



TEXAS TECH UNIVERSITY  
**DISCOVERIES**  
AND **RESEARCH**  
**INITIATIVES**



TEXAS TECH UNIVERSITY®

## DISCOVERY DRIVES TEXAS TECH UNIVERSITY

To quote Albert Szent-Gyorgyi, a Hungarian physiologist and Nobel Prize winner, “Discovery consists of seeing what everybody has seen, and thinking what nobody has thought.” And according to Louis Pasteur, “Chance favors only the prepared mind.”

Discovery happens every day on our campuses. The work of faculty and students constantly expands what we know. Each discovery, great or small, contributes to making our economy healthier, our lives better and our country stronger.

Much of what we discover is supported by federal, industry and private funding. Most of the nation’s research and development is now taking place at universities. At Texas Tech University we take our mission of research and discovery seriously and we pride ourselves on pushing the envelope a little further and digging a little deeper to accomplish these goals.

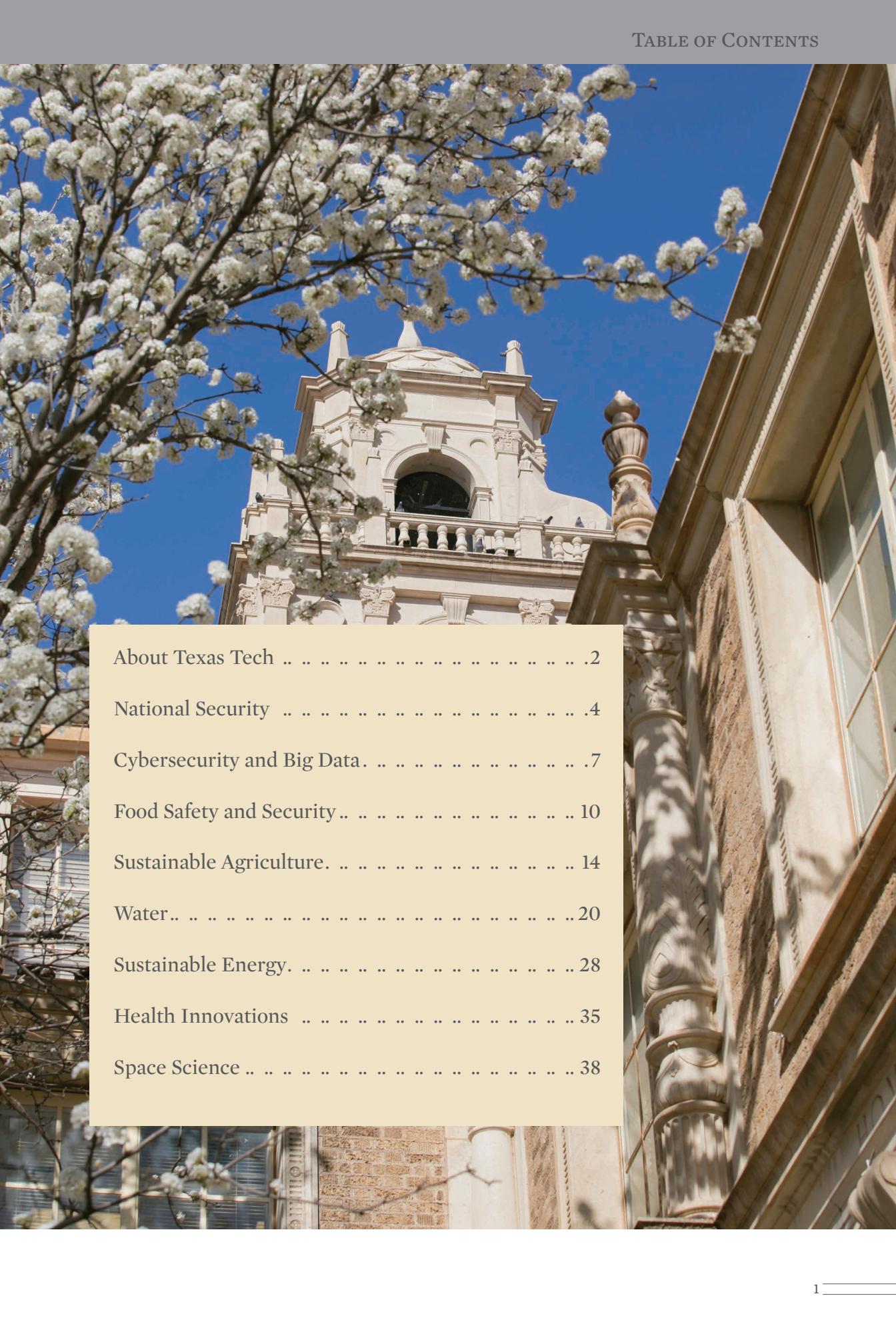
For example, a Texas Tech researcher looked at low-grade cotton and wondered if it could soak up toxic chemicals. With support from federal and private funds, he discovered that adding a carbon layer between two sheets of cotton will indeed wipe up toxic chemicals and in the process created a way to help keep our military and first responders safe.

Other Texas Tech scientists walked through a community devastated by a tornado and asked how people could be better protected from the wind and flying debris. The result is a reinforced above ground shelter that can be built into a closet in a home that will withstand the strongest winds.

A new project will improve the nation’s antiquated energy grid. The university is developing the world’s largest testing and certification facility for new technologies to manage and integrate new power sources into the nation’s electric grid.

These innovations would never have happened had it not for the belief and funding provided by generous and visionary people who see the value in what we do every day.



The background of the page features a low-angle photograph of a classical building with a prominent dome and ornate architectural details. In the foreground, the branches of a tree with white cherry blossoms are visible against a clear blue sky. The table of contents is overlaid on a light yellow rectangular area in the center-left of the image.

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# About Texas Tech

Texas Tech University met the research and academic criteria to receive the designation of National Research University from the state of Texas in 2012. That designation is the foundation of the university's goal of becoming a Tier One university.

The terms national research university and tier one are often used interchangeably and have no singular definition. Most consider Tier One universities to be members of the Association of American Universities or have characteristics of those institutions.

Texas Tech continues to strengthen its already excellent research and academic opportunities. The university also realizes that 21st century universities must contribute to the economic prosperity of their regions and states.

Texas Tech recognizes the importance of economic engagement and transferring our new knowledge into the marketplace. To that end, the university is providing its faculty, staff and students with opportunities to accelerate new businesses and support startup companies.

The university's dedication to the economic prosperity of the region, state and nation was recognized in 2014 when the university received the Innovation and Economic Prosperity University designation from the Association of Public and Land-grant Universities (APLU). The designation, instituted in 2013, acknowledges universities working with public and private sector partners in their states and regions to support economic development through a variety of activities, including innovation and entrepreneurship, technology transfer, talent and workforce development, and community engagement.

Perhaps the most visible symbol of the university's commitment to technology transfer is the new Innovation Hub and Research Park building on the northwestern side of the campus. The building provides common space for academic programs that promotes entrepreneurship and innovation. There is laboratory and research space for public-private partnerships with companies such as Chromatin, a major agbiotech company currently headquartered in Chicago. The facility also provides resources for new startup businesses that are built primarily around faculty intellectual property.



## INNOVATION HUB AND RESEARCH PARK BY THE NUMBERS

- \$29 million facility
- 40,000 square feet
- Laboratory, research and office spaces designed to meet tenant needs

Innovation Hub and Research Park



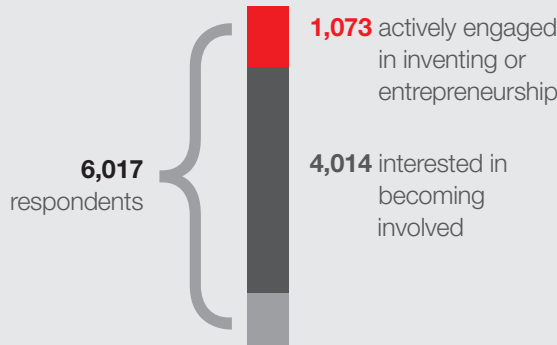
TEXAS TECH BY THE NUMBERS:

- Texas Tech is the flagship of the four-university Texas Tech University System. Also in the system are the Texas Tech University Health Sciences Center in Lubbock, the Texas Tech University Health Sciences Center at El Paso and Angelo State University.
- Texas Tech offers more than 300 undergraduate and graduate degrees through 12 colleges and schools, including the Graduate School and School of Law. There are more than 60 research centers and institutes at Texas Tech.
- The university has four members of the National Academy of Engineering. Election to the National Academy is considered one of the highest professional honors among engineers.
- Texas Tech’s economic presence extends beyond the South Plains and across the state. The university supplied more than \$6 billion to the state economy in 2012, a number projected to grow to \$10 billion by 2020.

