RESEARCH AT
NEBRASKA
THE UNIVERSITY OF NEBRASKA–LINCOLN
2015-2016 REPORT
Laser Creates Surfaces that Mimic Nature

Shark skin, rose petals and moth eyes.

This isn’t a weird memory test. It’s the seemingly random starting point of Dennis Alexander’s research. Each of these biological systems has a unique capability that the UNL engineer’s team is exploiting for defense and industrial purposes.

Alexander and colleagues use lasers to copy microscopic structures found in nature onto metal surfaces, giving them similar unique properties already honed by Mother Nature.

“Our structures are very important to the military, Boeing and NASA,” said Alexander, Kingery Professor of Electrical and Computer Engineering. “We’re emphasizing using these structures in harsh environments, but there really isn’t any metal surface we can’t functionalize.”

His team uses femtosecond laser surface processing, or short-burst laser pulses, to alter the top 100 microns of a metal surface, about the depth of a human hair, producing surfaces that mimic nature. Altering the laser angle and other parameters creates surfaces with different properties.

Sharks, for example, are highly efficient swimmers. By copying their microscale skin onto metal, researchers create a super-hydrophilic, or wicking, material. This property reduces drag, so a shark skin-like submarine shell, for example, would be able to travel farther using less power.

UNL’s laser-created surfaces also improve heat transfer, important to many military and commercial systems.

Rose petals, in contrast, are super-hydrophobic. Rainwater slides off in beads. Super-hydrophobic surfaces also reduce drag. Applications include medical supplies that can’t be contaminated by blood or other fluids, antibacterial metals for joint replacements, reducing ice buildup on traffic lights and improving condenser heat exchangers, including those used to reclaim water in space.

Current hydrophobic materials are created with a polymer coating that adds weight and eventually breaks down, creating undrinkable water. For the International Space Station, where recycling water is paramount, a super-hydrophilic condenser would avoid these problems. Alexander’s team works with NASA on improved heat exchangers.

Remember moth eyes? To see at night and avoid detection by predators, moths absorb a wide spectrum of light. Mimicking the eye’s surface creates an anti-reflective metal, improving solar panel efficiency and making stealth aircraft harder to track.

NU’s National Strategic Research Institute and NASA fund this research.
USSTRATCOM Delegation Visits UNL

UNL is expanding its innovative defense-related research through the National Strategic Research Institute at the University of Nebraska, one of only 13 U.S. Department of Defense-sponsored University Affiliated Research Centers in the nation.

NSRI-funded projects like engineer Dennis Alexander’s laser surfacing of metals have put UNL research on the radar of NSRI’s sponsor, the U.S. Strategic Command.

USSTRATCOM executives learned about UNL research with potential defense applications and explored potential areas of collaboration during an April 2016 campus visit. Tours of the Extreme Light Laboratory, Holland Computing Center, Center for Brain, Biology and Behavior and the Nebraska Athletics Performance Laboratory and presentations by faculty from business, computer science, transportation, engineering, physics and food microbiology provided an overview of UNL’s capabilities.

Three areas of potential UNL-USSTRATCOM collaboration grew from the visit: developing innovative leadership education and training programs through UNL’s Don Clifton Strengths Institute to meet USSTRATCOM’s workforce development needs; researching security against cyber threats with UNL computer scientists; and creating simulations with UNL engineers to detect and disrupt proliferation of nuclear weapons.
Prospecting with Biosensors at Home or in the Field

Prospecting – whether for gold in a mountain or lead in a city’s water supply – may one day be as quick and easy as a litmus test.

UNL chemist Rebecca Lai is developing a series of hand-held biosensors to detect a variety of metals, including gold, silver, lead, platinum and mercury. Instead of sending samples away for time-consuming tests, Lai’s portable devices can be used in the field or home, saving much time and money.

The reusable sensors, fabricated on paper strips, can handle water, air and solid samples. This flexibility opens numerous opportunities, for mining companies foraging for gold or regulators hunting down water or air contaminants. Homeowners may one day be able to use the sensors to test their tap water or yards for heavy metals.

“Geochemical exploration for gold is becoming increasingly important to the mining industry,” Lai said. “There is a need for developing sensitive, selective and cost-effective analytical methods capable of identifying and quantifying gold in complex environmental samples.”

The metal sensors rely on a surprising source: DNA’s building blocks. Researchers have long known that metal ions recognize and react to different DNA or other molecular building blocks. Lai’s sensors exploit that reaction.

They work by measuring the electric current passing from an electrode to methylene blue, a tracer molecule, attached to a molecular probe specific to each metal type. The current changes in the presence of the metal being tested.

To help combat contaminants found in groundwater, Lai also plans to develop biosensors to detect arsenic, uranium and selenium. She uses a similar approach to devise biosensors for viral antibodies, antibiotics and nitrates.

Lai is working with NUtech Ventures, UNL’s technology commercialization affiliate, to patent and license the biosensors. The National Science Foundation and the U.S. Environmental Protection Agency support her research.
University and industry scientists across the region are tapping a new resource at UNL designed to strengthen the nation’s nanoscience research.

UNL became home to the Nebraska Nanoscale Facility, a center of excellence in nanoscience and nanotechnology, in fall 2015. A nearly $3.5 million grant from the National Science Foundation funds the center, one of only 16 nationwide that constitute the National Nanotechnology Coordinated Infrastructure.

“There is a need for regional facilities,” said center director David Sellmyer, George Holmes University Professor of Physics. “Most universities do not have the resources to buy and operate these very expensive pieces of machinery.”

The center builds on UNL’s highly regarded reputation in materials and nanoscience research. While state-of-the-art facilities have helped UNL researchers make significant contributions to nanotechnology advancements, the university previously had limited capacity to serve researchers and industries beyond UNL, he said.

The new center uses shared laboratory facilities and specialized equipment, principally housed in UNL’s Voelte-Keegan Nanoscience Research Center, which opened in 2012.

Through the center, UNL makes instrumentation and technical support available to researchers from neighboring universities, companies and others. It has added personnel, purchased new equipment and is offering workshops and mini-courses to introduce visiting scientists to available resources.

Bolstering nanoscience and nanotechnology strengthens regional and national research collaborations and contributes to economic development throughout the U.S., Sellmyer said.

“We are well set up to do a lot of things now,” he said. “With a larger scientific staff, we’re able to do a better job at helping companies in Nebraska and neighboring states with their technical problems.”

The facility reinforces the university’s materials and nanoscience programs and centers, including the Nebraska Center for Materials and Nanoscience; the NSF-funded Materials Research Science and Engineering Center; the Center for NanoFerroic Devices, funded by the Semiconductor Research Corp. and the National Institute of Standards and Technology; the National Strategic Research Institute, which partners with USSTRATCOM; and others.
Early Career Awards Boost Promising Research

From smarter computers, robots and power grids to genetic advances and greener chemistry, UNL researchers are solving diverse problems with early career awards from the National Science Foundation and U.S. Department of Energy. These prestigious five-year awards support research by promising pre-tenure faculty. Eight UNL assistant professors won these awards in 2015-2016.

