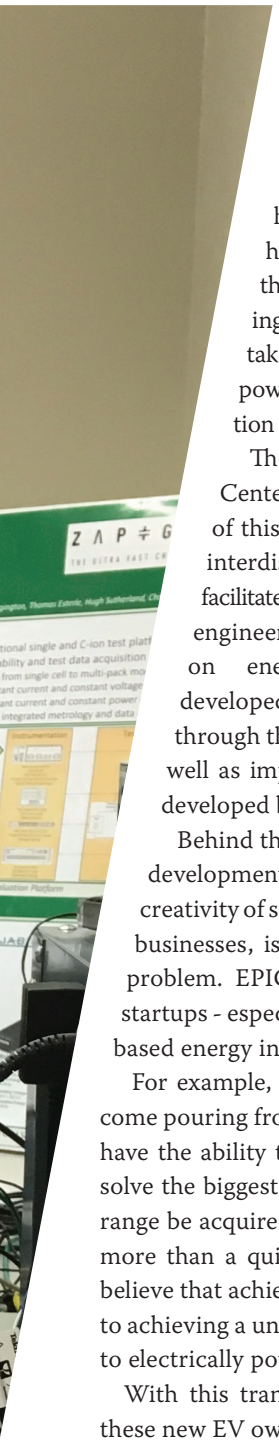
With the Summer Consulting Program, everyone wins. Graduate student interns gain hands-on experience with technology-based entrepreneurial companies. Companies receive high-quality assistance from motivated students learning the newest theory and techniques. State universities provide invaluable real-world experiences for their students and the SBTDC's Tech Team is able to expand its bandwidth and offer significantly greater services to clients.

> Consultancy Program
With the SBTDC's Summer Consultancy Program, everyone wins.

Driving forward innovation

UNC Charlotte's EPIC center is ahead of the future in electric vehicles.

The college's interdisciplinary research center is working toward viable solutions for electric vehicle charging.



Almost everyone in North Carolina has noticed the signs that something big is happening in the energy industry. Solar farms are seemingly being built overnight, fleets of hybrid, plug-in hybrid and battery-electric vehicles have become common enough to attract the attention of state legislators - and are impacting the funding of our road system. Debates are taking place about the future of coal-generated power in the state versus massive new wind generation projects.

The Energy Production and Infrastructure Center at UNC Charlotte strives to be at the center of this energy economy transformation. EPIC is an interdisciplinary research center with a mission to facilitate a university-industry collaboration in engineering research and development with a focus on energy-related systems. The partnerships developed with EPIC produce technical scholarship through the efforts of associated faculty and students as well as implementable solutions and tangible outcomes developed by experienced professional engineering staff.

Behind the larger societal goal for cleaner energy is the development of new and innovative technology. The creativity of small companies, both startups and established businesses, is being counted on to solve this challenging problem. EPIC is a ready collaborator with new energy startups - especially those trying to connect to the Charlotte-based energy industry.

For example, brand new electric vehicle models will soon come pouring from car manufacturers. Many of these cars will have the ability to accept ultrafast rates of electric charge to solve the biggest challenge: how fast can 300 miles of driving range be acquired. With conventional cars, this takes nothing more than a quick, five-minute stop at a gas station. Many believe that achieving this same convenience for EVs is the key to achieving a universal transition from gasoline-powered cars to electrically powered ones.

With this transition comes a big question: where will all these new EV owners find a charging place that can sustain an ultrafast charge for their cars without grid modifications? The answer could be a new energy storage technology pioneered by ZapGo, Inc., an early-stage company that has partnered with EPIC. With headquarters in Oxford, England and offices in Charlotte, ZapGo came to EPIC for help getting their carbon-ion cells into a fully integrated system as a solution to getting ultrafast DC EV chargers onto the electric grid.

"ZapGo has engaged EPIC to deliver an independent evaluation of our C-ion high energy storage technology, as well as develop the concept and key components for an engineering prototype of a large-format grid energy storage system using C-ion cells," Charles Resnick, ZapGo, Inc.'s president, says.

EPIC's C-ion Test and Development Laboratory was created for the purpose of assembling C-ion cells into larger component subsystems intended for large energy storage applications that can be used by electric utilities.