STUDENT  
ENTREPRENEURIALISM

Texas Tech recognizes that students play an important role in the university’s innovation successes. A campus-wide survey showed wide-spread interest in entrepreneurship. Armed with that information, the Office of the Vice President for Research created a new student-led organization, Texas Tech Innovation Mentorship and Entrepreneurship (TTIME) that is designed to create a culture of entrepreneurship across campus and is open to all undergraduate and graduate students from all majors across the university.

2014 Student Entrepreneurship Survey



# National Security

To help ensure our national security, U.S. troops must be able to work faster, harder and longer. In addition, their equipment must be able to operate efficiently and effectively while adapting to an ever-changing environment. Texas Tech is fully committed to serving U.S. national security interests.



Once 3-D printing of munitions is developed, the U.S. will be at the forefront of defense creating a more mobile, efficient military.

## 3-D PRINTED AMMUNITION

Work at Texas Tech could allow the military to eventually print the munitions troops need in the amounts needed and very close to the action. All it will take is a 3-D printer.

Currently munitions are made in vast quantities and stockpiled. The new research could ultimately create a production system that moves with any military group so that they can print exactly the ordnance that they need in a particular situation. The work will open a more effective, more mobile and ultimately more cost efficient system.

Researchers are working to introduce and stabilize explosives into plastic that can be printed into bullets and many other traditional munitions. Currently the fuels such as aluminium tend to settle to the bottom of the liquid plastic before it's printed. Scientists are working to develop a type of coating around the aluminium particles to keep them suspended, so that ultimately when a bullet, for example, is printed the energy will be evenly dispersed for the most effective explosion.



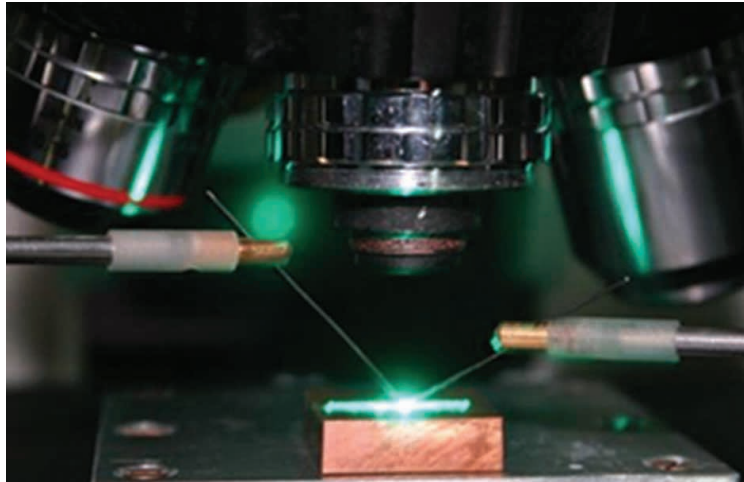
## NANOPHOTONICS

Working with materials less than one-thousandth the width of a human hair, scientists at the Nanophotonics Center at Texas Tech could revolutionize military defense systems and consumer products by creating smaller, more efficient light sources and detectors.

Researchers are developing nano-scale, chip-size materials that could lead to the creation of significantly more compact and powerful lasers for use by the military that, in effect, reduce the size of a missile defense system from the size of a 747 aircraft to something that could fit on a small truck.

Solid-state detector development would reduce the size of machines used at shipping ports to scan large crates coming off ships for nuclear materials, creating enhanced capabilities for countering nuclear terrorism with significantly lower cost and more capable radiation detectors.

Researchers also are working on the development of miniature displays in helmet-mounted or head-up display systems of aircraft pilots and on-deck air controllers. Researchers are working with technology that will create high definition television small enough to fit on a pair of eyeglasses or goggles, meaning a pilot would not have to look down to see a screen; the data will be right in front of him or her.



High efficiency green light emitting devices developed in the Nanophotonics Center at Texas Tech. These photonic devices have applications in ultra-portable products such as next generation pico-projectors, miniature displays, lighting, underwater laser communication and light source for neuronal stimulation.

## PULSED POWER AND POWER ELECTRONICS

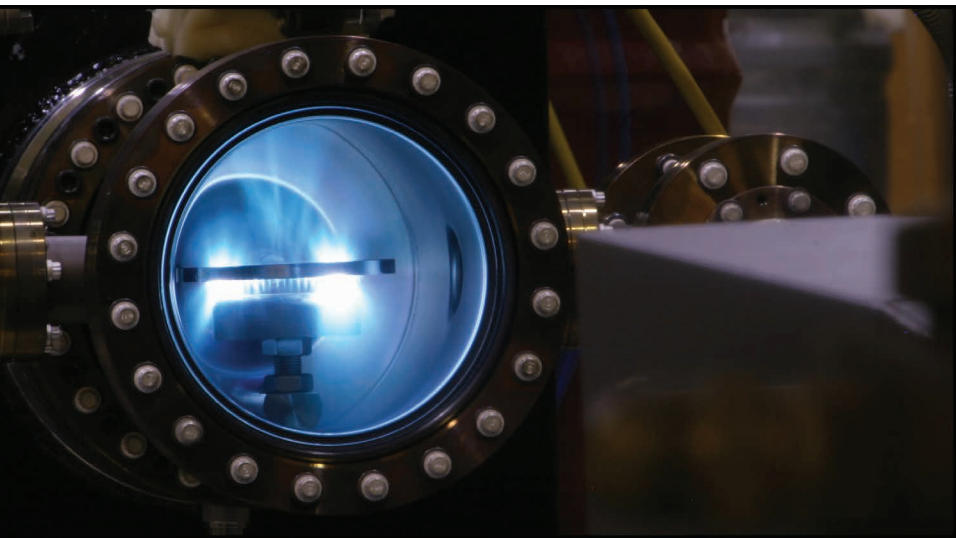
Military forces are facing new and unpredictable adversary attacks on the battlefield. Texas Tech utilizes its expertise in generating very high-power electrical pulses to provide troops on the battlefield with effective, innovative technology. Research covers the spectrum from basic physics to applied systems design.

Scientists are focusing on plasma, pulsed power and power electronics research involving high-powered RF and microwave generation, high-power switching, high-power advanced electrical and thermal packaging and high bandwidth monitoring and control of electronic machines.

A key focus is the development of systems that can be used in the field to disable improvised explosive devices, or IEDs. The goal is to develop a device that would allow troops to drive down the road and detonate IED's by remote control.

The same research could also allow U.S. troops to knock out the enemy's communications systems and weapons at a distance.

Researchers also are creating compact systems that will be more manageable for troops in the field. Among the work is developing methods for advanced communication over long distances.



Texas Tech has been involved in pulsed power research for more than 40 years. Today it has millions of dollars a year in research funding.



# Cyber Security and Big Data

Computers drive everything. The nation's transportation systems, water and sewer plants, electrical power grids and oil pipelines are all connected to computer networks. Cyberattacks are becoming more common, and the recent recent high profile attacks demonstrate how disruptive these attacks can be. The White House has created the Cyber Threat Intelligence Integration Center to coordinate cyber threat intelligence from federal agencies.

Along with security concerns, the demand for ways to better store and use big data is growing. Texas Tech researchers are developing numerous projects to learn more about how to protect the country's critical infrastructure and better handle the demands of the nation's data.



Texas Tech University researchers are looking not only at how best to defend our critical infrastructure from cyberattacks, but also how to train the next generation of engineers, business leaders and lawyers who must deal with cyber issues.

## BUILDING THE FUTURE

Texas Tech researchers have received almost \$750,000 in NSF funding for two programs to train the next generation of engineers, business leaders and lawyers who must deal with cyber issues.

An interdisciplinary education program aimed at strengthening Texas Tech's cybersecurity curriculum involves industrial, electrical, mechanical and computer engineering, computer science, mathematics and the Texas Tech School of Law. The program offers certificates in its bachelor's

and master's programs as well as an online certificate.