Gaining Control at the Nanoscale

Controlling certain materials’ polarization and other properties at the nanoscale could make electronics smaller, faster and less expensive. Physicist Xia Hong received a $750,000 DOE Early Career Award to upgrade equipment and hire researchers essential to that pursuit.

Hong studies extremely thin ferroelectric films, meaning their polarization – the alignment of their positive and negative charges – can be reversed when exposed to an electric field. Combining ferroelectric films with other 2-D materials could produce reconfigurable electronic states that help her team observe new quantum phenomena and expand the versatility of technologies ranging from solar cells to transistors.

Hong said her approach also could help overcome uncertainty inherent in manufacturing and testing nanoscale technology.

Expanding the Genetic Code

Chemist Jiantao Guo envisions expanding the genetic code to create innumerable possibilities for research and commerce, from developing pharmaceuticals to improving crop yields. He earned a $622,000 NSF CAREER award to continue working on a promising new method for incorporating new amino acids into proteins.

Organisms build proteins by linking amino acids, the order specified by the sequence arrangement of nucleotides, DNA’s basic structural unit.

Three-nucleotide sequences, called codons, identify a single amino acid. Increasing from three-nucleotide to four-nucleotide codons would significantly expand the repertoire of potential amino acids.

Previously, Guo created a tRNA, a molecule critical to linking amino acids together, that is capable of reading quadruplet codons. His discovery expands the potential to encode more artificial amino acids into living cells. With this award, Guo continues investigating quadruplet codon-reading tRNAs.
Spintronics for Ultralow-power Devices

Physicist Alexey Kovalev studies the fundamental properties of magnetic systems at the nanoscale with a $750,000 DOE Early Career Award.

Kovalev’s theoretical research focuses on spintronics, which controls electron spin in addition to charge, to generate power and store digital information. His research could lead to developing ultralow-power memory devices for computers and other electronic devices.

Today’s hard drives manipulate electron charge and magnetic spin to store information. Kovalev is investigating the strong spin-orbit interactions and interplay between spin and energy flows in magnetic systems. His work also could improve harvesting energy available in temperature gradients (or differences) to power electronic devices.

Stretching Possibilities for Hybrid Materials

Combining soft, organic materials with hard, inorganic ones could add important functionality to robotics and other emerging technologies. With a $650,000 NSF CAREER award, chemist Stephen Morin is crafting hybrid materials that could provide diverse properties for many applications.

Morin is exploring how best to deposit rigid films atop the surfaces of elastic polymers. One challenge lies in the different thermal and mechanical properties of the two materials; another is melding a brittle material with something as elastic as a rubber band.

Morin is especially interested in how stretching a polymer affects the harder material’s formation and structure. He’s already built adaptable patterns of microscopic crystals on rubber films and created elastic materials that become highly reflective when stretched.
To make electronics smaller, faster and more energy efficient, physicist Xiaoshan Xu earned a $590,000 NSF CAREER award. He’s investigating hexagonal ferrite, a nanomaterial with the rare quality of having both magnetic and electric polarizations.

Harnessing that unique property could help shift electronics away from requiring an electric current, which uses energy and produces heat, limiting the efficiency and size of devices.

Previously, Xu helped discover the nanomaterial’s multiferroic properties. Now, he’s studying the fundamental mechanism underlying the coexistence of electric and magnetic properties and how to couple them for use in devices. The material’s multiferroic capability functions at a nippy minus 220 degrees Fahrenheit, so Xu also is investigating ways to raise its functional range to above room temperature.

Producing clean energy fuels and other “green” chemicals using solar energy isn’t as sustainable as it could be. Solar-powered chemical reactions often require a catalyst made with rare and expensive metals.

Chemist Jian Zhang developed a solar-powered, organic-based catalyst to facilitate chemical reactions. With a $527,000 NSF CAREER award, he is further investigating and improving its properties for industrial uses. The material, a type of porous organic framework, acts like a semiconductor, encouraging electrons to move when hit with solar energy.

Industry could use the organic catalyst to develop more environmentally friendly products, including cleaner hydrocarbon-based fuels. Zhang also is investigating using the catalyst to break down lignin, an abundant plant-based carbon source, for use in creating industrial products, such as pharmaceuticals and biofuels.
Finding Genetic Clues to Drought Resistance
UNL biologists have uncovered clues about the collective role two genes play in protecting plants against drought. Their discoveries are an important step toward developing crops better able to defend against challenging environmental conditions. Heriberto Cerutti and colleagues studied the results of breeding a mutant variety of model plant species Arabidopsis thaliana that effectively deactivated both genes. The mutations stunted plant growth and increased susceptibility to drought. The team discovered that the double-mutant plants lack two kinases, catalysts required to facilitate histone phosphorylation. Research suggests that adding phosphate molecules to histone proteins helps optimize plant responses to environmental cues. They reported their findings in the Proceedings of the National Academy of Sciences.

Solving Nitrous Acid Puzzle
UNL chemists have solved the long-standing puzzle of how nitrous acid forms in Earth’s lower atmosphere, where it contributes to both cleansing and polluting. Scientists first detected nitrous acid in the 1970s, but how it forms in the ionosphere remained unclear. Through quantum mechanics-based simulations, the UNL team identified how the atmosphere’s charged atoms and electrons combine to form nitrous acid 40 to 55 miles above the Earth. This discovery contributes to better understanding of how to manage human activities that harm health and the environment, said study co-author Joe Francisco, Elmer H. and Ruby M. Cordes Chair in Chemistry and dean of the College of Arts and Sciences. Xiao Cheng Zeng, Ameritas University Professor of Chemistry, and colleagues co-authored the study, which appeared in the Proceedings of the National Academy of Sciences.

McCormick Heads Water for Food Institute
Peter G. McCormick, an internationally known water and food researcher, became the new executive director of the Robert B. Daugherty Water for Food Global Institute at the University of Nebraska in August 2016. McCormick is former deputy director general for research at the International Water Management Institute in Colombo, Sri Lanka. He has dedicated his career to improving sustainable water resource management and has led research and development programs on water, agriculture and the environment in Africa, Asia, the Middle East and the U.S. McCormick earned his doctorate in agricultural engineering from Colorado State University and has been a senior fellow at Duke University’s Nicholas Institute for Environmental Policy Solutions. The Scotland native grew up on a livestock and dairy farm. He succeeded Roberto Lenton, the institute’s founding executive director.

Fritz Co-leads Climate Change Group
UNL geoscientist Sherilyn Fritz is co-chairing the international Scientific Steering Committee for Past Global Changes, or PAGES. The organization includes scientists from 125 countries and sponsors research exploring climate shifts across millions of years to better predict future climate and environment. During her two-year term, Fritz will guide decisions on the diverse international PAGES-sponsored research. She’ll also advance the organization’s effort to engage more closely with policymakers, resource managers and business leaders. Sharing research results with those who can use them is increasingly important in promoting sustainable practices, she said. Formed in 1991 with support from the U.S. and Swiss National Science Foundations, PAGES features a co-chair from each country. Fritz, George Holmes University Professor of Earth and Atmospheric Sciences, studies North and South American lakes to better understand historic climate change.
Common Nanoparticle May Harm Brain
Even moderate concentrations of a common nanoparticle used to whiten foods, milk and toothpaste could compromise the brain, UNL research found. Biochemist Oleh Khalimonchuk, engineer Srivatsan Kidambi and colleagues examined how three types of titanium dioxide nanoparticles affect the functioning of astrocyte cells, which play important roles in cognition, memory and learning. The team found that many rat-derived astrocyte cells died following exposure to titanium dioxide and those cells that survived were severely impaired. Evidence suggests these nanoparticles can cross the blood-brain barrier, but more research is needed, Khalimonchuk said. The study was featured on the cover of *Nanoscale*. The National Institutes of Health funds this research.

