If all of us have been researchers. As young children, we satisfied our curiosity by poking bugs with sticks, taking apart a telephone or transistor radio, asking endless questions about a dance or painting and challenging the answers given, and watching with wonder and fear as lightning danced across the sky. For some, that curiosity to understand not only failed to diminish, but rather intensified to become a way of life for both studying the world and sharing knowledge about it.

Such is the life of an academic researcher, and we are pleased to share in this document some of the important work being done by the many outstanding researchers on the University of Oklahoma’s Norman Campus, including Norman Campus programs at OU-Tulsa.

The activities highlighted here represent not only the work of deeply committed faculty, students and staff in addressing some of the most intellectually challenging and fascinating problems of our time, but they also yield practical outcomes that improve the quality and security of our lives, lead to the creation of new industries and high-paying jobs and enhance the ability of our nation to compete in a globally-engaged society. We offer these activities not as singular examples, but rather as illustrative of a broader body of scholarship, across all disciplines, that makes the University of Oklahoma a unique place to impact the world.

In this report you will see how advanced imaging technology is leading to dramatic improvements in the early detection of breast cancer, and how new types of radars are being created to track weather and the increasing vulnerability to extreme weather has highlighted the need for better planning and preparedness for these events. The response to this call has been a collaborative effort among emergency response teams, federal agencies and academic and weather entities, such as the National Weather Center, to address how we can unite to become a Weather-Ready Nation.

These collaborations address problems that threaten the nation’s economic stability and natural environment. Chemical engineers and plant biologists are working together with other academic institutions and state and federal agencies to develop alternate sources of transportation fuel using existing infrastructure such as oil refineries. Finally, these collaborations gather local communities to help their future workforce realize their potential. Early childhood education researchers at the OU-Tulsa campus work with more than 11 agencies in 14 community-based early learning centers to study learning in infants and toddlers. Their research points a beacon on the path we need to take to close, or even prevent, the academic achievement gap that impacts a lifetime.

These collaborations are the genesis for creating faster and more accurate warning systems. At the Advanced Radar Research Center, for the first time, meteorologists work side-by-side with engineers to design ways to gather richer weather data more quickly. Conducting this research in tandem has led to more accurate warnings with longer lead times.

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The University of Oklahoma is an institution on the move. Classified by the Carnegie Foundation as a Very High Research Institution, placing it in the highest tier of research universities in the nation, OU is a relevant engine for research and creative activity and a foundation for economic growth. I trust you’ll enjoy this report as much as the researchers enjoy the work they do and the satisfaction they feel in knowing the benefits it brings to you.

Kelvin K. Droegemeier
Vice President for Research
University of Oklahoma
CONSTRUCTION UNDER WAY FOR NEW RADAR INNOVATIONS LABORATORY

Dedicated to advancing OU’s radar program, the 35,000-square-foot facility will include a large microwave lab, high-bay garage, prototype fabrication facilities, machine shop, two precision anechoic chambers, experimental observation deck and “Ideas Room” to foster collaboration and innovation. The Radar Innovations Laboratory is the only facility of its kind in the nation for performing world-class research, educating the next generation and demonstrating the practical value of both to the citizens of Oklahoma and the nation.
It is estimated that, with the right processes, 30 percent of the nation’s transportation fuel needs could be sustainably supplied by biomass.

Early each year more than a billion drivers pull their cars into gas stations to fill their tanks and keep them on the go. That is a lot of cars using a fuel that will eventually run out. When the number reaches two billion cars, as expected in the next two decades, how will we continue to be a mobile nation? Surprisingly, the answer may lie in matter such as grass clippings, landfills and chicken poop.

Chemical engineers at the University of Oklahoma Center for Biomass Refining are developing a process to make transportation fuels from multiple renewable materials called biomass. Although it is often tied to plant-based materials, biomass can be anything from garbage to algae and, yes, even animal waste. The team’s goal is to create a conversion process that is flexible enough to accept any type of biomass.

“This country already has a multi-trillion dollar infrastructure of refineries, fueling stations and cars based on gasoline and diesel fuel,” Lobban said. “We are looking at how the refineries would work with bio-oil instead of, or in addition to, petroleum.”