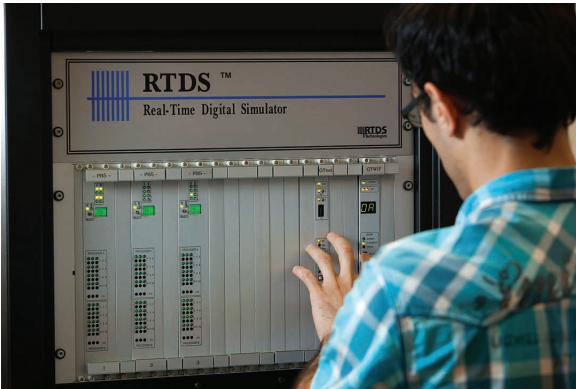
A second effort focuses on increasing the number of trained cybersecurity professionals. A joint effort between Texas Tech and sister institution Angelo State University focuses on the region's community colleges. The program will bring faculty members to Texas Tech for two summer workshops to assist in creating new courses and integrating more cybersecurity material into existing curricula.

## PROTECTING THE INFRASTRUCTURE

A National Science Foundation Major Research Instrumentation grant provides funding for researchers to build a real-time simulator for smart grid systems, such as the nation's electric grid, that will allow researchers to see how the systems behave in real time if they are interrupted by an attack or a natural disaster.

Building on Texas Tech's wind engineering program, scientists are investigating the stability and power ratings of the generators powered by wind turbines. The turbines at Texas Tech's wind research facility will be used to power a mini-smart grid for research projects, including cybersecurity threats.

Researchers have simulated a basic manufacturing application, with simple manipulators standing in for industrial robots. The manipulators are networked together to provide a testbed for both control system education and cybersecurity research. Students are introduced to the fundamentals of networked industrial control systems, including vulnerability to cyberattack, in undergraduate and graduate courses.



A real time simulator mimic's the nation's power grid so that researchers can see how the system behaves when it is interrupted by a cyber attack or is damaged by a natural disaster such as a hurricane.

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## CREATING A FASTER, BETTER METHOD FOR SUPERCOMPUTING

Supercomputing has become a popular and useful tool to conduct computer simulations and data analysis for scientific discovery in many fields from climate sciences, healthcare, biology, chemistry to astrophysics. As data volume grows over time in the current "computing-centric" model, data floods into the computer system, creating a bottleneck of information.

A computer scientist at Texas Tech recently received a \$1 million grant from the National Science Foundation to create a faster, better method for supercomputing.

This project will develop new concepts and methodologies of "data-centric" solutions. It intends to achieve better performance, efficiency and productivity in scientific discovery via computer simulations and analyses.



## CLOUD COMPUTING AND SUPER COMPUTERS

Researchers at Texas Tech University are playing a leading role in an industry-oriented consortium of experts called the Cloud and Autonomic Computing Center (CAC) to provide research and development to businesses interested in these computing areas.

Cloud computing is an important new major industry trend. The term refers to the storing and accessing of data and computational services on the Internet rather than using only a single computer's hard drive and processor.

Autonomic computing systems are designed to work automatically with self-healing, adaptive learning algorithms.

The National Science Foundation selects only a small number of premier research centers in the country to lead such research through its Industry/University Cooperative Research Centers (I/UCRC) program. The CAC at TTU partners with another site at Mississippi State University through this program to solve real-world problems of business value to its

members while managing risk factors such as information security, privacy, compliance and regulation.

CAC funding comes primarily from industry, with the NSF providing only administrative support, selection and program oversight. Companies pay a fee to join the center, earning them the ability to select and approve research projects and gain access to brand-new research and university capabilities. Companies participating as members in Texas Tech's CAC so far include computing hardware manufacturers, health care and banking entities and the Defense Information Systems Agency, which serves as the information technology advisory arm to the U.S. government for the Department of Defense.



The CAC at TTU specializes in development, conformance testing, production of reference implementations and performance evaluations of a wide variety of cloud software and standards.

## Food Safety and Security

The U.S. is blessed with a plentiful food supply, yet the Centers for Disease Control estimate that 48 million cases and more than 3,000 deaths occur in the U.S. annually due to food-borne illness. In Mexico, the situation is worse. Food-borne illness is the leading cause of death in children younger than 5 years old.

Safe, healthy food is not the only concern. Worldwide, the United Nations estimates that 2 billion people and nearly 200 million children under five years old suffer from under nutrition, with more than 3.5 million children dying from under-nutrition each year.

Texas Tech's International Center for Food Industry Excellence (ICFIE) is focused on making food safer for consumers around the world through approaches that can be implemented in a variety of production settings from farm to table. Researchers at The Institute of Environmental and Human Health (TIEHH) are taking a different tact focusing on the spread of emerging diseases from domestic animals and wildlife to humans.





## GLOBAL IMPACTS - FOOD SAFETY, FOOD SECURITY AND PUBLIC HEALTH RESEARCH

Working with government agencies, universities and development agencies across the U.S., Central America, the Caribbean and Europe, ICFIE researchers are assisting in the development of food production and safety practices and public health education.

In particular, much effort is focused on understanding the food safety culture of workers in food production environments, a critical issue as attitudes toward food safety affect the likelihood of effective and sustained behavior change.

One example of the work ICFIE is doing is in Honduras. Working with the government, researchers are using local resources to feed cattle as a sustainability project to increase both the economic value and the amount of meat available to the people of Honduras. The project also puts an emphasis on public education in food safety.

The ICFIE team's public health efforts also focus on reducing cases of salmonella, E. coli and listeria as well as looking at implications of antimicrobial resistance.

Antibiotic resistance is a growing and profound threat to public health. ICFIE researchers are providing critical new information to better understand the extent and factors that contribute to antibiotic resistance. Just as importantly, they are discovering and testing practical approaches to mitigate this urgent threat.



In the Bahama the ICFIE team is working with the government to develop a new agriculture school by teaching artificial insemination techniques and food safety.

Photo by Alejandro Echeverry



## SALMONELLA DISCOVERIES

With more than a decade of experience working on Salmonella, researchers have recently reported that salmonella can be harbored within peripheral lymph nodes, which may pose a threat to consumers. Texas Tech was the lead institution on the first competitive award from the United States Department of Agriculture and National Institute of Food and Agriculture to understand this phenomenon in cattle populations and is now focused on reducing the threat to human health.

## NEW SEROTYPE

A Texas Tech research assistant professor recently discovered a new serotype of the salmonella bacteria. The discovery has been confirmed by the Pasteur Institute in Paris, the international reference center for salmonella. The discovery means it is now possible to simultaneously detect and distinguish specific strains of salmonella by targeting a specific combination of DNA. That will allow for early detection in food while also identifying whether it belongs to a highly pathogenic strain. Because convention calls for a new serotype to be named after the city in which it is discovered, this one will be called Salmonella Lubbock (officially *Salmonella enterica* subsp. *enterica* Lubbock).

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## THE ANIMAL-TO-HUMAN CONNECTION

Researchers at TIEHH are focused on public health surveillance for man-made contaminants and biological threats that naturally occur in the environment, as well as various pathogens and toxins that may be intentionally introduced.

Zoonotic diseases such as anthrax, brucellosis, plague and tularemia that naturally occur may enter the food supply and infect humans through meat, meat products and dairy products. Another transmission point is through wildlife. Hunting and fishing are big business in the U.S. In Texas more than \$14 billion dollars is generated annually to the economy, and those who handle, clean or eat wild game face a risk of exposure to disease.

By understanding the transmission dynamics between animals and humans and how to interrupt that cycle, humans are less likely to be exposed to diseases.



The addition of the biological safety level three laboratory allows Texas Tech to function as a public resource for the identification and confirmation of biological samples for outbreaks of infectious diseases and other public health emergencies, as well as increase research into how to break the disease transmission cycle.





## PUBLIC HEALTH CONCERNS

TIEHH also is bringing chemical analysis expertise to bear on potential public health concerns through man-made contamination. TIEHH researchers are working with Barksdale Air Force Base in Louisiana to look at the impact of perfluorinated compounds (PFCs), which are used in foams used to put out fires.