The fast charging stations needed for zero-emission battery EVs are generally not compatible with the electric utility infrastructure, so the development of a high-power energy storage system can help. Right now, the companies pursuing these systems see only one technology, and that is the same type of lithium-ion batteries found in EVs. But according to a study performed by Nicolas Sockeel, a post-doctoral researcher at EPIC, this isn't a viable option. Another type of technology is needed.

Jim Gafford, EPIC's assistant director for special projects, and Madhav Manjrekar, EPIC Assistant Director for Power Management, have forged a group of engineers and students to team with ZapGo's research labs and tackle the problem of building a prototype energy storage system to meet the need for ultrafast EV charging, without relying on costly and limited Li-Ion batteries.

"Evaluation capabilities, methodologies and results to date have been demonstrated to ZapGo clients and industrial partners, including Electrify America, LS Energy Solutions, Jabil, Duke Energy and ABB," Gafford says. Duke Energy has agreed to test the system at their Mount Holly Microgrid Innovation Research Center later this year.

EPIC continues to work on the design of the energy storage system. Blueprints of subassemblies filled with ZapGo C-Ion cells will be used by Jabil in Florida to manufacture the subassemblies. The fully tested subassemblies will be returned to the Charlotte-based manufacturing plant of LS Energy Solutions to perform the final system integration of the subassemblies into the grid-tied energy storage prototype, which will be sent to Duke Energy for evaluation.

The schedule is tight, but the team is in place to meet ZapGo customer commitments in the U.S. and Europe next year. Not a minute too soon, because in the next decade, cars that need the "zap and go" treatment will roll out of design studios and be headed for mass manufacturing.

EPIC is not only on time for our clients. We are ahead of the future.

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Chrissy Roselli and Javier Grajeda, former PhD students in UNC's Department of Chemistry, use inert atmosphere glove boxes to keep the chemical environment sterile for experimentation. After graduating in May 2018, both took jobs as advanced research chemists at Eastman.

Powering breakthroughs

Partnerships drive discovery at UNC Chapel Hill.

Leveraging the power of industry sponsorships, University of North Carolina at Chapel Hill creates solutions for emerging challenges. The school attracts over $1 billion in sponsored research funding each year and ranks fifth in the nation for federal research.

Partnerships comprise a growing part of the university's diverse research portfolio. Industry leaders, both globally and locally, are drawn to its strengths in biomedical, health and population sciences, and to its nationally recognized programs in nanotechnology, computer science and big data. The UNCs concentration on practical outcomes and commercially viable solutions is powering breakthroughs in multiple fields.

UNC boasts a research culture that is both highly collaborative and interdisciplinary. To capitalize on these strengths, the university is coalescing resources, facilities and brainpower around six areas of strategic priority. By supporting faculty initiatives which advance these priorities, the school is making early-stage investments at the forefront of innovation.

Life-Changing Advancements in Targeted Therapeutics

Seeking a prominent university leader in health sciences, Deerfield Management, a private investment firm committed to advancing healthcare, partnered in late 2018 with UNC to create Pinnacle Hill, a $65 million private venture committed to the discovery of new medical technologies that address urgent unmet needs. Through Pinnacle Hill, Deerfield will invest in promising therapeutic research at UNC and apply its significant expertise in drug development to select projects with high potential for commercial application.

Pinnacle Hill will support projects identified by a joint steering committee composed of members from Deerfield as well as

leaders from UNC's Office of the Vice Chancellor for Research, School of Medicine and Eshelman School of Pharmacy.

Bonding Business and Science

What began as a collaborative research partnership around chemistry and materials science in 2013 between UNC and Eastman Chemical Company, a materials and specialty additives company based out of Tennessee, has today extended across the entire university community. The company has sponsored research projects in the Gillings School of Global Public Health's Department of Environmental Sciences and Engineering, in three departments within UNC's College of Arts and Sciences and the Kenan-Flagler Business School. Eastman has also joined forces with UNC's BeAM makerspace program, supplying materials that feed over forty 3D printers across campus at makerspace locations. The company has heavily recruited campus graduates over the past five years. Recognizing the valuable and mutually-beneficial relationship it enjoys with the college, Eastman recently extended its agreement with the university another six years, committing $5 million over the life of the partnership.