Of course, the availability of fuel is only one of the beneficial reasons to use biomass. Another is the benefit to the environment. Biomass takes carbon out of the atmosphere while it is growing, and returns it as it is burned, making it closer to carbon neutral. If it is managed on a sustainable basis, biomass is harvested as part of a constantly replenished crop, reducing greenhouse emissions by up to 86 percent.

“Even if you ignore the beneficial impact on the environment, fossil fuels are finite and must eventually run out,” Lobban warned. “If we wait until there are shortages, there will be economic and political disruptions as we’ve seen whenever petroleum prices spike. We need to develop the alternate sources so we are ready for the future.”
Making the Switch

Even if you ignore the beneficial impact on the environment, fossil fuels are finite and must eventually run out.

Back in the early 1900s during the prohibition frenzy, the U.S. banned all manufacturing, sale and consumption of intoxicating liquors. But that didn’t stop innovators like Henry Ford from advocating the use of fermented grains as a fuel source for cars. Nearly a century later scientists are exploring using organic material of all matter as biofuel for ground and air transportation.

Currently, corn is the primary crop source used in the U.S. to produce the transportation fuel ethanol. However, there is competition for its use since corn is also a food and animal feed source. Corn also requires large amounts of fertilizer and water compared to other crops. A better alternative for biofuel production may be perennial crops, such as native prairie grasses like switchgrass. Known for its quick growth and hardiness, switchgrass can be grown virtually anywhere in the U.S.

"Switchgrass straw produces sugars and other necessary biofuel components at a much greater yield per acre compared to grains,” explained Laura Bartley, microbiology and plant biology professor. “But the plant’s biology also makes the fuel processing more complicated, and for now, more expensive.”

Bartley is researching the switchgrass genes that build leaves and stems to figure out how to produce a plant that can more efficiently be converted to fuel.

“The sugars we want are part of the plant cell wall, which is a complex mixture of polymers,” explained Bartley. “If we can understand the enzymes that connect the sugars, we can control the composition of the cellular network to better access the sugars.”

Bartley is one of only a handful of scientists in the region researching the plant wall genes. Her research has resulted in not only a better understanding of the chemical breakdown of plant cells, but also the possibility of new varieties of plants. Bartley has grown a plant with an altered enzyme level that reduces the cross-linking of cell wall sugars and makes it easier to break down the protective cell wall.

Bartley works with scientists in multiple fields to apply her research for commercial use. She collaborates with the research team at the OU Center for Biomass Research to advance the processing of switchgrass as a fuel source. She also works with the Oklahoma Bioenergy Center, a collaboration between OU, Oklahoma State University and the Noble Foundation to help improve the feasibility and understanding of the long-term impact of bioenergy crops.

“Bioenergy could be a significant new industry,” said Bartley. “It would financially help agriculture and rural communities while producing a sustainable fuel for the nation.”

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The nation’s aging radar system for keeping us safe is due a makeover—both physical and scientific. The current radar network that supplies data for critical decisions in weather, air traffic and security is running on 1980 technology in radars up to forty years old. Advancements in radar technology could greatly improve decision-making and response time.

Realizing the potential for growth in radar technology, the University of Oklahoma created the Advanced Radar Research Center to capitalize on its radar expertise. Furthermore, OU’s state-of-the-art Radar Innovations Lab is under construction and will house the ARRC.

“We are one of the strongest academic programs in the nation that encompasses all aspects of radar development from designing the systems, to building the radars, testing through lab and field experiments and then working with industry collaborators, such as Lockheed Martin and Enterprise Electronics Corporation, to optimize its use and production,” said Robert Palmer, ARRC director and an OU professor in the School of Meteorology and College of Engineering. The ARRC also has strong collaboration with academic institutions around the world including Kyoto University in Japan, the University of Massachusetts and the Georgia Tech Research Institute.

One of the next big projects for the ARRC is to help set the path for the nation’s next generation radar.

The nation’s current radar networks consist of nearly 1,000 radars using several different radar types operated by the National Weather Service, Federal Aviation Administration, Department of Defense and Homeland Security. And although the radars scan the same space, the networks operate and are maintained within their respective agencies.