Researchers are focused on two bayous near an old fire training area that have detectable levels of PFCs in water, sediment and fish tissue. Although access to the base is controlled, those bayous flow off of base property. TIEHH researchers are looking not only at the ecological impacts of PFCs, but also at the potential for human health risks associated with fish consumption in these waters.

## FOOD SAFETY AND SECURITY RESEARCH HIGHLIGHTS:

- Using a farm-to-fork approach to reduce food-borne pathogens such as E. coli and salmonella
- Working to preserve the efficacy of antimicrobial drugs for future generations by mitigating antimicrobial resistance in bacteria carried in food-producing animals
- Working with developing countries to create sustainable food sources, improve public health education and increase economic value
- Examining how contaminants may affect the food chain
- Disrupting the cycle of disease transmission from animals to humans
- The cattle industry is widely adopting pre-harvest interventions to eliminate foodborne pathogens that were critically evaluated or discovered by Texas Tech researchers.
- State-of-the-art packaging methods have added value to existing products by extending shelf life. Data generated from Texas Tech's work has been used to support industry needs before the USDA and the Food and Drug Administration
- Microwave technologies have been developed to extend shelf life of food and improve food security to meet growing food demands worldwide



# Sustainable Agriculture

Cotton is still king in Texas. The Texas High Plains produces about 30 percent of U.S. cotton. However, producers are facing drought conditions and rapidly declining ground water sources. The line between irrigated and dry land crops is blurring. In effect, a great deal of the cotton grown on the High Plains is dryland, with many producers using supplemental irrigation with varying capacities.

## *The line between irrigated and dry land crops is blurring*

Agriculture accounts for 40 percent of the region's economy but depends heavily on water from the rapidly declining Ogallala Aquifer for irrigation. Finding more water-efficient, drought-tolerant crops is vital. Texas Tech researchers have a variety of projects focused on cotton as well as other crop varieties and urban plant solutions.



## BUILDING BETTER COTTON

A team of Texas Tech researchers has moved the science of producing cotton forward through the significant accomplishment of sequencing the cotton A-genome. The research, done in collaboration with Bayer CropScience and the National Center for Genome Resources, significantly advances cotton research worldwide. This important breakthrough will lead to improved cotton varieties, particularly ones that are more tolerant to drought and that contain environmentally friendly traits, which are favored by producers, processors, manufacturers and consumers. In addition, it provides the basis to link genomics and phenomics.

The public-private partnership between Texas Tech and Bayer CropScience has created a joint research venture named Project Revolution. The program is designed to develop cotton fibers that have unique characteristics for the textile market. Specifically, scientists from Project Revolution are working to develop cotton fibers that decrease the need for chemical processing in textile manufacturing.

Since 1998, Bayer CropScience has contributed \$27.6 million to Texas Tech. The university received State matching funds from the Texas Research Incentive Program and from the Regents Professorship program to bring the total impact of the Bayer CropScience gift to \$54.85 million, making it the largest investment for research in Texas Tech history. In addition to research, the Bayer CropScience gift is funding numerous scholarships for students and an endowed faculty chair primarily in the Department of Plant and Soil Science.



The most visible result of the Bayer CropScience partnership is the expansion of the existing Plant and Soil Science building, which is now under construction. The building and addition will be named the Bayer Plant Sciences Building.

### COTTON RESEARCH HIGHLIGHTS:

In addition to genome sequencing and Project Revolution, the Texas Tech cotton research program is broad-based, addressing virtually all aspects of cotton production and utilization of cotton fiber. Among the research goals addressed by the Texas Tech cotton research program are:

- Mitigate the effects of water and heat stress on cotton yield and quality
- Minimize the effects of insects, weeds and diseases on cotton yield and quality
- Develop innovative genetic improvement tools through conventional breeding, molecular breeding, and structural and functional genomics
- Increase knowledge and application of the cotton genome (further genome sequencing, marker-assisted selection, etc.)
- Extend genomics research in cotton through high-throughput phenomics in the laboratory and the field
- Use knowledge of the genome to better exploit the available genetic diversity (leading to the release of new germplasm)
- Characterize the effects of crop termination, harvesting and ginning methods on cotton fiber quality
- Develop improved crop management practices (pre- and post-harvest) to optimize farmers' revenue (yield and quality)
- Elucidate the effect of the chemical and physical properties of cotton fibers on the ability to process the raw material
- Develop new uses for the biopolymers extracted from cotton (cellulose, proteins and fatty acids) such as bioplastics, functionalized substrates, filtration, etc





TEXAS ALLIANCE FOR WATER CONSERVATION

Texas Tech’s research into more efficient and effective agriculture practices has provided timely information and techniques to producers during the state’s recent severe drought.

Since 2005, Texas Tech has managed the Texas Alliance for Water Conservation (TAWC), a consortium of public and private producers and agencies. TAWC has received nearly \$11 million in funding from the Texas Water Development Board.

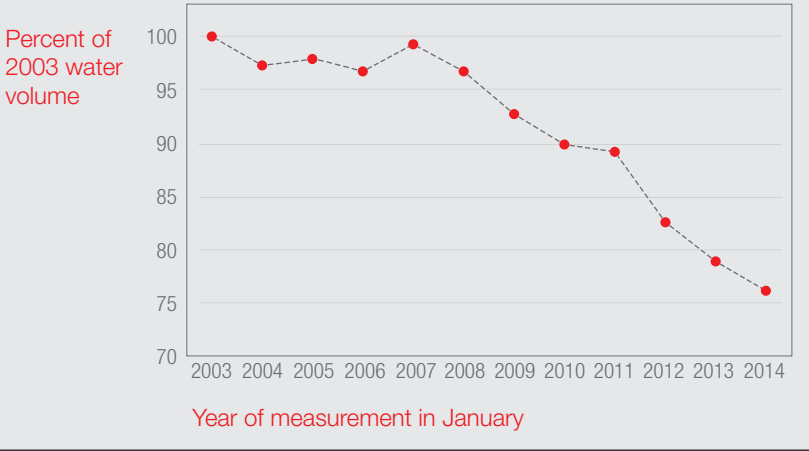
The project monitors 34 sites and more than 6,000 acres with varying types of crop and cattle production. During the past decade,

the group has devised online decision-making tools, including an irrigation scheduler and resource allocation analyzer to assist producers in making more cost-effective decisions about which crops to grow in which fields and to know when and how much water to apply.

The TAWC program has expanded the number of producer sites and the number of counties taking part in the project and plans to enhance the online tools with the addition of more crop options and to promote wider use outside the High Plains region.

GROUNDWATER DECLINE

The amount of groundwater stored under the area that encompasses the Texas Alliance for Water Conservation farm demonstration sites shows a 24 percent decline during the study period, most of which occurred in the last seven years. The numbers indicate groundwater is declining at a faster than anticipated rate.



## TAWC GOALS FOR DEMONSTRATION AND COMMUNICATION:

- Decrease total water use through precise irrigation management
- Enhance profitability and sustain rural communities
- Identify the most effective crops, cropping practices and irrigation systems
- Understand decision-maker behavior to extend the impacts of water conservation measures
- Develop sustainable agricultural systems that involve drought-tolerant crops and the use of livestock and pasture systems that decrease water use and diversify income sources for farmers

About 30 percent of the nation's cotton is produced on the High Plains of Texas. It's estimated that about 40 percent of the region's economy is based on irrigation. A major research focus of the TAWC is to develop ways to decrease total water use through precise irrigation management.



AGRICULTURE POLICY

The International Center for Agricultural Competitiveness is dedicated to the creation and dissemination of knowledge related to the competitiveness of U.S. and global agriculture. The experts in the center regularly provide reports on the medium-term outlook for the U.S. and world markets for cotton and other commodities and brief members of the U.S. Senate and House Agriculture Committees for projections for those markets. They also analyze the effects of alternative policies and external factors on production, utilization, farm and retail prices and farm income.

While the center focuses on both domestic and international policy, research also focuses on how producers adopt new technology, product development, resource management, trade, and international development.

URBAN AGRICULTURE

Agriculture is not just crops and cattle. It also includes urban parks and golf courses, home lawns and gardens.

Texas Tech has research underway to develop practices that decrease amounts of water used in irrigating urban lawns and greenspaces. Scientists also are identifying ornamental plants that use less water, while making urban environments cooler and more comfortable. Research focuses on increased commercialization of planting materials adapted to the West Texas urban landscapes, as well as the education of urban policymakers, landscapers and residents on methods of providing aesthetics and improved comfort of outdoor urban living, while limiting water.