Yielding Greater Results

UNC Chemistry Professor J. Michael Ramsey recently partnered with global biopharma companies Celgene and MilliporeSigma to develop a new bioreactor monitoring technology to accelerate the manufacture of biologic medicines. North Carolina is home to an extensive biologics manufacturing cluster, and Ramsey's work grew out of UNC's participation in the National Institute for Innovation in Manufacturing Biopharmaceuticals (NIIMBL) – a national consortium co-led by North Carolina State University. A key industry partner on Ramsey's $1.3 million award is 908 Devices, Inc., a company he founded to commercialize his highly sensitive microfabricated chemical measurement technologies.

Working with industry partners and NCSU's Biomanufacturing Training and Education Center, Ramsey and 908 Devices are producing a device that will monitor nutrients and cell metabolites in bioreactors, improving the quality and yield of biologics manufacturing lines and ultimately reducing the cost of these life-saving therapeutics. His project received matching funds from the North Carolina General Assembly for scientists awarded grants through NIIMBL.

STRATEGIC RESEARCH PRIORITIES

By fostering and supporting collaborative, interdisciplinary teams, UNC is accelerating new discoveries and solutions to emerging challenges in these areas:

BRAIN

Discovering the biology and diseases of the nervous system and drivers of human behavior.

CANCER

Improving lives through cancer research and advancing cancer prevention, detection, treatment, and health practice.

DATA SCIENCE

Developing and applying big data tools to solve scientific and societal problems.

ENVIRONMENT

The study of natural systems, global environmental change, resilience, and health.

OPPORTUNITY, WELL-BEING, & CULTURE

Exploring how opportunities shape success and well-being over a lifetime and across societies; and humanities as a lens for understanding our world.

PRECISION HEALTH & SOCIETY

Tailoring health care practice, delivery, and therapeutics to individual circumstances, using factors from genetics to social and environmental influences.

UNC | RESEARCH

UNC Chapel Hill
Office of the Vice Chancellor for Research
Chapel Hill, N.C.
Research.unc.edu

UNCG's Dr. Deborah Lekan (right), Cone Health's Dr. Marjorie Jenkins, and their collaborators are tapping into electronic health records to improve patient outcomes.

Big data boom

UNC Greensboro is developing smarter solutions to real-world problems.

If we must be hospitalized, most of us hope to leave healthier than when we entered – or at least well on the road to recovery.

But some patients head home and grow sicker instead of better, requiring more treatment. Some even end up back in the hospital.

What's the difference between patients who make a full recovery and patients who don't? One major element is what clinicians call "frailty" – a constellation of factors that include age, nutrition, psychological health, social supports and more.

When UNC Greensboro Assistant Professor of Nursing Deborah Lekan did her dissertation on frailty several years ago, she conducted a painstaking analysis of information drawn from electronic health records, which had just begun to change how providers cared for patients.

"I basically had PDF copies of nursing documentation and physician notes," Lekan says. Getting the information was time consuming and limited by how many records she could analyze herself.

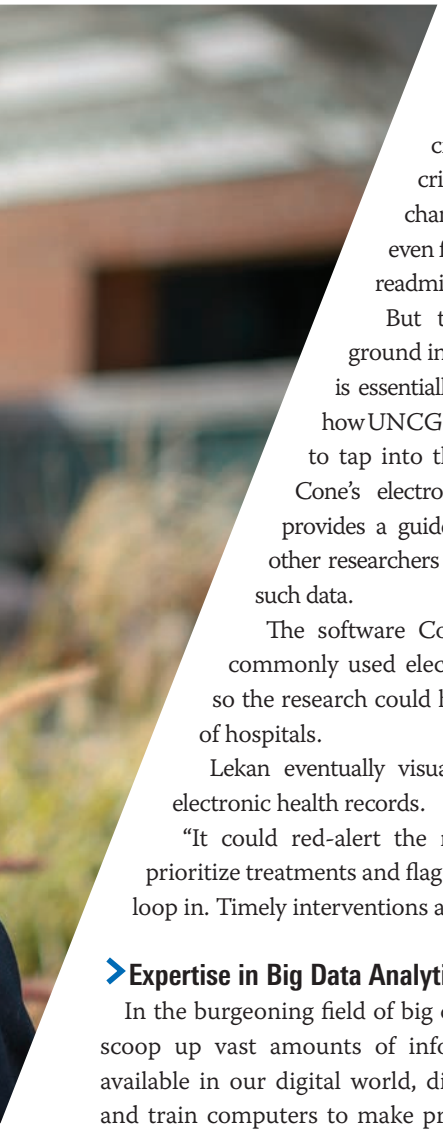
But now, she and collaborators at UNCG and Cone Health System are harnessing the power of computers, sophisticated statistical techniques and machine learning to dive much deeper.