“Working closely with the National Severe Storms Laboratory located on OU’s Research Campus, our goal is to leverage our weather and radar expertise to design one radar system that can do the job for all of these agencies,” Palmer said.

This energetic group of scientists and engineers has already adapted an advanced radar concept that could be used in the new network. The multi-mission phased array radar combines two technologies into one radar with more accurate and faster data than any radar currently in existence. The novel radar concept has multiple transmitters and receivers on all sides, which can be used in concert to steer the radar electronically. This is a critical part of MPAR because it allows multiple radar functions to be engaged at the same time. For example, one MPAR could track several airplanes and monitor weather simultaneously.

“With MPAR, a safer, more sophisticated system for the country is possible, while reducing the costs of maintenance and operation tremendously.” The project has been estimated to save taxpayers up to $1.8 billion in initial replacement costs and an additional $3 billion over the next 30 years.
Imagine looking out the window and seeing a tornado in the distance. Now close your eyes for five minutes and then look out the window again. A lot can happen in five minutes with severe weather. Yet, that is the typical gap time between updated weather radar information. Researchers at the University of Oklahoma Advanced Radar Research Center have investigated that by combining two separate radar technologies more accurate weather updates can happen in a matter of seconds, a significant time difference when faced with life and death decisions.

Building upon prior radar research at the university and the National Severe Storms Laboratory, Norman scientists apply the distinct strengths of phased array and dual polarization radar technologies into one multi-mission phased array radar. The improved product not only gives faster updates, but also provides significantly more informative and accurate data. MPAR data can help meteorologists tell the difference between miniscule objects high in the atmosphere, such as raindrops or hail, or even confirm a rain-wrapped tornado not visible to the eye. Combined with advanced weather modeling, the advanced radar technology could help forecasters potentially give the public a 30- to 60-minute lead time.

But traditional radar design still poses forecast challenges, even with the new technology. Conventional flat plate phased array radars create different characteristics when pointed different directions. The distorted signal returns make it harder to accurately interpret.

“It is similar to how we see things without moving our heads,” explained Guifu Zhang, OU School of Meteorology professor. “The objects seen through our side view are not as clear as what we see straight ahead.”

Zhang, whose research involves the design and calibration of radars, envisioned a novel solution around the problem—literally. He introduced a cylindrical concept to polarimetric phased array weather radar. Instead of using flat plates, the new design observes weather 360 degrees preventing measurements from being corrupted by radar scan angles.

“The design of a full-scale MPAR is challenging, but feasible,” said Zhang. “A cylindrical MPAR would open many opportunities for advancing technology and improving weather decision making. The more precise and faster we can make measurements, the better we can predict weather and warn the public.”

300 SECONDS IN THE DARK

We can provide a safer, more sophisticated system for the country, while reducing the costs of maintenance and operation costs tremendously.”

ROBERT PALMER
In 1950 the average life expectancy was 68 years. In 2012 the number was 79. The increased lifespan means more time to enjoy life. It also brings increased health risks, such as cancer and diabetes.

Biomedical engineering is the application of engineering principles to the medical and biological field. The profession helps translate medical discoveries from the lab into medical devices, therapies, drug treatments and improved patient care.

One area is neural imaging for brain diseases, like Parkinson’s and Alzheimer’s, a disease predicted to affect more than three million elderly people in the next 20 years. Another area focuses on biomechanics, such as cochlear implants to help people with hearing problems.

“The field is wide considering the health issues and medical care that confronts us,” said David Schmidtke.

University of Oklahoma chemical engineering professor and director of the OU Bioengineering Center.

Comprised of researchers from different departments within the College of Engineering—electrical, computer, industrial, mechanical and chemical—the Bioengineering Center focuses on several of the country’s most pressing health concerns.

Schmidtke said the center’s work helps people in situations the researchers may not have imagined when they first began. “We now have U.S. soldiers coming back from war with traumatic brain injuries and new physical challenges, like loss of hearing, from being too close to an explosion,” said Schmidtke. “We can help these veterans with the work we are doing now.”