Researchers are working with area golf courses, including Texas Tech’s own Rawls Course, to examine better, more water-efficient turf grass varieties and water use patterns.



# Water

Severe drought can be economically devastating. Researchers at Texas Tech are taking an integrated approach to understand the long-term impacts of drought in groundwater dependent regions such as West Texas.

Droughts occur when existing water supplies cannot meet demands. They are unique from other hazards in that their arrival, persistence and cessation cannot be readily defined. Long-term persistent droughts in water parched arid and semi-arid regions such as West Texas can be devastating. In 2011, Texas experienced the worst single year drought, which is estimated to have caused a \$7.6 billion in losses to the agriculture sector alone. Such droughts have ripple effects throughout the economy.

Reacting to the long persistent droughts during the 1950s, a large number of reservoirs were constructed and existing ones expanded to meet the growing water demands of the state and to protect against drought hazards. This strategy no longer works as the river basins that often feed the reservoirs have been over used. Lakes and reservoirs also lose large quantities of water during droughts due to reduced inflows and increased evaporation, making them unsuitable for water storage in arid and semi-arid regions.





The state of Texas, in its most recent water plan, has recognized that during serious drought conditions, Texas will not have enough water to meet the needs of the people, its businesses and its agricultural enterprises.



**2011 DROUGHT IMPACT IN TEXAS**

167,000 lost jobs  
net loss of \$17 billion in lost output  
can lead to other hazards such as property loss to wildfires



**CURRENT CALIFORNIA DROUGHT IMPACT**

estimated to result in losses exceeding \$2 billion  
17,000 lost jobs.



# GROUNDWATER

Groundwater sources, such as the Ogallala Aquifer, are increasingly relied upon during periods of drought, and the total groundwater use in Texas increased by 30 percent between 2010, a relatively wet year, and 2011, an extremely dry year. While groundwater historically has been used primarily for agriculture in West Texas, many cities are increasing their reliance on groundwater resources. However, as groundwater is not directly exposed to the atmosphere and usually exhibits a delayed response to changes in precipitation, the effects of droughts on this slowly replenished resource is poorly understood.

Unlike lakes and rivers which dry up under drought conditions, aquifers offer no visual clues with regard to their depletion making it extremely difficult to communicate the effects of drought to the public in order to promote conservation of this precious resource.





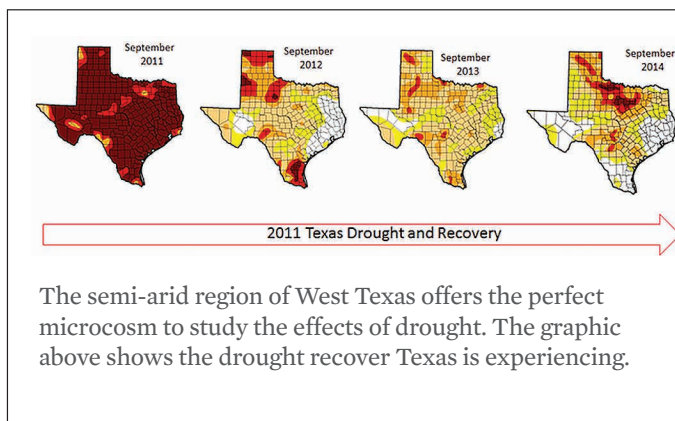
## A PERFECT LABORATORY

The semi-arid region of West Texas offers the perfect microcosm to study the effects of drought. The area lies at the cusp of Atlantic and Pacific influences which results in a highly erratic climate regime punctuated by severe droughts and extremely wet years. The impacts of droughts tend to persist over longer periods of time compared to other parts of the state.

Projections indicate that this variability will further increase in the 21st century as the region warms up by 2 – 4 degrees C. This traditionally agrarian area has dwindling water supplies due to the over-exploitation of the Ogallala Aquifer. The region also is home to the largest oil and gas reserves in the nation and sharp increases in oil and production using unconventional, hydraulic fracturing, techniques have increased the competition for water between food and energy sectors. This growing competition for water under a more erratic climate regime requires us to fundamentally rethink the way we manage this resource for the long-term sustainability of the region. New water management strategies and innovative engineering solutions are needed to solve the problem of projected future deficits arising from over-exploitation of ground water sources.

To address these needs, Texas Tech's group of interdisciplinary researchers is currently focused on:

- Developing new tools and techniques to forecast drought characteristics
- Understanding public perceptions related to droughts and improving drought communication strategies
- Evaluating the resilience of existing water infrastructure in the region to withstand long-term droughts and developing engineering solutions to improve storage and management of water resources
- Augmenting water supplies in the region through wastewater reuse and development of brackish water sources



## TEXAS WATER PROJECT – SUPPORTING THE FUTURE ECONOMIC NEEDS OF THE STATE

The difficult job of meeting Texas' future water needs will only be exacerbated by an expected 82 percent population growth by 2060, long-term climatic changes and the continued growth of a water-intensive but high value-added industrial and energy economy.

Texas Tech University researchers are at the forefront of addressing the state's future water needs and are offering potential solutions.

### CURRENT SITUATION

Current efforts are focused on conservation and better capturing and using our existing fresh water resources. While these efforts hold great potential, the economic future of Texas will be constrained without the injection of a significant new water supply. Current plans are likely to only partially meet future needs and will not attract substantial investment in new high value-added industries that need to be the foundation of the future Texas economy. Moreover, these “bottom up,” or individual plans, do not address Texas-wide solutions for a new water supply that can complement and supplement local and regional plans.

### POTENTIAL SOLUTION

New water supplies must largely come from the exploitation of poor quality waters in the state including seawater and inland brackish waters. These sources generally cannot be used directly but instead require costly treatment and transport to the areas where they are needed.

Because many of the areas in need of water are located far from the coast or have needs that transcend what might be available from brackish waters, a large coastal desalination facilities to remove salt, and a pipeline project that can significantly enhance water supplies throughout Texas is envisioned. Such a “top-down,” or statewide project that transcends individual communities and regional water planning projects can take advantage of significant economies of scale and complement

the current “bottom-up” efforts to be the cornerstone of a future high value-added Texas economy. The project should benefit all areas of Texas, including providing water for water-strapped communities in West Texas as well as the rapidly growing communities in central and southeastern Texas. The project should also aid irrigated agriculture by reducing demand on traditional water sources on which this sector depends

A rigorous economic evaluation and cost-benefit analysis is required to fully define a viable source of new supply across Texas. A particular concept is defined here to illustrate the potential of integrated cross-Texas planning and define a starting point for a preliminary engineering design and cost-benefit analysis.



## THE FEATURES OF THIS CONCEPT FOR DEVELOPING NEW WATER RESOURCES FOR TEXAS INCLUDE THE FOLLOWING:

- Develop a large desalination capacity in south-central Texas. The capacity of the facility, or facilities, should be 500 million gallons per day (560,000 acre-ft/yr) or more. This single project would provide the order of 20 percent of the expected additional needs for water in the high growth areas of central and southeastern Texas in 2060.
- Emphasize local or regional seawater desalination projects in south Texas in recognition of their proximity to the coast and distance from large population centers in north and central Texas. Projects totaling 50 million gallons per day would also be of significant benefit to this region and help reduce competition with agricultural irrigation.
- Develop or repurpose a reservoir near the desalination facility(ies) that could serve as temporary storage and flow equalization system. By locating this storage facility near the southeastern Texas coastline, evaporation is minimized and the ability to respond to fluctuations in rainfall and river flows maximized. Subsurface aquifer storage facilities should also be evaluated in central Texas to add further storage capability.
- Develop a pipeline capable of moving the desalinated water to points of need. It is envisioned that this could follow existing utility easements toward Dallas/Fort-Worth metropolitan area and allow diversion of a portion of the water to locations of need, (e.g. Houston and Austin/San Antonio or south to Corpus Christi).
- The costs of the water at delivery locations would be high, \$2,000 /acre-ft, \$6 per thousand gallons, or more, but the project would benefit from economies of scale that would ensure that the cost would be less than smaller projects supported by individual communities as well as open up sources of water currently unavailable to those communities. The cost would support high-value added industrial activity and act as supplemental municipal water. High cost sources of supplemental water are currently envisioned in many parts of Texas and the proposed effort would allow these areas to share in the cost and benefits of a new water supply. The reduced demand for other water sources may also reduce pressure on water supplies for relatively low value uses like agricultural, particularly during times of water surplus.
- A major component of the cost of the proposed project is the energy needed to desalinate and transport the water. It is envisioned that much of this energy could be from renewable sources such as onshore or offshore wind, wave or solar or from nuclear power generation. Innovative scheduling and power/desalination integration to take advantage of off-peak power pricing will help minimize operating costs. To take advantage of the innovative scheduling and integration of power and water treatment, intermediate storage in reservoirs or aquifers as described above will likely be required.
- An additional 4 million acre ft/year coupled with substantial conversion of irrigation waters to the municipal and industrial/energy sectors is needed to meet 2060 projections, according to the 2012 Texas State Water Plan. Much of the increased demand for water is in the semi-arid central portions of the state from Dallas to San Antonio and the southeastern coastal areas.
- Water pipelines could possibly follow existing natural gas pipeline easements. Specific routing and regions to be connected to the water supply system would be dependent upon a detailed feasibility and cost-benefit analysis. Focusing the desalinated water on needs in central and coastal Texas minimizes the piping distances and elevation changes and provides water to the areas with the highest population growth and expected future needs.