Their goal? Identify patients at risk of not fully recovering, in real time, and improve the care provided to them.

The project sets machine learning algorithms loose on clinical measurements, notes from nurses and doctors, demographic information and other data to see if they can predict which patients will need additional care.

"One of the benefits of our models is they actually tell us how important different variables are," Assistant Professor of Computer Science Somya Mohanty says. Clinicians should be able to see key features putting a person at high risk of readmission

> Want to learn data science?
UNCG is launching an interdisciplinary master's degree in informatics and analytics this fall. To learn more and to apply, visit msia.uncg.edu.



and strategically target interventions.

Patient readmission, especially among older patients, is a critical and costly issue. With changes to Medicare, hospitals can even face penalties if patients must be readmitted within a month.

But the frailty project will break ground in other ways, too. One outcome is essentially a road map which illustrates how UNCG and Cone Health collaborated to tap into the massive amounts of data in Cone's electronic health record system. It provides a guide to legal and technical issues other researchers and hospitals will face in using such data.

The software Cone uses is one of the most commonly used electronic health record systems, so the research could have applications at thousands of hospitals.

Lekan eventually visualizes an app for a hospital's electronic health records.

"It could red-alert the nurse," Lekan says. "It could prioritize treatments and flag the care specialists we want to loop in. Timely interventions are critical."

Expertise in Big Data Analytics

In the burgeoning field of big data research, scientists scoop up vast amounts of information increasingly available in our digital world, discover new insights and train computers to make predictions. Here's a snapshot of some of the big data buzz across disciplines at UNCG:

Tackling our region's most vexing issues. Students and professors are collaborating across disciplines to help local and state government better understand the data they have, and in the process create better solutions to community problems. Recent partnerships target the opioid epidemic, eviction rates, asthma and substandard housing and even government spending.

Rapid response. In cybersecurity research funded by the U.S. Department of Energy, Mohanty used machine learning to predict attacks on computer networks. Now, the computer scientist is part of an effort funded initially by the National Oceanic and Atmospheric Administration to track tweets during and after hurricanes to help identify areas of focus for disaster recovery efforts.

Big data applications are limitless.

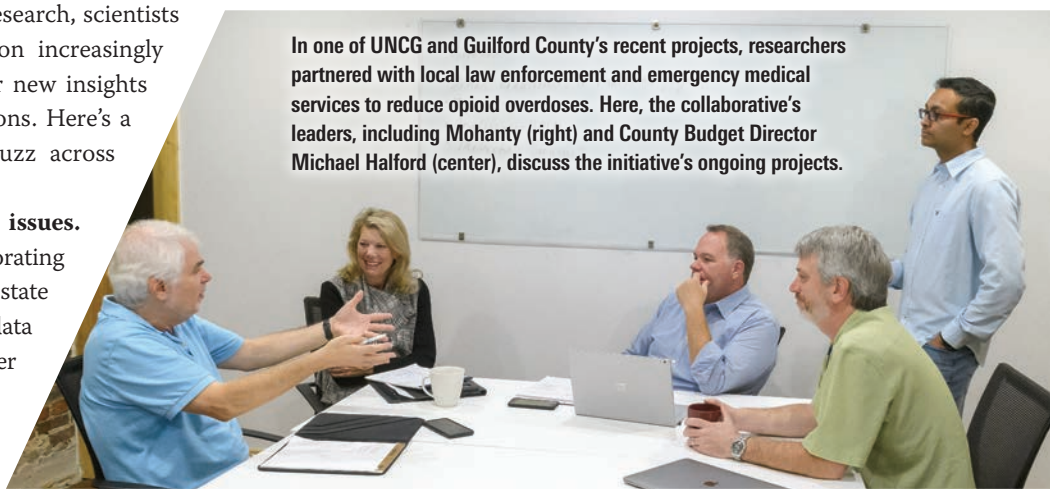
Genomic analyses for complex diseases. Finding fraud in stock price trends. Tracking domestic violence. And that's just from the portfolio of a single data scientist in UNCG's Institute for Data, Evaluation, and Analysis. IDEA connects university experts with external groups seeking help with data-informed decision making. Learn more at idea.uncg.edu.