Safer Material for X-rays
UNL engineers have identified a material that could reduce the risk of X-ray exposure. Used for more than a century to detect broken bones, X-rays are increasingly employed at security checkpoints. But exposure poses a cancer risk, particularly for youngsters. Jinsong Huang, Susan J. Rosowski Associate Professor of Mechanical and Materials Engineering, and colleagues discovered that methylammonium lead tribromide, a type of perovskite crystal, is four times more sensitive to X-rays than leading commercial detectors. This property could allow for lower X-ray doses in medical and security settings, making the material a substantial upgrade over the commonly used amorphous selenium, Huang said. Huang and collaborators at Ohio State University, University of Groningen in the Netherlands and the University of Rochester reported their findings in *Nature Photonics*. The Defense Threat Reduction Agency, the European Research Council and the National Science Foundation funded this research.

Detecting Gravitational Waves
The university’s Holland Computing Center helped make history as part of the global supercomputing network that detected gravitational waves emerging from colliding black holes, a scientific first. UNL is part of the Open Science Grid, which provided computing assistance to the U.S.-based Laser Interferometer Gravitational-Wave Observatory, or LIGO, which led the research. The grid, a global consortium of over 125 institutions, offers its collective large-scale computing power to scientific projects. Holland served as a hub for distributing LIGO’s data to 15 computing clusters nationwide, said UNL computer scientist Brian Bockelman, who leads an Open Science Grid division.
Eight UNL Faculty Named AAAS Fellows

David Berkowitz, Scott Gardner, Ronnie Green, Andrzej Rajca, Mark Riley, Daniel Schachtman, Janos Zempleni and Tian Zhang were named American Association for the Advancement of Science Fellows in 2015. It was the first time eight UNL scientists were elected fellows in the same year.

- **Berkowitz**, Willa Cather Professor of Chemistry and chair of chemistry, was recognized for contributions to chemical biology and synthetic chemistry.
- **Gardner**, professor of biological sciences and parasitology curator at the University of Nebraska State Museum, was recognized for contributions to parasitology and biodiversity.
- **Green**, UNL chancellor and professor of animal science, was honored for contributions to quantitative genetics and advancement of science through academic and federal administration, advocacy and service.
- **Rajca**, Charles Bessey Professor of Chemistry, was recognized for contributions to organic magnetic materials.
- **Riley**, professor and department head of biological systems engineering, was recognized for contributions to biological engineering.
- **Schachtman**, professor of agronomy and horticulture and director of UNL’s Center for Biotechnology, was honored for service to the life sciences and contributions to plant molecular physiology.
- **Zempleni**, Willa Cather Professor of Molecular Nutrition and director of the Nebraska Center for the Prevention of Obesity Diseases through Dietary Molecules and of the Nebraska Gateway to Nutrigenomics, was recognized for contributions to nutrition research.
- **Zhang**, professor of civil engineering, was honored for exemplary professional work and research, prolific contribution to technical literature and voluntary activities as a technical expert and global adviser.

William G. Thomas III, John and Catherine Angle Professor in the Humanities and professor of history, received a John Simon Guggenheim Memorial Foundation Fellowship to research his book A Question of Freedom: The Ordeal of an American Family in the Age of Revolution, which chronicles a mixed-race family’s history over four generations in Maryland. Thomas, a pioneer in digital history, specializes in the Civil War, the U.S. South and slavery.

Terri Norton, associate professor of construction engineering, earned a Fulbright Scholar grant to travel to Japan and research the country’s faster-than-expected recovery from a devastating earthquake and tsunami in 2011. The grant also allows her to investigate how people in the U.S. have responded to major disasters.

Galen Erickson, Nebraska Cattle Industry Professor of Animal Science, received the American Feed Industry Association Award in Ruminant Nutrition Research from the American Society of Animal Science.

William Kranz, professor of biological systems engineering, won the 2015 Heermann Sprinkler Irrigation Award from the American Society of Agricultural and Biological Engineers in recognition of his outstanding contributions toward the advancement and worldwide adoption of sprinkler irrigation systems.

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Kathy Krone, professor of communication studies, received the Charles H. Woolbert Research Award from the National Communication Association. The award honors their Journal of Applied Communication Research article, “The policy exists but you can’t really use it: Communication and the structuration of work-family policies.”

James Van Etten, William B. Allington Distinguished Professor of Plant Pathology, earned the Award of Distinction of the American Phytopathological Society. The society’s highest honor, this award is presented on rare occasions to people who have made exceptional contributions to plant pathology. An international leader in algal virology, Van Etten is a member of the National Academy of Sciences.

John Brunero, Robert R. Chambers Distinguished Associate Professor of Philosophy, won the 2016 Article Prize from the American Philosophical Association for his “Cognitivism about Practical Rationality,” published in Oxford Studies in Metaethics, Volume 9.

Tian Zhang, professor of civil engineering, and John Stansbury, associate professor and associate chair of civil engineering, won the Rudolph Hering Medal from the American Society of Civil Engineers. The award honors their Journal of Environmental Engineering article, “Contributions of Internal and External Fouling to Transmembrane Pressure in MBRs: Experiments and Modeling.”

Patricio Grassini, assistant professor of agronomy and horticulture, received the 2016 Early Career Professional Award from the American Society of Agronomy for outstanding contributions in agronomy. Grassini is an internationally recognized authority on crop yield gaps and input-use efficiency.
The semiconductors powering modern electronics are fast approaching their functional limits, threatening further advancements in computing technology. Scientists and engineers in UNL’s Materials Research Science and Engineering Center lead basic research needed to create a new generation of electronic and computing technologies.

UNL established this highly collaborative center in 2002 with a $5.4 million National Science Foundation grant. In 2008, NSF awarded $8.1 million to continue the center. A new $9.6 million grant funds its work through 2020.

“Ten years ago, it was hard to imagine how vigorously nanomaterials research would advance in Nebraska. Now, we are among the leaders in the field,” said Evgeny Tsymbal, George Holmes University Professor of Physics and MRSEC director.

Major advances in understanding nanomaterials’ unique properties underpin the center’s success. Now called Polarization and Spin Phenomena in Nanoferroic Structures, or P-SPINS, the center focuses on two key research areas. Each aims to create new nanomaterials to enable smaller, more powerful and energy-efficient computers and other electronics.

Magnetoelectric materials and functional interfaces research builds on UNL physicist Christian Binek’s advances in spintronics and nanomagnetism. This team is developing voltage-powered logic and memory devices.