# NEXT STEP

As indicated previously, a preliminary analysis is needed to define the most viable concept to move forward, ultimately to detailed design and implementation. This evaluation should assess the most feasible approach to pursue, provide a preliminary estimate of total cost as well as the expected delivery cost of supplying the water. In addition, the evaluation should identify the potential economic benefits of providing new water in this quantity to Texas. The cost of conducting such a feasibility cost/benefit study is expected to be approximately \$1million. The Water Resources Center at Texas Tech University has begun initial efforts to lay the groundwork for the necessary study.







A potential new source for water could come from local or regional projects such as brackish desalination for west Texas communities due to their relatively modest expected increases in population and demand and the availability of substantial brackish resources. Projects totaling 50 million gallons per day would provide substantial benefit to the region, reduce competition for irrigation water and could be aided by the availability of extensive, inexpensive wind power resources. The desalination project above is conducted by Texas Tech water researchers in the small South Plains town of Seminole.



Texas Tech's Llano River Field Station (LRFS) bring together diverse stakeholders to address and provide solutions to critical natural resource and water issues in the Texas Hill Country of the Edwards Plateau. The LRFS provides a comprehensive spectrum of collaborations focused on recognizing, understanding and finding solutions to regional problems related to watershed and range science, freshwater systems and the environment, with national and international implications. Community partners include federal and state agencies, municipalities, universities, K-12 schools, landowners

and other local groups who share expertise, planning and resources. LRFS' Outdoor School, the Texas Natural Resource/Environmental Literacy Plan, Upper Llano River Watershed Protection Plan, Texas Water Symposium, and Discovery Point Trail are just some of the significant outcomes of these collaborations. Places like the Texas Tech LRFS can play a significant role in convening communities to address important cultural and ecological issues for current and future generations, and also provide economic benefits through quantifying ecosystem services.

# Sustainable Energy

Texas Tech sits at the nexus of major oil and gas production and the wind energy corridor. Texas Tech has made a commitment to developing and improving technologies that will supply the U.S. with cleaner, more efficient and less expensive energy sources while also examining a variety of water conservation and environmental issues. The university has attracted four National Academy members to leverage our already substantial research in both areas.







## WORKFORCE DEVELOPMENT

With wind energy growing quickly in the U.S., the demand for a skilled workforce also is growing. Texas Tech is a leader in workforce development for the emerging wind energy field by offering a Bachelor of Science Degree in Wind Energy and a doctoral degree program in wind science and engineering. A graduate level wind energy credential for wind energy professionals and a Wind Energy Graduate Certificate Program for non-technical professionals who wish to assume managerial responsibilities in the wind energy industry are also offered.



## WIND RESEARCH HIGHLIGHTS

- Assessment of the risk and effects resulting from wind turbine exposure to events, such as low-level jets, extreme wind speed and directional shear, thunderstorm outflow and micro-bursts, and wind vortices
- Impact of wind speed and directional shear on turbine power performance
- Investigation of the impact of the increasing wind power capacity onto the electrical grid
- Enhancing short term wind power forecasting using ensemble-based forecasting techniques
- Analysis and testing of utility-scale wind turbines designed for use in less-energetic wind regimes
- Full-scale testing of wind-driven water desalination systems and their associated economics

## OIL AND GAS

Oil and gas exploration and water issues go hand in hand in Texas. Through the launching of its Unconventional Production Technology and Environmental Consortium (UpTec), Texas Tech is taking a multidisciplinary approach by

integrating engineering with natural resource utilization and preservation, public policy, economic analysis and modeling, business, law, and complex sociological considerations.

## WIND ENERGY

Texas Tech is positioning itself as a world leader in wind energy. In 2013, Texas Tech; Sandia National Laboratories; Vestas, a leading turbine manufacturer; and Group Nire, a wind energy development company opened the Scaled Wind Farm Technology (SWiFT) facility.

SWiFT will serve as a cornerstone in the U.S. Department of Energy’s wind research program towards building “smart” wind farms. The initial installation includes three research-scale wind turbines and two anemometer towers, but there are plans to expand the facility.

Research at the facility focuses on advanced rotor technologies and analysis of wind flow and turbine-to-turbine interaction across a research-scale wind farm array. Array performance is one of the primary research concerns of the wind energy industry.



The SWiFT wind energy test facility is located at Texas Tech’s 67-acre wind research facility at Reese Technology Center. It makes use of existing state-of-the-art atmospheric observing facilities, including the 70-station West Texas Mesonet, a regional SODAR network, the TTUKa mobile research radars and an instrumented 200-meter tower.

## HYDRAULIC FRACTURING

Hydraulic fracturing has revolutionized oil and gas production in the U.S. and has the potential to sustain conventional energy resources at low cost throughout the 21st century. To meet that potential, there are significant challenges that extend beyond the traditional interests of the oil and gas industry. These concerns include possible environmental damage, particularly water contamination.

UpTec researchers are working toward a goal of becoming a global leader in hydraulic fracturing research by developing sustainable practices for hydraulic fracturing technologies, examining public understanding and media coverage of hydraulic fracturing, designing and implementing effective hydraulic fracturing communication and education efforts, and exploring the human and environmental impacts of hydraulic fracturing within the water-scarce region of West Texas.

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## ALTERNATIVE WATER SOURCES FOR HYDRAULIC FRACTURING

Freshwater is a scarce resource in semi-arid West Texas. The Ogallala Aquifer, the predominate water resource for the area, is used extensively to meet agricultural and municipal demands. Heavy use of this aquifer during the last 60 years significantly has diminished its useful life, particularly in the lower portion of the Southern High Plains, where there is extensive oil production.

Unconventional oil and gas production using hydraulic fracturing techniques has increased over the last few years and has fueled competition for water between agriculture and energy sectors. Water must be efficiently managed in West Texas such that our nation's energy independence does not come at the cost of its food security. Research at Texas Tech is focused on augmenting water supplies in West Texas to sustain both energy production and agricultural activities for years to come.

It is estimated that the State of Texas has 2.7 billion acre-feet of brackish groundwater reserves and nearly 35 percent is trapped in deep aquifers under West Texas. Brackish groundwater resources offer an alternative source for use in oil and gas production activities. However, the hydrogeological characteristics of these aquifers is poorly known. Elevated levels of certain chemicals

such as phosphates, sulfates, iron, barium and strontium can interfere with hydraulic fracturing operations. A comprehensive evaluation of hydro-geochemical characteristics of the Dockum Aquifer was undertaken by researchers at the Texas Tech Water Resources Center using funding from Apache Corporation. The Dockum Aquifer lies partially under the Ogallala Aquifer.

The results of the study indicate that the quality of water from the aquifer mostly meets hydraulic fracturing requirements. However, elevated levels of sulfate and strontium can be problematic. The aquifer has lower well yields and smaller storage and transmission characteristics, meaning that the impacts of the production will be felt over larger areas and water production activities must be planned in advance to ensure sufficient water supply. As such, this resource must be managed differently than freshwater aquifers where groundwater pumping leads to more localized effect. While additional studies are warranted to understand local scale geological differences, initial assessment indicates that the brackish aquifer offers an enormous potential to reduce the freshwater footprint of hydraulic fracturing operations -- freshwater that can be used to sustain agricultural activities in the area.