Ramping up research. Assistant Professor of Computer Science Prashanti Manda and Mohanty are teaching computers how to read complex academic journal articles. The goal is to make research more accessible, cut down on duplicate research and help scientists more quickly expand their knowledge.

Rhetoric writ large. Assistant Professor of English Aaron Beveridge has created software to better understand how social media influences the media and popular opinion. "What I'm interested in, broadly, are the ways in which social networks are a macroscopic form of persuasion," Beveridge says.

Seeing the big picture. Professor of Computer Science Shan Suthaharan's latest computational modeling project seeks to improve detection of macular degeneration – the leading cause of age-related vision loss – using digital medical images. He's also interested in the consequences of big data use. Suthaharan is working on smarter machine learning techniques that take privacy into consideration.

See the full version of this article in the Spring 2019 issue of UNCG Research Magazine at researchmagazine.uncg.edu.



In one of UNCG and Guilford County's recent projects, researchers partnered with local law enforcement and emergency medical services to reduce opioid overdoses. Here, the collaborative's leaders, including Mohanty (right) and County Budget Director Michael Halford (center), discuss the initiative's ongoing projects.

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Professor John Morrison's nanosatellite, SeaHawk-1, launched in December 2018 aboard SpaceX Falcon 9.

Expanding a culture of innovation

UNCW's widespread research initiatives earn national recognition and have global significance.

The University of North Carolina Wilmington's efforts to advance research and push the boundaries of innovation have created a thriving campus culture rooted in inquiry, curiosity and imagination. In 2018, researchers secured a 36% increase in new grants over 2017, and the university earned an elevated Carnegie Classification of Institutions of Higher Education as a "High Research Activity" doctoral institution.

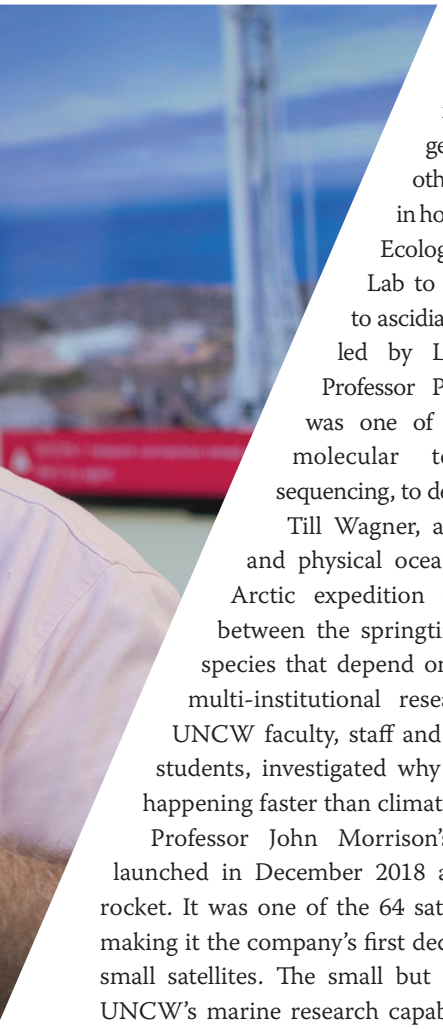
With help from a $400 million investment in capital improvements and $9.3 million in new grant funding, UNCW's community of scholars continues to expand research endeavors and address issues of local, regional and wide-reaching importance.