The second focus on polarization-enabled electronic phenomena evolved from Tsymbal’s theoretical predictions and physicist Jesse Govers’ experimental work on quantum tunneling through a nanoscale ferroelectric barrier. This team is investigating novel ferroelectric materials and structures to advance nanoelectronics.

MRSEC faculty also are developing more efficient solar cells, superior magnetic and nanoscale structural materials, and techniques to better understand nanomaterial properties.

Through the center, 18 UNL researchers from diverse disciplines share expertise. Faculty also collaborate with scientists nationally and internationally.

To transform MRSEC’s discoveries into products, the center partners with industry. For example, faculty work with UNL’s Center for Nanoferroic Devices, funded jointly by an industry consortium and the National Institute for Standards and Technology.

MRSEC also is known for its educational and outreach programs.

“I believe we now have the strongest, most cohesive, most accomplished team yet,” said Axel Enders, a UNL physicist and associate center director. “I have no doubt we’re going to be awesome.”

Illustration of 3-hydroxyphenalenone (3-HPLN) molecules assembled on a copper surface. MRSEC research showed that 3-HPLN molecules self-assemble into a network that enables them to stand upright.

Axel Enders and Evgeny Tsymbal

Graduate students Iori Tanabe (left), Zahra Ahmadi and Keith Foreman

Research Driving Nanomaterials’ Huge Potential

Graduate students lead projects with UNL’s Advanced Research Institute.
Putting Graphene to the Test

Graphene has the potential to improve electronics, solar cells and other devices. UNL chemist Alexander Sinitskii is testing this promising nanomaterial with a $538,500 National Science Foundation CAREER award. He’s capitalizing on a technique he developed to create atomically precise graphene nanoribbons, ultranarrow bands of one-atom-thick sheets of carbon. This precision allows Sinitskii to create nanoribbons with different widths and edges. Now, he’s investigating how these differing characteristics influence the nanoribbons’ properties.

Understanding changes in nanoribbon properties will help Sinitskii and others design materials that improve performance in diverse applications, such as semiconductors, solar cells and fuel cells. He plans to develop prototype devices incorporating graphene nanoribbons.

Sinitskii is an affiliate of both UNL’s NSF-funded Materials Research Science and Engineering Center and the Nebraska Center for Materials and Nanoscience. He’s the latest MRSEC faculty member to earn a prestigious NSF CAREER award, which supports pre-tenure faculty who exemplify the role of teacher-scholars through research, education and the integration of education and research. Other MRSEC-affiliated CAREER award winners are:

- 2006-2012: Christian Binek, physics and astronomy, $500,000 for education and research on nanoscale spintronic systems and heterostructures. Binek leads one of MRSEC’s research teams.
- 2008-2013: Axel Enders, physics and astronomy, $412,000 to study self-assembled magnetic nanostructures to improve data storage and other computing devices. Enders is MRSEC’s associate director.
- 2009-2014: Eva Franke-Schubert, electrical engineering, $400,000 for research on hybrid chiral nanostructures to enhance computing, electronics and solar cells or batteries.
- 2012-2017: Xia Hong, physics and astronomy, $600,000 for work on nanomaterials with both magnetic and ferroelectric properties, which may lead to novel materials and devices.
- 2013-2014: Jingjun Huang, mechanical and materials engineering, $400,000 to study methods for increasing solar cell efficiency using organic polymers as a semiconductive material.

When light strikes an object, it triggers atomic changes that happen too fast for scientists to observe. But UNL physicists are honing ultrafast techniques to decipher how light interacts with molecules, atoms and nanostructures.

Their discoveries could lead to much faster computers, more efficient solar power and other enhanced light-based technologies, such as lasers.

“Ultrafast science is the next step in humanity’s ability to understand nature and ultimately control these processes,” said Anthony Starace, George Holmes University Professor of Physics.

UNL’s physicists have partnered with colleagues at Kansas State University and the University of Kansas in a Nebraska-Kansas Consortium that expands all three universities’ capacity to study atomic, molecular and optical physics.

The consortium is taking two approaches to observe ultrafast processes. The first is based on stop action made famous by 1925 Nebraska alumnus Harold Edgerton and his iconic image of a bullet piercing an apple. Today, scientists use superfast electron and laser pulses instead of strobe lights.

UNL physicists are designing and building a new source of electron pulses that uses high-powered lasers to accelerate electrons even faster. The souped-up equipment will be housed in UNL’s Extreme Light Laboratory.

The device also may help elucidate transformations in solids, which could open new avenues in materials science research.

The second approach uses light pulses to overcome electronics’ relatively slow speed. Merging light with the electrons used in electronics may result in much faster computers and other devices.

The consortium also will provide educational and outreach activities to small Nebraska and Kansas colleges and students underrepresented in science and engineering.

Thirteen UNL physicists and engineers participate in the consortium. Starace and physicists Herman Botezatu and Martin Centurion lead UNL’s participation.

The National Science Foundation’s Experimental Program to Stimulate Competitive Research, or EPSCoR, funds the consortium with a three-year, nearly $6 million award, of which UNL received nearly $3 million. It is one of three science and engineering consortia funded by the program nationwide.

Consortium Targets Ultrafast Processes

From left, Anthony Starace, Martin Centurion and Herman Botezatu
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Solar energy remains tantalizingly out of reach as a widely used power source, but a UNL engineer is making big strides in his quest to harness the sun.

Current silicon-based solar cells are too expensive and inefficient, said Jinsong Huang, Susan J. Rosowski Associate Professor of Mechanical and Materials Engineering. “Our target is to reduce solar cell costs by half, so it can compete with energy from fossil fuels.”

He’s attacking that goal on several fronts with grants of more than $1.2 million from the U.S. Department of Energy and $2.6 million from the National Science Foundation.

Perovskites, a class of abundant crystalline compounds, are a promising solar cell material that potentially could cost a thousand times less than silicon, Huang said.

His evolving techniques are helping to set records in perovskite solar energy efficiency. Thanks to his and others’ advances, the material now rivals silicon’s 20 percent energy efficiency and promises greater improvements.

Huang and his team also created a single, large perovskite crystal using a low-cost fabrication technique. They demonstrated the material’s potential capacity as a sun catcher is thousands of times greater than previously reported. Their findings, published in Science, provide insight into future improvements. Huang continues to study what makes perovskite crystals so exceptional.

He’s also investigating a new fabrication technique to make inexpensive, large-scale solar cells for a variety of applications.

Perovskite degrades easily so more research is needed before it can replace silicon.

As an intermediate step and to take advantage of established technology, Huang is investigating ways to overlay silicon with an ultrathin film of perovskite to increase current solar cell efficiency.

Another major solar cell avenue replaces silicon with less expensive organic polymers, or plastics, which are cheaper and more flexible, but also less energy efficient. Huang continues explaining ways to improve organic polymer semiconductors.

“Renewable energy is the No. 1 issue for the future,” Huang said. “Solar energy still has a relatively long way to go, but the path is clear to me. I firmly believe renewable energy will one day be a major energy source.”

“We Our target is to reduce solar cell costs by half, so it can compete with energy from fossil fuels.”