*continued on next page*



More than 30 percent of the water injected during hydraulic fracturing returns back to the surface during early stages of oil and gas production. This water, referred to as flowback/produced water, contains very high levels of total dissolved solids and other chemicals. Most of the flowback/produced water is currently

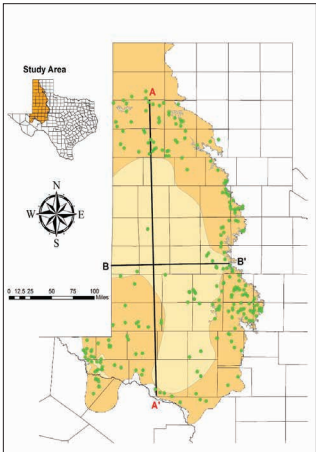
operations. While reuse is acceptable to both environmental groups and oil and gas industry alike, the water is extremely salty, three-to-four times saltier than seawater. Models to reliably predict the chemical behavior of such extremely salty water do not exist. Researchers from Texas Tech's Water Resources Center and the

*Water must be efficiently managed in West Texas such that our nation's energy independence does not come at the cost of its food security*

disposed of in deep injection wells in Texas. This practice simply removes the wastewater from the water cycle. Reusing produced water is not only beneficial from an environmental standpoint, but also is economically advantageous to the oil and gas industry.

Research also is currently underway to understand what chemicals in the flowback/produced water pose problems and identify suitable ways in which produced water can be made fit for reuse in hydraulic fracturing

Department of Chemical Engineering are closely working together to develop cutting-edge models to describe the behavior of chemicals in extremely salty solutions. This effort not only will help our understanding of produced/flowback water but also will help engineers develop cost-effective treatment technologies to make produced waters compatible for hydraulic fracturing.



The Dockum Aquifer has enormous brackish water resources that could augment water supplies needed for hydraulic fracturing techniques.

## HYDRAULIC FRACTURING RESEARCH HIGHLIGHTS

- An inventory of brackish groundwater resources (location, productivity and chemistry) that could be used as an alternative water resource for hydraulic fracturing
- Fundamental developments in brackish water chemistry and their prediction to support alternative water sourcing and produced and flowback water treatment and reuse
- Treatment technologies to optimize use-specific water reuse
- Defining water resource quality baseline to better identify water quality impacts
- Casing design and cementing to enhance well integrity
- Educational programs and technical conferences to enhance the oil and gas workforce
- Public communication and outreach programs to aid effective public participation



Unconventional oil and gas production using hydraulic fracturing techniques has dramatically increased during the last few years and has fueled competition for water between agriculture and energy sectors. Texas Tech researchers are developing sustainable practices for hydraulic fracturing technologies, examining public understanding and media coverage of hydraulic fracturing, designing and implementing effective hydraulic fracturing communication and education efforts, and exploring the human and environmental impacts of hydraulic fracturing within the water-scarce region of West Texas.

# Health Innovations

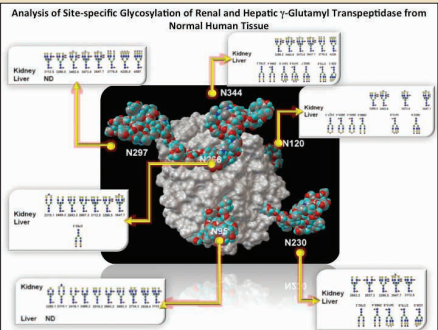
While incredible advances have been made in disease prevention, diagnosis and treatment in the past few decades, Texas Tech researchers continue to find ways to diagnose and treat diseases more effectively.

## EARLY DETECTION OF CANCER

How do diseases such as cancer develop and spread? One Texas Tech researcher is working in the areas of glycomics and glycoproteomics, which are essential to our understanding of many aspects of human and animal health.

This research is critical in the understanding of the development and progression of many diseases, including cancer, HIV and immune system diseases. Specifically the research may lead to early detection of breast cancer cells that may have the ability to invade the brain. The project looks at how certain sugar signatures on breast cancer cells might gain entrance past the blood-brain barrier and allow them to metastasize in the brain. The blood-brain barrier is semi-permeable and allows some materials to cross into brain tissue but prevents others.

Preliminary results are suggesting that certain breast cancer cells contain sugar compounds that trick pathways in the barrier into letting the cancer cells pass through into the brain.



Researchers are focusing on early detection of cancer by studying specific changes in sugars found in the body such as the one pictured here.



## HEALTH ADVANCES

- Obesity costs in Texas are projected at more than \$15 billion annually, and nationally, could rise to \$300 billion per year. Texas Tech researchers have received more than \$2 million in federal funding for research looking at nutrition and obesity, with emphasis on diabetes, inflammation and metabolic disorders; the endocrine function of adipose tissue; and diet-gene interactions, using cell and animal models.
- Engineers at Texas Tech are developing technology that can predict when a person might fall—even days in advance of the incident. The researchers have created a prototype wireless sensor, small enough to be clipped to a belt that analyzes posture and gait, and sends an alert when there is a break in routine that could indicate a fall is imminent.
- Use of Doppler radar-on-a-chip technology is being used for tumor tracking in lung cancer radiotherapy.



A \$1.6 million National Institutes of Health grant is funding a study into the biochemistry of a microscopic parasite responsible for the tropical disease Leishmania in the hope of finding a cure.

## NOVEL DRUG DELIVERY SYSTEMS

The pollen grains that may make you sneeze may also be the basis for a groundbreaking drug and vaccine delivery system.

Research at Texas Tech is focused on using pollen grains as a drug and vaccine delivery system that is painless, and could revolutionize vaccination worldwide by ushering in an era of oral vaccines, and by creating novel ways to treat cancers.

Pollen grains have a tough outer shell that can withstand the harsh acid and enzyme-rich environment in the stomach associated with the digestion process. By removing the plant material inside the pollens grains, vaccine can be loaded into the empty shell for delivery

through the stomach to the intestine and into the body, much like a Trojan horse.

Currently, a vaccine is typically given by a health care professional through intramuscular injection, which can be expensive, painful and has an element of risk. A vaccine given orally can be painless, child-friendly, self-administrable and increases mucosal immunity in areas like the intestines and lungs, so that the bacteria or virus can be neutralized even before it can infect the body. Risk of pollen allergies is mitigated in this delivery system, because not only is the pollen shell made of a natural polymer that is non-allergenic, but also the plant proteins that cause allergies are removed during the pollen-cleaning process.

## CHANGING DRUG TESTING

To develop a new drug, a company must develop not only the drug compound, but also determine how much of the drug should be given to a patient to be effective – an expensive and time-consuming process.

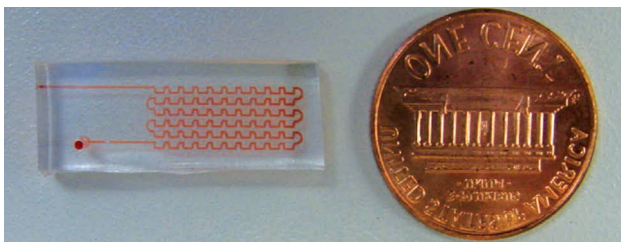
The pharmaceutical industry screens hundreds of thousands of drug candidates each year using large robots

that deliver one specific concentration of the drug at a time. A new Texas Tech device can test 60 concentrations of a drug in about 10 minutes.

The new device looks like a computer chip with multiple microchannels and nanoliter-capacity wells to hold an array of droplets of a substance. A scientist can vary the presence of other materials from drop

to drop, thus testing multiple concentrations of the drug at the same time.

The chip should make the drug screening process faster and more inexpensive for the pharmaceutical company and, hopefully, reduce the ultimate cost to the consumer.



A new device about the size of a penny invented in a Texas Tech lab could replace the current pharmaceutical drug screening systems.

# Space Science

NASA is making plans to send humans to Mars. In the NASA Authorization Act and the U.S. National Space Policy, both issued in 2010, the space agency outlined its goals to send humans to an asteroid by 2015 and to Mars by 2030.