Schmidtke’s own area of research focuses on diabetes and glucose monitoring. “By keeping the body’s sugar level consistently normal, diabetes can delay, or even prevent, many complications associated with the disease, such as blindness or nerve damage,” explained Schmidtke. “The best way to do that is constant monitoring.”

With the finger prick method, a diabetic may measure their levels up to four times a day without knowing if his blood sugar level is going up or down. Schmidtke is working on a sensor implanted in the body that would give a continuous read of sugar levels and send an alarm if the level becomes too high or too low.

Although we have made tremendous progress in healthcare,” said Schmidtke. “longer lifespan also means new diseases and health risks. As bioengineers, we can help improve the quality and care of that longer life.”
In the fight against breast cancer, the battle is often won based on early detection. And one of the most effective weapons in the arsenal are mammograms. Yet, even then, some 30 percent of women with early stage breast cancer go undetected.

That figure is 100 percent too high for Hong Liu, a researcher at the University of Oklahoma’s College of Engineering. Liu is an internationally recognized leader in medical imaging and the Charles and Jean Smith Chair in Biomedical Engineering. His research focuses on developing new technologies that can facilitate the early detection of cancer and help clinicians better interpret X-rays and other medical images.

“Breast tissue is one of the difficult human organs for X-ray imaging including state-of-the-art digital mammography because in part its dense tissue can result in low contrast on the image – it’s hard to distinguish subtle variations,” said Liu.

To address these issues, Liu and his collaborators are developing a new type of breast imaging technique called phase sensitive X-ray tomosynthesis. The X-ray beam provides additional information, called phase, to improve the contrast in the image. In addition, the 3D capability of the technique can remove the superimposed breast parenchymal structures and create a better quality “picture.” The technique has the potential to increase diagnostic accuracy and at the same time, reduces radiation dose to patients.

Liu’s prototype of the phase sensitive X-ray has been tested in the engineering laboratories and under clinical conditions in hospitals with successful results.

“Interdisciplinary collaboration is the key to success; here at OU, engineering researchers and physician cancer researchers are constantly working together to develop and test new technologies,” said Liu.

“Breast cancer is a curable disease if we find it in the early stages. If we can develop an engineering solution to help physicians better screen, diagnose and treat breast cancer patients, the opportunity for cure is so much higher.”

“EARLY DETECTION IS THE KEY”

About 1 in 8 (12 percent) women in the U.S. will develop invasive breast cancer during their lifetime. It is estimated that 232,340 new cases of invasive breast cancer will be diagnosed in women this year.

American Cancer Society, Last Medical Review: 08/23/2012

Death rates from breast cancer have been declining since about 1989. These decreases are believed to be the result of earlier detection through screening and increased awareness.
What if your smartphone could be wrapped around your wrist like a watch? Or, if an electronic tablet could easily fold to the size and thickness of a business card? Having flexible smart devices like these may be closer to reality than you think, thanks to nanotube research.

Nanotubes are the next frontier in the field of high-tech materials. They are small bits of carbon with multiple facets and atomic arrangement that greatly vary their properties in a tunable way. Daniel Resasco is researching these catalytic properties and has created the next advancement in nanotechnology—smart nanohybrids (i.e., chemically modified nanotubes).

“We make nanoparticles which are switchable and smart,” said Resasco, researcher at the Center for Interfacial Reaction Engineering and a professor in the School of Chemical, Biological and Materials Engineering at the University of Oklahoma. “We assign one behavior to the particle until it reaches the target, then the nanoparticle ‘switches’ to do something different than it did earlier in the process.”

For example, smart nanoparticles designed for oil recovery will react differently in water than they will in oil-embedded rock. When injected into the water, it would flow through the reservoir without dissolving. Upon detecting oil, the smart nanohybrid would stick to the surface of the rock and cause a chemical reaction that would release the oil from the rock.

In another example, nanohybrids used in the biomass conversion for fuel could essentially combine multiple steps of the process into one. It is difficult and costly to convert biomass solids into liquid.

“Nanoparticles will revolutionize the things we use in our everyday lives, from medical and aerospace to electronics and even the glass cover on your smartphone,” Resasco said. “We have amazing data, where you can literally see the tumor go into remission or disappear.”