Jinsong Huang and colleagues in his lab
Protecting Nanoparticles Carrying Therapeutic Drugs

The liver and spleen have been thwarting researchers’ attempts to deliver a nanoparticle carrying therapeutic drugs to its target. A UNL team has discovered that citric acid is the key ingredient in armorng the nanoparticle against the organs’ molecule-chomping. Nanocarrier drug delivery techniques are potentially safer and more effective methods of administering drugs than conventional treatments.

One method of slipping synthetic drugs past the body’s immune defenses is to use a Trojan horse, enveloping the drug in a nanomaterial made from zein, a corn protein that appears nonthreatening. Zein is widely used in the food, paper and other industries.

But that friendly exterior also makes it susceptible to the liver and spleen, which break down proteins and other biological products. The UNL team learned that citric acid acts as a kind of mortar to bind the nanoparticle’s protein molecules together more tightly, creating a much more durable structure. They’ve shown that zein nanoparticles fortified with citric acid successfully delivered the cancer drug 5-Fluorouracil to the kidneys in mice. Importantly, citric acid is nontoxic, said project leader Yiqi Yang, Charles Bessey Professor in textiles, merchandising and fashion design and biological systems engineering. Other successful strengtheners are carcinogenic, limiting their medical usefulness.

The reinforced structure also has potential for use in regenerating human tissue, he added. Earlier, Yang and his colleagues improved the zein nanoparticle’s functionality as a drug delivery system by creating a hollow center that increases its loading capacity.

Yang said he hopes to work with an industry partner to develop the enhanced zein nanoparticles for use in delivering targeted drug therapies. He was prompted to work on zein because the protein is a ubiquitous byproduct of the corn industry. “In Nebraska, we have a lot of corn protein left after utilization of corn starch,” Yang said. “Our initial motivation was to figure out a way to add value to our agricultural industry.”

3-D Model Helps Manage Bridge Repairs

Checking bridges for structural safety is imperative, but every inspection generates a colossal amount of complex data. Pinpointing which parts most urgently need repair is difficult.

To solve this “big data” challenge, a UNL team created a visually based 3-D data management tool that helps officials more easily monitor deteriorating bridges and prioritize repairs.

“A typical steel bridge has hundreds of thousands of elements. That’s enormous amounts of data. The elements all have a spatial relationship to each other, but the current data system doesn’t reflect that relationship,” said project leader Zhigang Shen, an associate professor in the Charles W. Durham School of Architectural Engineering and Construction at the Peter Kiewit Institute in Omaha.

Their tool creates a 3-D model of a bridge. With a mouse click, engineers can identify which parts require fixing. The model color codes each component based on condition, from good-to-go green to urgent red. Clicking on a component brings up inspection reports as well as photos of cracks, corrosion or other damage. Engineers can compare data and photos from several years to understand the rate of deterioration and better plan repairs.

He hopes to continue adding features like sensors to monitor bridge conditions in real time and to better understand what causes deterioration, such as weather conditions. The Nebraska Department of Roads funds this project. State bridge engineer Mark J. Traynowicz said he thinks roads officials nationwide would find the system useful.

“It’s a good product to see how our bridges are aging and how they’re holding up,” Traynowicz said.

More than 61,000 of the nation’s bridges are structurally deficient, according to the U.S. Department of Transportation. It would cost an estimated $115 billion to repair all these deficiencies.

When completed in late 2015, the tool should help cash-strapped municipalities prioritize bridge repairs, Shen said. He already has received lots of national and international inquiries and is considering starting a company to commercialize the tool.
Research Highlights

UNL Research Fair

This annual UNL Research Fair provided opportunities to explore university research priorities, hear from federal experts and celebrate faculty and student successes. The fall 2014 event featured a faculty retreat on digital creativity and interdisciplinary collaborations with the Johnny Carson School of Theater and Film. It included presentations on defense funding opportunities, increasing participation in STEM disciplines, mentoring for postdocs and a celebration of the Center for Children, Youth, Families and Schools’ 30th anniversary. Featured presenters included Barry Pallotta, Dean of the College of Arts and Sciences; Suat Irmak, Harold W. Eberhard Professor of Biological Systems Engineering; Bernard Most, Harold W. Eberhard Professor of Biological Systems Engineering; and Alex Weisgerber, associate professor of English.

UNL’s Nebraska Food Safety Initiative

Food safety in Nebraska, and across the nation, is a concern for many. A recent study by researchers at UNL found that nearly 50% of Nebraska’s food processors were not in compliance with new food safety regulations. Collaborators are Michigan State University, Washington State University and University of Nebraska-Lincoln. The team will share findings with food processors and work with them to address concerns and meet new food safety regulations. Collaborators are Michigan State University, Washington State University, Illinois Institute of Technology and North Carolina State University.

Driver’s Ed Reduces Teen Crashes, Tickets

Driver’s education significantly reduces crashes and traffic violations among new drivers, according to a UNL study of nearly 152,000 Nebraska teen drivers over eight years. Young drivers who have not completed driver’s education are 75 percent more likely to get a traffic ticket, 24 percent more likely to have an accident, the study concluded. Findings by educational psychologists Duane Shell and Ian Newman of UNL’s Nebraska Safety Center showed more than three decades of assumptions about the value of driver’s education. The study appeared in Prevention in Medicine, the journal of the National Association for Alcohol and Drug Abuse. The study appeared in Prevention in Medicine, the journal of the National Association for Alcohol and Drug Abuse.

Sending Drones into Storms for Science

Flying drones into storms is giving researchers new insights about severe weather. To stay on the forefront of this burgeoning research area, UNL and University of Colorado Boulder colleagues founded the Unmanned Aircraft System and Severe Storm Research Group. This consortium provides a structured working relationship among an expanding number of research partners. It’s an outgrowth of ongoing research by UNL atmospheric scientist Adam Houston and University of Colorado colleagues. The CU-UNL team’s research with drones has yielded several findings, including the first direct sampling of a thunderstorm system by a drone and the first simultaneous samplings of thunderstorm outflow by multiple drones. Consortium collaborators from universities, federal laboratories, the private sector and other institutions work to advance the use of drones in severe storms research.

Accolades

John Woolfolk, George Holmes University Professor of Theatre and Film, was named a Fellow of the National Academy of Inventors. Woolfolk, an internationally known expert in ellipsometry and a UNL faculty member since 1976, also is founder and president of the J.A. Woollam Co. A university faculty retreat on digital creativity and interdisciplinary collaborations with the Johnny Carson School of Theater and Film. It included presentations on defense funding opportunities, increasing participation in STEM disciplines, mentoring for postdocs and a celebration of the Center for Children, Youth, Families and Schools’ 30th anniversary. Featured presenters included Barry Pallotta, Dean of the College of Arts and Sciences; Suat Irmak, Harold W. Eberhard Professor of Biological Systems Engineering; and Alex Weisgerber, associate professor of English. Woolfolk was honored for his comprehensive investigative work on food allergens. Woolfolk received the 2014 Massey-Ferguson Educational Gold Medal Award for contributions to improved understanding of soil, water and plant relationships through advances in evapotranspiration modeling and environmental biosciences. Irmak also received the 2014 Alexander von Humboldt Research Award for his comprehensive investigative work on food allergens. Woolfolk received the 2014 Massey-Ferguson Educational Gold Medal Award for contributions to improved understanding of soil, water and plant relationships through advances in evapotranspiration modeling and environmental biosciences. Irmak also received the 2014 Alexander von Humboldt Research Award for his comprehensive investigative work on food allergens. Woollam is named on 57 patents and his company has secured more than 100 patents.