Exploring the Land, Air, Seas and Space

UNCW was named a top producer of Fulbright U.S. Scholars for the 2017-18 academic year among master's institutions. The Fulbright Program is a highly competitive, merit-based grant for the international educational exchange of students, scholars, teachers, professionals, scientists and artists. One of UNCW's award recipients, Narcisa Pricope, associate professor of geography, will research landscape degradation and teach courses in satellite remote sensing and unmanned aerial systems photogrammetry at the University of Namibia. Pricope, an expert in land change science, water resources and climate change, will work with international researchers to address the relationships between land degradation and livelihoods in Namibia and the larger Kavango-Zambezi Transfrontier Conservation Area.

Assistant Professor Raymond Danner is leading a team studying the wintering habits of two species of sparrows, with an eye on helping the North Carolina Wildlife Resources Commission enhance conservation efforts. The two-year study will focus on salt marsh and seaside sparrows that winter along the southeastern North Carolina coast. Most of the research will take place on Masonboro Island in the National Estuarine Research Reserve, but the project will also examine other North Carolina habitats.

The research of a UNCW associate professor and lab have been immortalized with the naming of two new sea squirt species in their honor. Sea squirts are a type of marine invertebrate. The species P. lopezlegentilae recognizes biology and marine biology



Associate Professor Susanna López-Legentil for her work in ascidian, or sea squirt, genetics and systematics. The other species, P. imesa, was named in honor of the Integrated Molecular Ecology of Sponges and Ascidians Lab to acknowledge its contributions to ascidian molecular ecology. The lab is led by López-Legentil and Assistant Professor Patrick Erwin. López-Legentil was one of the first researchers to use molecular techniques, namely DNA sequencing, to delve into sea squirt genetics.

Till Wagner, assistant professor of physics and physical oceanography at UNCW, led an Arctic expedition to explore the relationship between the springtime sea ice melt and marine species that depend on the ocean for survival. The multi-institutional research team, which included UNCW faculty, staff and graduate and undergraduate students, investigated why the collapse of Arctic ice is happening faster than climate computer models predict.

Professor John Morrison's nanosatellite, SeaHawk-1, launched in December 2018 aboard the SpaceX Falcon 9 rocket. It was one of the 64 satellites included in this flight, making it the company's first dedicated ride-share mission for small satellites. The small but powerful device will expand UNCW's marine research capabilities by providing a unique vantage point for observing the changing biology on the ocean's surface and understanding key coastal processes and ecosystems. The high-resolution images collected by SeaHawk-1 will be made available at no cost to scientists around the world.