According to NASA's web site, "Mars is a rich destination for scientific discovery and robotic and human exploration as we expand our presence into the solar system. Its formation and evolution are comparable to Earth, helping us learn more about our own planet's history and future. Mars had conditions suitable for life in its past. Future exploration could uncover evidence of life, answering one of the fundamental mysteries of the cosmos: Does life exist beyond Earth?"

If space truly is the final frontier then Texas Tech researchers are playing a role in helping NASA "boldly go where no man has gone before."



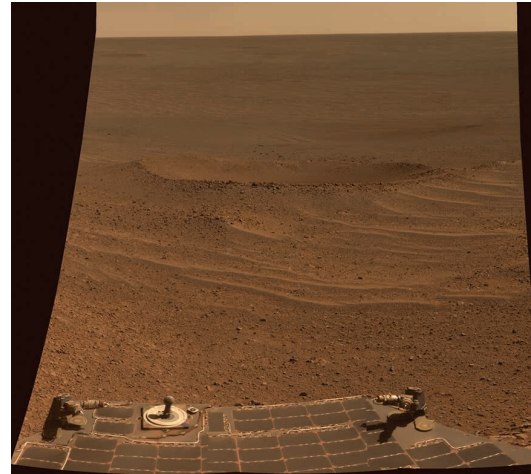
## LIVING ON MARS

Robotic explorers have been gathering data on Mars for four decades. One thing we know is the planet's surface is covered in perchlorate. That's good news, in that perchlorate could be used to generate oxygen. But it's problematic for humans.

Perchlorate occurs naturally in earth's environment including some fertilizers. It is also used as an additive in rocket and jet fuel. If humans ingest too much perchlorate, it can cause health issues including thyroid problems. Texas Tech researchers have studied perchlorate for a number of years focusing on, among other studies, detecting perchlorate limits in lakes and streams, groundwater, as well as breast and store-bought milk.

In December 2014, two Texas Tech scientists were invited to speak at a NASA-sponsored workshop on "Perchlorate on Mars: Implications for Human Exploration and Astrobiology."

One of the goals is to see if there is a way to establish an economy on Mars based on perchlorate, much like most of the earth's economy is based on carbon-based products.



This scene is from NASA's Mars Exploration Rover Opportunity and shows "Lunokhod 2 Crater."

Courtesy: NASA/JPL-Caltech/Cornell /Arizona State Univ

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## WATER IN SPACE

Since 2001, Texas Tech researchers have led efforts to develop water recycling technologies to support human space habitation.

The work has focused on developing micro-gravity compatible bioreactors to treat wastewater. These new bioreactors could reduce the costs associated with current physical- and chemical- based technologies.

Currently, researchers are working in concert with the Johnson (JSC), Kennedy and Ames Space Centers to develop a full-scale, flight-like membrane aerated bioreactor (MABR) for integrated testing for a next-generation wastewater recycling system composed of a biological reactor and FO/RO desalination system. JSC is currently using the initial design in integrated testing. The center also will support our efforts to develop the flight-like version. If successful, the MABR will be part of a ground-based demonstration project for the water treatment system for the manned Mars mission.

## SPACE SCIENCE RESEARCH HIGHLIGHTS

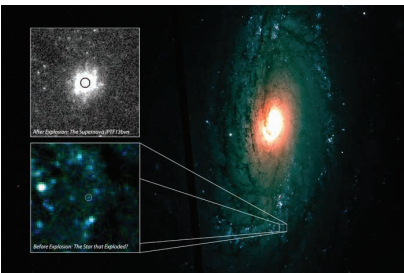
Texas Tech has developed extensive astrophysics and astrobiology expertise in recent years.

- Scientists are developing an organic analyzer that can be used on the surface of Mars to detect and identify organic molecules with the sensitivity needed to uncover evidence of past life on Mars.
- One of the hazards faced by crews of spacecraft in deep space is exposure to ionizing radiation in the space environment. Researchers are working to enhance modeling tools used by the NASA Johnson Space Center (JSC) Space Radiation Analysis Group to develop effective projections for space radiation applications.
- A postdoctoral research fellow at Texas Tech led an effort exploring the evolution of galaxies and why some evolve from ones full of life to passive, star graveyards. It's a question that has intrigued astronomers for decades. Potentially powerful, monstrous black holes at the centers of galaxies are commonly considered responsible for heating up and expelling gas needed to form stars. But new research shows evidence that black holes have less importance than the stars themselves in these extreme cases where formation of new stars is quickly halted.

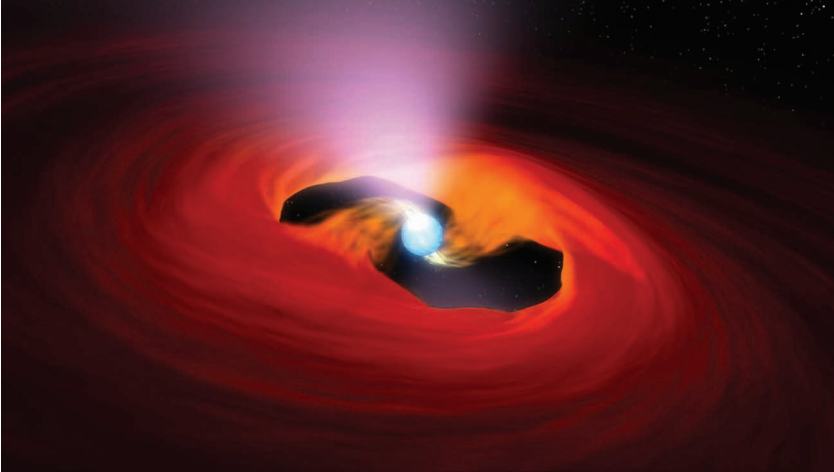


A Texas Tech University post-doctoral researcher was part of an international team of astronomers that recently discovered the glowing wreckage of the youngest-known neutron star yet discovered in a binary system in our Milky Way Galaxy. The discovery provides critical information about the way neutron stars evolve.

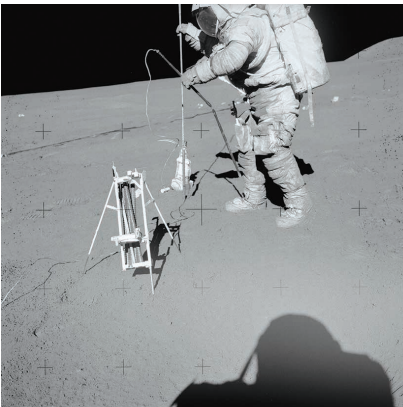
Image courtesy: NASA/CXC/UW-Madison/S. Heinz et al; Optical: DSS; Radio: CSIRO/ATNF/ATCA



With the help of a special spectroscopic camera developed by a Texas Tech University physicist, researchers at Caltech and Las Cumbres Observatory Global Telescope Network captured rare images of a star in another galaxy going supernova within a day of the star's explosion. Catching a supernova as it happens is rare, and has only been done about a dozen times. Researchers were able to use Hubble Space Telescope imaging to capture the area of the supernova before it happened. It took 73 million light years for the illumination from the star's explosion to travel to Earth.



A Texas Tech astrophysicist was part of a team of researchers who recently discovered a new reason for mysterious ultraluminous X-ray sources to exist in the universe. Pulsars are dense stellar remnants left over from a supernova explosion. The one discovered glows with the light intensity of about 10 million suns. Understanding how matter can fall so quickly onto this neutron star will help astronomers understand how black holes gorge and grow so quickly, which the scientists say is an important event in the formation of galaxies and structures in the universe.



A Texas Tech researcher is working to solve a mystery for NASA. From 1969 to 1972, astronauts with NASA's Apollo missions planted geophysical instruments on the surface of the moon that discovered moonquakes and measured the heat released from the interior of the moon. The data beamed back to Earth by radio signal. Then in 1974, NASA cancelled most of the funding for the data analysis project. But that didn't stop the data from collecting for another three years. With grants from NASA's Goddard Space Flight Center and Planetary Science Division, the scientist is trying to restore, digitally archive and reanalyze the data collected from the geothermal heat-flow instruments placed on the moon during Apollo 15 and 17. The goal is to use modern computers to reanalyze the data to better understand the moon's internal structure and why different areas of the moon give off different amounts of heat.



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