David J. Besser, associate professor of history and ethnic studies, received a fellowship from the Andrew W. Mellon Foundation to conduct research in Germany for the 2015-2016 academic year. He is conducting research for a book about Martin Luther and is part of a group of about 30 humanities scholars in the institute’s School of Historical Studies. Burnett also received a Humboldt Research Award from Germany’s Alexander von Humboldt Foundation. The award, which recognizes researchers whose work has significant impact and who are expected to continue cutting-edge work, will allow Burnett to conduct research for his book in Germany.

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Accolades

**Six UNL Faculty Named AAAS Fellows**

Judy Diamond, Concetta DiRusso, Sherilyn Fritz, Alan Kamil, David Sellmyer and Charles Wood were named American Association for the Advancement of Science Fellows in 2013. It was the first time six UNL scientists were elected fellows in the same year. Diamond, professor and curator of informal science education at the University of Nebraska State Museum, was recognized for distinguished contributions to promoting scientific literacy. DiRusso, professor of biochemistry, was honored for advancing understanding of nutritional fatty acids and for education advocacy. Fritz, George Holmes Professor of Earth and Atmospheric Sciences, was recognized for distinguished contributions to paleolimnology and paleoclimatology. Kamil, George Holmes Professor of Biological Sciences, was recognized for distinguished contributions to research into animal behavior and cognition. Sellmyer, George Holmes Professor of Physics, was honored for distinguished contributions to the physics of magnetic materials and nanostructures and for his leadership as director of UNL’s Nebraska Center for Materials and Nanoscience. Wood, Lewis Lehr/3M Professor of Biological Sciences and director of UNL’s Nebraska Center for Virology, was recognized for significant contributions to molecular virology and HIV/AIDS epidemiology and to building global scientific capacity.

**National Academy of Inventors Fellow**

Biochemist Donald Weeks was named a National Academy of Inventors Fellow in 2013. The distinction is a high honor bestowed on academic inventors whose inventions improve quality of life, spur economic development and benefit society. Weeks, the Maxcy Professor of Agriculture and Natural Resources, was recognized for contributions in plant and algal biology, especially his novel approach to engineering herbicide-resistant crops. He holds 10 U.S. patents and 22 international patents. Weeks’ selection marks the second year members of the UNL faculty have been named NAI Fellows.

**Jefferson Science Fellow**

Concetta DiRusso, professor of biochemistry, is a 2014-2015 Jefferson Science Fellow. DiRusso is known for her work to understand nutritional fatty acids and their impact on human health, including diabetes and other diseases commonly linked to obesity. The National Academies program gives fellows the opportunity to spend one year in Washington, D.C., as advisers on science and engineering policy issues to the Department of State and U.S. Agency on International Development.
<p><strong>Faculty Recognized</strong></p>

- The Fulbright Program offers UNL scholars opportunities to grow in teaching and research. **Carole Levin**, Willa Cather Professor of History, will spend the spring 2015 semester in York, England, studying the Celtic queen Boudicca’s leadership style and her connections to modern female political leadership. **Wendy Weiss**, emeritus professor of textiles, merchandising and fashion design, received a Fulbright-Nehru Senior Scholar grant to travel to Gujarat, India, to study development and design of the ikat print. **Gary Kebbel**, professor of journalism, and **Sriyani Tidball**, assistant professor of practice in advertising and public relations, earned Fulbright Specialist grants. Kebbel is helping the U.S. Mission to the African Union, based in Ethiopia, draft a strategic communications plan. In January, Tidball will work with the Centre for Women’s Research in Sri Lanka to form a communications strategy for helping migrant workers stay in touch with their families.

- **Tyler White**, professor of composition and conducting, won a Global Music Awards silver medal in composition for his opera <i>O Pioneers!</i> that reimagined the Willa Cather classic novel in musical form. He also was a finalist for The American Prize in Composition in opera/theater/film.

- **Xiao Cheng Zeng**, Ameritas University Professor of Chemistry, was named a Fellow of the United Kingdom’s Royal Society of Chemistry. Zeng has made groundbreaking discoveries using computer modeling to reveal how matter behaves under extreme conditions, and in computer-aided molecular and materials design.

- **Gregg Rothermel**, Dale M. Jensen Chair of Software Engineering, earned 2013 Distinguished Scientist and Distinguished Member honors from the Association for Computing Machinery for significant accomplishments in computer science. Rothermel’s research areas include application of program analysis techniques, software maintenance programs and end-user software engineering.

- Two UNL faculty members became American Mathematical Society Fellows in 2013: **John Meakin**, Milton Mohr Professor of Mathematics, and **Srikanth Iyengar**, Willa Cather Professor of Mathematics. Meakin was selected for contributions to semigroup theory and leadership in UNL’s mathematics department. Iyengar has lent his expertise in commutative algebra to numerous international research collaborations. UNL has a strong tradition of mathematics excellence, with five researchers joining the inaugural class of AMS Fellows in 2012.

- **Cory Forbes**, associate professor of science education in the School of Natural Resources, received the 2014 Early Career Research Award from the National Association for Research in Science Teaching for his potential to significantly contribute to science education. Forbes has studied third-grade students’ learning about biological structure and function and the hydrologic system, and teachers’ implementation of curricula to help students learn about water and food systems.
Collaborating on Nanoelectronics

Transforming university nanoscience discoveries into smaller, faster electronics is the aim of a new multi-institutional collaboration.

A UNL physics team leads the Center for NanoFerroic Devices, a $7.125 million research collaboration involving six universities and an industry consortium. Funded by the Semiconductor Research Corp. and the National Institute of Standards and Technology, it’s one of three new multi-university research centers that are part of the second phase of the Nanoelectronics Research Initiative.

“The new center is a natural continuation of the research that we’ve been doing. Now we’re rising to a new level,” Tsymbal said.

Today’s electronics use an electric charge to store and process information, which limits the number of transistors that can occupy a chip. The new center is pursuing three alternatives to take advantage of nanoscale properties that require less energy, which could enable more compact and powerful devices.

UNL’s university partners are University of California, Irvine; University of Wisconsin-Madison; University at Buffalo, SUNY; University of Delaware; and Oakland University. Industry partners include IBM, Intel, Micron Technology, Texas Instruments and GLOBALFOUNDRIES. Semiconductor Research Corp. is the world’s leading university-research consortium for semiconductors and related technologies.

UNL physicist Alexei Gruverman leads a team focused on nanofilm ferroelectric oxide, a material with both positive and negative polarization directions that can be read like a binary code to store information. A second initiative relies on UNL physicists Christian Binek’s work with spintronics, which manipulates electron spin to store information. The third initiative, led by Ilya Krivorotov at the University of California, Irvine, focuses on how electrons carry information by generating spin waves. UNL physicists Kirill Belashchenko and Xia Hong also work with the center.