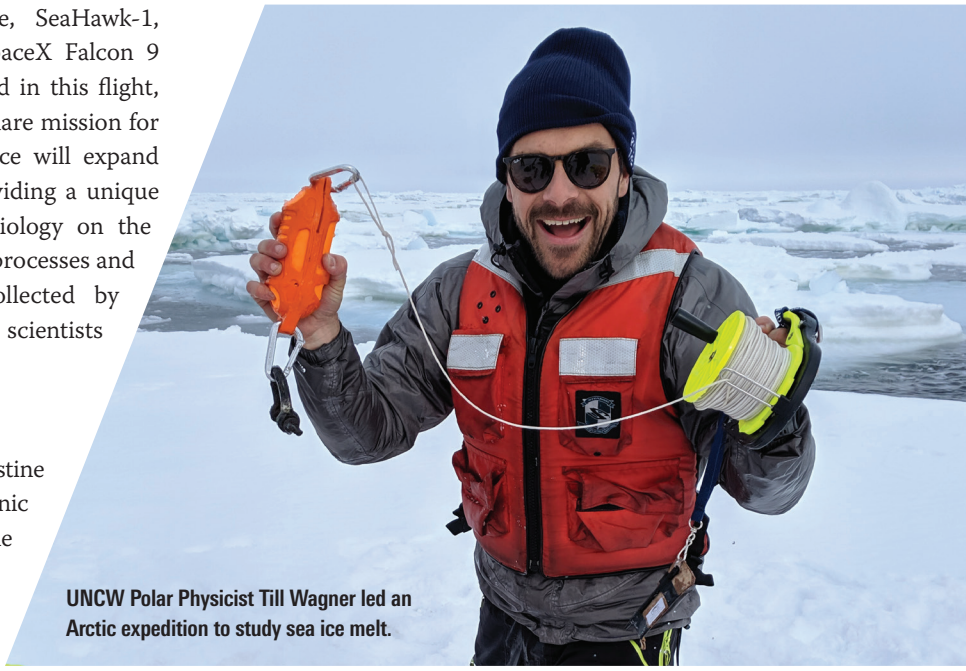
Spurring Social Change

Psychology Professors Raymond Pitts and Christine Hughes are studying how acute and chronic exposure to the prescription opioid oxycodone affects specific reward processes involved in impulsive and risky behavior. Their research will specifically examine how psychoactive drugs can change an individual's choices by changing the impact of the immediacy and/or size of the reward.

Both the Innovation Advisory Council in UNCW's College of Health and Human Services and the Office of Innovation and Commercialization invited faculty and staff from various departments to submit their innovative proposals in the inaugural CHHS "Kickbox" initiative. Seventeen applicants and six teams were selected to participate in the program to compete for funding for their projects. The winner was Stacey Kolomer, the UNCW School of Social Work director and professor who pitched the development of an app called "Safe and Sound." The app assists organizations in communicating with employees during a crisis and is a collaboration with UNCW's Cameron School of Business Associate Professor Elizabeth Baker and students Codie Nichols and Tyler Hall. The idea for the app stemmed from Kolomer's experience trying to check on faculty and staff during Hurricane Florence in September 2018.

The Next Generation of Researchers

Computer science Assistant Professor Toni Pence and Watson College of Education Assistant Professor James Stocker are working to inspire students from underrepresented groups to consider STEM careers through an immersive virtual reality experience. Students in the program will learn by stepping into the virtual shoes of a STEM occupation. They will encounter real-life problems that involve decision-making, applied learning and critical thinking skills. The project will focus initially on third-fifth grade students, but eventually could expand to middle school curriculum, Pence says.



UNCW Polar Physicist Till Wagner led an Arctic expedition to study sea ice melt.

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Improving health through innovation

Research at Wake Forest School of Medicine translates into better care for North Carolina and beyond.

North Carolina has long been known as a hub for medical innovation, but that influence extends far beyond just the Raleigh-Durham area. Year after year, Wake Forest School of Medicine continues to expand its research efforts across strategic areas, impacting not only the field of healthcare, but North Carolina's economy as well.