Resasco and the research team at the Center for Interfacial Reaction Engineering collaborate with multiple organizations and institutions, including the Department of Energy’s Argonne National Laboratory, SouthWest Nanotechnologies, Oklahoma State University, the University of Tulsa and Rice University in Houston. Their research is focused in four specific areas that have a tremendous impact in commercial applications: biomedical engineering, enhanced oil recovery, biomass conversion, and composite materials, but has explosive potential in many areas.

Cancer treatments like chemotherapy are designed to be cellular warriors. While the potent chemicals kill tumorous cancer cells in the body, they also destroy healthy cells. This unselective process leads to the negative side effects often associated with the therapy. But promising research in the area of nanoparticles could help.

University of Oklahoma Chemical, Biological and Materials Engineering researchers Daniel Resasco, Roger Harrison and colleagues are exploring ways to destroy cancer cells from within. They are collaborating with medical researchers at the OU Peggy and Charles Stephenson Cancer Center.

“With nanotubes, we can design a smart nanomaterial that can travel through the bloodstream without dissolving,” said Resasco. “When the nanoparticles reach the specific cancerous cells, they can ‘switch’ some of their physical properties and be absorbed into the cancerous cells.”

Resasco and Harrison have engineered the nanoparticles to absorb near-infrared light. Once the cancer cells take up the nanoparticle, they can effectively absorb infrared radiation and the intense heat inside the nanoparticles selectively kills tumor cells without disturbing the healthy cells. Laboratory results are promising. So far in tests with mice, the survivability rate is near 100 percent.

“Cancer treatment gets smart with nanotubes.”

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DANIEL RESASCO
MANY PEOPLE ARE KILLED OR SERIOUSLY INJURED BY SEVERE WEATHER, DESPITE ADVANCE WARNING. A WEATHER-READY NATION WILL SAVE MORE LIVES AND LIVELIHOODS.
Da Vinci conceived the hygrometer to measure humidity and Anders Celsius devised the temperature scale. Now meteorology professor Phil Chilson has built his own machine to study the weather.

Chilson and his research team at the University of Oklahoma built and maintain a small unmanned aerial plane called SMARTSonde – Small Multifunction Autonomous Research and Teaching Sonde.

The plane is primarily used to study the lowest layer of the atmosphere, called the boundary layer.

“Having a portable measuring device like the SMARTSonde allows us to research a multitude of areas under a variety of conditions,” said Moore, who is also vice president for Weather and Climate Programs and dean of the College of Atmospheric and Geographic Sciences. “It allows collaboration and feedback on the impact of our work in real-time.”

The next step for the NWC is to prepare the public for what Moore calls “the space in between.” It is the gap between short-term weather forecasts and long-range climate predictions. OU has established a chaired professorship, sponsored by the Williams Companies, Inc., which will work conjunctively with other NWC affiliates to address this issue directly. The focus will be on seasonal and intra-annual variability to help bridge the gap.

“It is not just tornados,” Moore said. “We have got to be ready for snow storms, ice storms, strong winds and even droughts. Knowing the impact the weather will have 30 days or even a year from now can help people better plan, prepare and make informed decisions on both a personal and industry level.”

The NWC is also helping build a Weather-Ready Nation. Led by NOAA and supported throughout the weather community, the project aims to better prepare the public for severe weather.

The first in a series of National Dialogue events was held at the NWC where key actions were identified and set in motion to improve the nation’s resiliency against all weather-related events including, but not limited to, severe weather. With assistance from NOAA, the National Severe Storms Laboratory, Storm Prediction Center and OU’s School of Meteorology, NWC leadership is reviewing recommendations stemming from the National Dialogue events and collaborating to take a leadership role in determining the most effective way to educate the public in how to be more “weather-ready.”

The expertise in weather research, forecasting and analysis that resides in Norman to address weather issues plaguing the nation has positioned the NWC as a magnet for people who want solutions. “That is really the purpose of the NWC,” said Moore, “to have a place where the nation’s weather business is done.”

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By 8 a.m. on May 24, 2011, the National Oceanic and Atmospheric Administration National Weather Service was predicting a potential tornadic outbreak that day between 5:30 and 6:30 p.m. along the I-35 corridor in Norman, Okla. The news surprised National Weather Center Director Berrien Moore III.