Tsymbal said collaboration among researchers and industry is critical to moving fundamental principles from the laboratory to specific devices.

Going home after months, even years, in an out-of-home care program is an exciting milestone for at-risk teens and their families.

“It’s also a vulnerable time. Youth with emotional or behavioral disorders can make laudable progress in treatment, but they may backslide into old, familiar behaviors if their home and school environments don’t reinforce new skills. That leaves them at risk for further problems, including quitting school, strained relationships, drug and alcohol abuse, and criminal behavior. Alex Trout, research associate professor in special education and communication disorders, leads a team of researchers, educators and family service workers from UNL, Boys Town and five other residential agencies in eastern Nebraska to evaluate On the Way Home, a set of programs to help youth make a successful transition.

“These youth receive lots of targeted help and education while they’re in treatment,” Trout said. “It’s heartbreaking to watch them fall apart after they’ve made big strides.”

The need for proven, research-based programs is huge, Trout said. UNL researchers developed On the Way Home in collaboration with researchers elsewhere, with support from an earlier IES grant. With further research, the program could become a national model for aftercare support.

Preliminary findings show that nearly 91 percent of participants maintained their home placement after one year, and approximately 88 percent had graduated or were still enrolled in school.

With a nearly $3.5 million grant from the U.S. Department of Education’s Institute for Education Sciences, the team is building on earlier research, evaluating educational, family and behavioral outcomes at a larger scale and expanding services to additional agencies. More than 4,000 Nebraska youth receive out-of-home care; Trout hopes to include 250 in the research.

The aim is to involve the teen’s parents, school and workplace in the transition. Interventions include parent training, dropout prevention and intervention, and homework support. A family consultant is available 24/7 for parents to seek advice. Weekly check-ins help identify struggles and problematic behaviors early.

“The children, families and schools have confirmed the value of supporting these youth through this often difficult transition,” said Patrick Tyler, director of the aftercare program at Boys Town. “On the Way Home provides an important service, at the right time, so these children can sustain the gains they’ve made.”

UNL physicists Alexei Gruverman, Peter Dowben, Kirill Belashchenko, Xia Hong and Eugeny Tsymbal (not pictured, Christian Binek)
Nanoscience Center Strengthens Research

UNL’s new Voelkle-Haegens Nanoscience Research Center strengthens UNL’s capacity to address some of the nation’s pressing problems through nanoscience.

Completed in early 2012, the 32,000-square-foot center houses the seven core facilities and two shared laboratories of the Nebraska Center for Materials and Nanoscience. It consolidates UNL’s state-of-the-art nanoscience research facilities in a single, central location accessible to the more than 80 faculty affiliated with the NCMN.

The building also provides researchers access to specialized equipment, such as a National Science Foundation-funded transmission electron microscope and a high-tech clean room that eliminates dust particles.

“This truly puts us on the map,” said David Sellmyer, NCMN director and George Holmes University Professor of Physics and Astronomy. “It makes for much greater ease of collaboration and a lot more efficiency.”

UNL’s Materials Research, Science and Engineering Center, funded by the NSF and focused on quantum and spin phenomena in nanomagnetic structures, relies on the core facilities, said physicist Evgeny Tsybailo, MRSEC’s director and a Charles Bessey Professor. Thanks to the facility’s centralized services and new equipment, faculty are pursuing research that wasn’t previously possible.

“The center will boost research and collaborations in nanoscience and create the infrastructure necessary to enhance our competitiveness,” Tsybailo said.

Funding agencies increasingly are encouraging large collaborative projects that engage cutting-edge expertise and facilities worldwide to solve formidable challenges, Sellmyer said. The new center strengthens UNL’s competitiveness for grants, both for individual researchers and for UNL’s increasing participation in these large multi-institutional collaborative projects.

Improving UNL’s nanoscience research facilities also benefits Nebraska, Sellmyer added. The center enhances collaboration with industries that also use these facilities and is an incentive for startup companies to locate here.

Major funding for the research center came from a $5 million donation from UNL alumnus Don Voelkle and his wife, Nancy Haegens, a University of Nebraska Foundation board member, and a $7 million competitive federal grant from the National Institute of Standards and Technology through the American Recovery and Reinvestment Act.
“The center will boost research and collaborations in nanoscience and create the infrastructure necessary to enhance our competitiveness.”
Expanding Data Storage Potential

Nanoscience is blazing new trails in making the technology of daily life—from computers to cell phones and memory storage devices—more powerful and efficient. Now, a UNL-led team’s recent discovery is expanding possibilities for data storage.

A team led by physicist Alexei Gruverman, a researcher in UNL’s Materials Research Science and Engineering Center and the Nebraska Center for Materials and Nanoscience, identified a way to store data significantly more densely than previously possible.

Gruverman’s research on electronic materials is done at the nanoscale, where objects exhibit unexpected chemical and physical properties. Central to his research is the scanning probe microscopy technique, which uses a tiny physical probe to exert highly localized mechanical, electrical or magnetic influence on an object and then measure its response.

The probe’s tip—invisible to the naked eye—can be used to electrically change the properties of the electronic or ferroelectric materials used in memory devices.

Data storage has always relied on electrical voltage. But Gruverman’s team found that the same nanoscale-sized bit of data could be written simply by pressing harder against the ferroelectric material’s surface without damaging it, working much like a nanoscopic typewriter.

The team was the first to demonstrate that mechanical force can be used to change an area’s polarization. Gruverman, UNL graduate student Haifong Lu and researchers from Spain and the University of Wisconsin reported their findings in the journal Science.

“It’s a completely voltage-free switching of polarization, which is what makes the results of this research unique,” Gruverman said. The finding establishes a scientific basis for creating more powerful storage devices. The team hopes to build on the discovery by investigating other possible applications.

Grants from the U.S. Department of Energy and the National Science Foundation support Gruverman’s broader research. NSF also funds UNL’s MRSEC, which focuses on nanomagnetism.
Designing New Nanomaterials

A key to making computers and other electronics smaller, faster and less expensive lies in overcoming the limitations of existing materials. UNL physicist Xia Hong’s research into nanoscale materials may one day help break through current barriers.

For decades, scientists have been squeezing more power out of today’s silicon-based electronics, which are approaching the material’s fundamental limits. To continue advancing, researchers are exploring materials that exhibit unusual physical, chemical or biological properties at the nanoscale and fabricating new nanomaterials with multifunctional properties.

Hong is combining two oxides to create a nanomaterial with both magnetic and ferroelectric properties. Ferroelectric materials have positive and negative polarization directions. Applying electricity can reverse the polarization and control magnetism. Storing data with an electric charge alone or using electricity to manipulate magnetic signals would be more energy efficient and allow greater storage capacity in a smaller space.

Hong predicts it will take one to two years to fabricate the new nanostructure. She’ll then study the material’s characteristics. Her research promises to advance the understanding of magneto-electric coupling and could lead to novel materials and devices. Hong, a member of UNL’s Materials Research Science and Engineering Center, earned a prestigious $600,000, five-year National Science Foundation CAREER program award for this research.