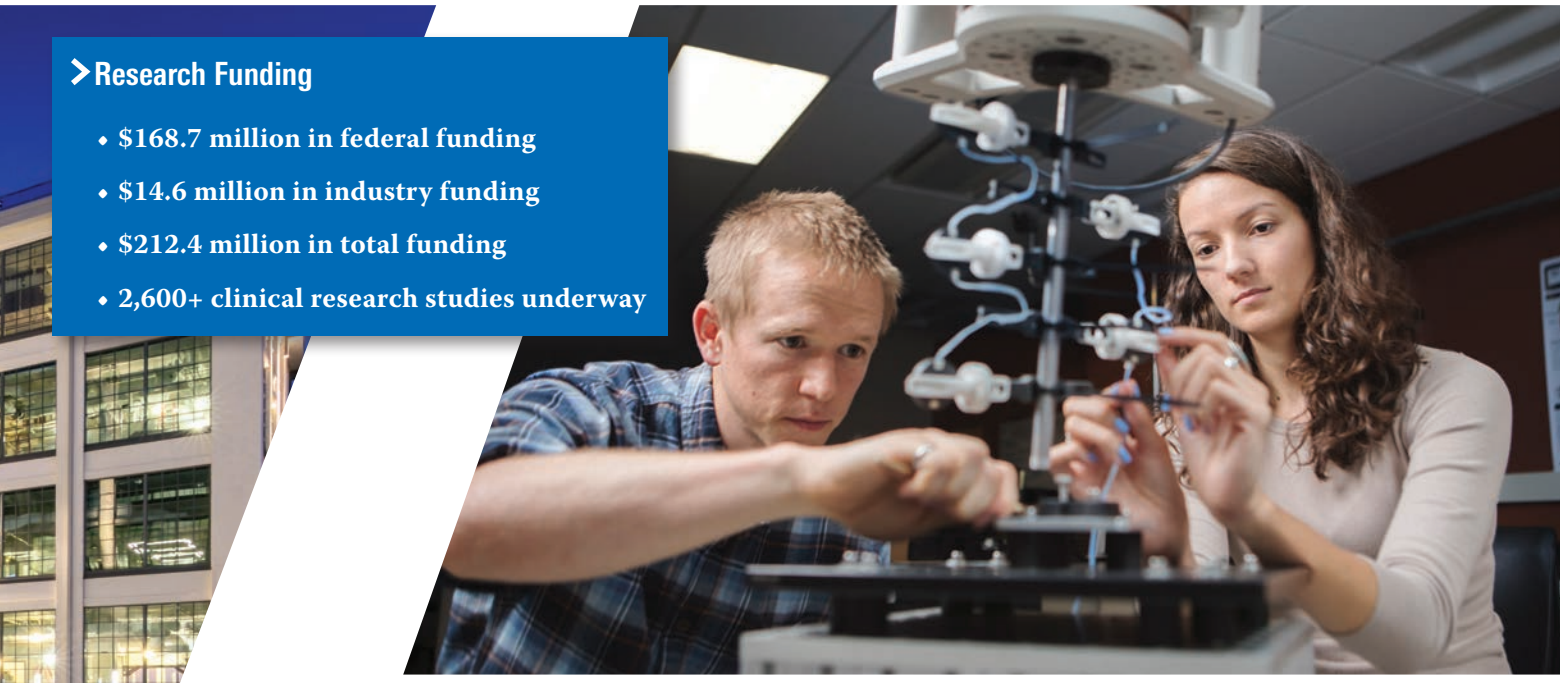
At Wake Forest School of Medicine, faculty researchers are strategically investigating opportunities that expand basic and clinical investigations, resulting in nationally and internationally recognized excellence in biomedical research. They seek to leverage current areas of strength and improve the integration of research programs with areas of major importance in population health. The ability to offer patients the latest technologies, evidence-based treatments and clinical trials makes Wake Forest Baptist Health a national leader among academic medical centers.

>Innovation – in the past 5 years, Wake Forest School of Medicine:

- **Filed 497 patent applications**
- **Formed 17 startup companies**
- **Saw 248 patents issued to faculty and staff**
- **Executed 120 licensing and option agreements**
- **Generated $222 million in licensing revenue**
- **Generated $12.1 million in industry research collaboration revenue**

Research Funding

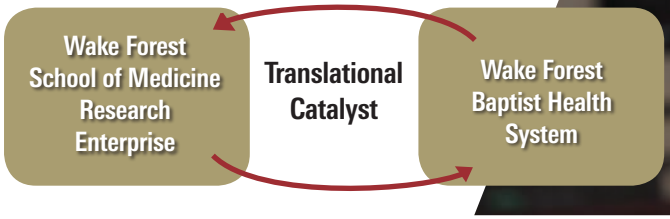
- **$168.7 million in federal funding**
- **$14.6 million in industry funding**
- **$212.4 million in total funding**
- **2,600+ clinical research studies underway**



Major Research Focus Areas Include:

- Aging and cognition
- Diabetes, obesity and metabolism
- Cardiovascular, stroke and neurological illness and injury
- Cancer
- Regenerative medicine

As a learning health system, Wake Forest doesn't stop at research. Our translational catalysts help translate what we learn into what we do, integrating discovery into clinical care and health.



Examples of Our Translational Catalysts Include:

- Biomedical informatics
- Implementation science
- Precision medicine
- Clinical trials
- Healthcare innovation

The research discoveries being made at Wake Forest School of Medicine have a wide-reaching impact by improving lives and creating valuable economic development for the state.

Learn more at School.WakeHealth.edu

Wake Forest® School of Medicine

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