“I remember looking out the window and not seeing a cloud in the sky,” Moore said. “In fact, I was going to play golf that afternoon.” Throughout the day, as satellite photos, weather models and radar data converged, university meteorology researchers monitored the situation and NWS forecasters provided detailed warnings to the public. At 5:35 p.m., the first tornado appeared and by the end of the day, Oklahoma experienced multiple tornadoes.

“Well in advance of severe weather, top scientists and weather agencies collaborate to develop tools and knowledge used by NOAA forecasters to provide forecasts and warnings. In this case, the NWS was able to sufficiently warn people that in eight hours we are going to have tornadic conditions,” Moore said.

The combination of university, federal and state weather agencies all housed in the same building with private weather companies nearby is unusual. “There is no other place like it on the planet,” said Moore, who is also vice president for Weather and Climate Programs and dean of the College of Atmospheric and Geographic Sciences. “It allows collaboration and feedback on the impact of our work in real-time.”

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Knowing the impact the weather will have 30 days or even a year from now can help people better plan, prepare and make informed decisions on both a personal and industry level.”
KNOWING YOUNG CHILDREN STRUGGLE IN SCHOOL DUE TO LOW INCOME IS A DIFFICULT FACT. REALIZING IT DOESN’T HAVE TO EXIST AND STILL DOES IS EVEN MORE DIFFICULT.
Looking at toddlers, constant explorers and curious minds, you can easily imagine the opportunities their futures may hold. Although they may not be able to reach the water fountain, and think dirt is fun to play with and eat, you trust with time and guidance they will grow to their unlimited potential. But what if the quality of child care, even as young as infants, limits their potential in life?

“Long-term research on early childcare shows that young children who experience high-quality early care do better in school, graduate from high school and college at higher rates, earn more as adults and establish more stable families,” reported Diane Horm, George Kaiser Family Foundation Endowed Chair of Early Childhood Education. “That is why the ECEI focuses its research on this narrow, but critical window of time.”

The ECEI and the ECE bachelor’s-completion program at OU-Tulsa were established in 2006 with two objectives. The first is to focus on early childhood workforce development because caregivers with more professional preparation are shown to provide higher-quality early care and education for very young children. The second is to build a research institute that conducts applied research on this narrow, but critical window of time.

The ECEI’s goal is to become the nation’s foremost center for research on the development of infants to three year olds. This area is the frontier of early childhood education, yet lacks robust research.

The ECEI works as local evaluators with the early childhood professional to use data to understand their young students and inform the distinct development and learning of infants, toddlers, twos and threes within early care and education settings through research, dissemination and application.

“We do much more than simply hand over the data,” said Horm. “We want the program, the teachers and, ultimately, the child to be successful. That is why we work collaboratively with the early childhood professional to use data to understand their young students and program better.”

FINDING THE KEY TO CLOSING THE ACHIEVEMENT GAP

Family income shouldn’t be a predictor of school success. But, sadly, study after study documents a relationship between family income and child achievement with children from low-income families not doing as well in school than their more advantaged peers.

One of the University of Oklahoma-Tulsa Early Childhood Education Institute’s key areas of research is the achievement gap, or the difference in academic performance between children from low-income families and their middle-class peers. The center has found that high-quality early childhood education is key to closing, and even preventing, that gap.

In the ECEI’s research with Educare, a comprehensive program serving young children living in poverty, it was found that children who enter the program as infants and toddlers started kindergarten performing at national averages. Kids who joined the program at three already show evidence of the achievement gap.

Across the national network of Educare sites, the research shows that children who enter a high-quality program as infants and toddlers consistently score near the national average for children of all income levels. This same impact was not evident in children who started the program later. Said another way—starting early in a high-quality early care and education program can prevent the achievement gap from forming.
2013 UNIVERSITY OF OKLAHOMA RESEARCH REPORT
DIGITAL EDITION NOW AVAILABLE

This report is also available free of charge online, and as a digital edition for iPad® users. Both the online version and digital edition include the entire publication as well as videos that further explain the exciting programs highlighted in the 2013 University of Oklahoma Research Report.