The expertise of other MRSEC faculty and the center’s focus on nanoscale magnetism and magneto-electric interfaces aid her research, Hong said. “My research is very complementary to the existing efforts here. There is a lot of collaboration.”

The award also allows her to make physics accessible to young people, particularly girls, by using her drawing skills to develop educational cartoons.

“Many people think physics is very difficult,” Hong said. “I thought it was a good idea to use a teenage girl’s point of view to illustrate physics principles … to make physics more likable.”
Game-changing Research Sparks Startup

UNL chemist Stephen DiMaggio was confident his research could revolutionize medical imaging with positron emission tomography, or PET scans. But was it commercially viable?

With help from two National Science Foundation programs designed to guide promising NSF-supported scientific discoveries into the marketplace and assistance from NUtech Ventures, a nonprofit affiliate that helps commercialize UNL research, DiMaggio realized the answer was yes.

His new company, Ground Fluor Pharmaceuticals, develops imaging agents for PET scans. PET is a widely used diagnostic tool for detecting and managing certain cancers, heart disease and neurodegenerative disorders including Alzheimer’s and Parkinson’s diseases. This technology might also help companies develop new drugs.

A nuclear medicine imaging technique, PET relies on radiotracers to give information about the function and metabolism in the body’s organs. DiMaggio developed a technique to attach the radioactive isotope fluorine-18 to different carrier molecules. The isotope enables a PET scanner to detect a compound’s metabolic fate.

“Our methodology allows us to create more potent imaging agents more rapidly, reliably and in high yield,” DiMaggio said. “Previously, these agents were unknown or very difficult to synthesize.”

A $50,000 NSF Innovation Corps award, or I-Corps, enabled DiMaggio to meet with more than 100 potential customers, suppliers and distributors to gauge their interest in the technology. These meetings helped DiMaggio revise his business plans and identify potential partners.

NUtech Ventures helped him license the technology and introduced DiMaggio to Allan Green, a Boston physician, scientist and lawyer who became Ground Fluor’s co-founder and chief executive officer. The company is based in Lincoln, Neb.

A $150,000 NSF Small Business Innovative Research award supports the startup’s activities, including hiring two scientists and expanding its network of academic collaborators. Ground Fluor is testing its method in labs across the country to ensure it can be replicated in a variety of settings.

This technology could increase the availability of existing experimental PET agents and support development of new ones, DiMaggio said.

Left: Stephen DiMaggio
Above: Pouring liquid nitrogen
Binek’s team discovered how to switch ferromagnets’ magnetization using voltage, which doesn’t generate heat. The magic ingredient is chromia, the oxide form of chromium, which can be magnetized with voltage. Making a precisely ordered thin film of chromia, bringing it into contact with a ferromagnet and applying voltage also switches the ferromagnet’s magnetization.

Binek now is developing voltage-powered logical and memory devices, which could lead to less expensive, smaller and more powerful gadgets that use less energy. Consumers, for example, would be able to store more movies on longer-powered mobile devices. Researchers also may one day have the computing power to run mind-blowingly complex calculations, enabling new scientific discoveries.

Binek credits collaborations made possible by MRSEC, which is funded by the National Science Foundation. Co-investigators, UNL physicists Kirill Belashchenko and Peter Dowben, a Charles Bessey Professor, contributed invaluable expertise. The team reported its discovery in *Nature Materials*.

“I was forced to leave my comfort zone and look more broadly, with different methods and different ideas. Working together gave us this breakthrough,” Binek said.

**Discovery Could Spark Smaller, Faster Electronics**

Nanopods, cameras the size of credit cards, computers that run trillions of calculations per second. Can gadgets get any smaller or more powerful?

Yes, engineers say, but the limit is looming.

To help head off this predicted size barrier, a team at UNL’s Materials Research Science and Engineering Center (MRSEC) has made an important breakthrough in spintronics, which exploits electron spin for use in advanced information technologies.

“In a nanometer, there are only so many atoms next to each other. After you reach that level, you can’t make things smaller,” said physicist Christian Binek, the project’s lead investigator.

“Tos move on from that point, we have to do something fundamentally new.”

Today’s electronics use an electric current to store and process information. But currents generate heat, limiting the number of transistors that can be packed onto a chip. Currents also use energy, reducing battery life. Based on their findings, the UNL researchers envision a conceptually new generation of ferromagnetic transistors overcoming these limitations.

UNL’s Materials Research Science and Engineering Center provides valuable collaborative and financial opportunities for nanoscientists studying new magnetic structures and materials.

That’s paying off, said physicist Evgeny Tsybulya, MRSEC’s director, and a Charles Bessey Professor at UNL.

In addition to the Christian Binek team’s breakthrough in spintronics, Tsybulya cites other MRSEC collaborations.

Physicist Atassie Gruverman’s group used advanced scanning probe techniques to improve ferroelectric tunnel junctions for use in nanoelectronic devices and data storage. Physical Axel Enders is able to grow and characterize nanoscale films and new nanomaterials, which may lead to improved high-density magnetic recording.

Strong ties with industry ensure scientists concentrate on problems industries face and provide opportunities for industry-financed support. Several researchers have received MRSEC supplemental funds provided by an industry consortium.

Established in 2002 with a $5.4 million National Science Foundation grant, MRSEC received an $8.1 million, six-year renewal grant in 2008. MRSEC’s research focuses on quantum and spin phenomena in nanomagnetic structures. This research has potential applications in advanced computing, data storage, energy production, handheld electronic devices, sensors and medical technologies.

“MRSEC plays a very significant role,” said Tsybulya, “providing opportunities for collaborations, infrastructure, access to facilities and very important educational and outreach programs.”
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**MRSEC Fosters Collaboration**

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That’s paying off, said physicist Evgeny Tsymbal, MRSEC’s director, and a Charles Bessey Professor at UNL.

In addition to the Christian Binek team’s breakthrough in spintronics, Tsymbal cites other MRSEC collaborations.

Physicist Alexei Gruverman’s group used advanced scanning probe techniques to improve ferroelectric tunnel junctions for use in nanoelectronic devices and data storage. Physicist Axel Enders is able to grow and characterize nanoscale films and new nanomaterials, which may lead to improved high-density magnetic recording.

Strong ties with industry ensure scientists concentrate on problems industries face and provide opportunities for industry-financed support. Several researchers have received MRSEC supplemental funds provided by an industry consortium.

Established in 2002 with a $5.4 million National Science Foundation grant, MRSEC received an $8.1 million, six-year renewal grant in 2008. Its research focuses on quantum and spin phenomena in nanomagnetic structures. This research has potential applications in advanced computing, data storage, energy production, handheld electronic devices, sensors and medical technologies.

“MRSEC plays a very significant role,” said Tsymbal, “providing opportunities for collaborations, infrastructure, access to facilities and very important educational and outreach programs.”
Carbon, the ubiquitous element of life, has many special properties. Harnessing it at the atomic level to create nanostructures promises to transform many everyday products, from computer chips to sunglasses.

Discovering fast, cost-effective ways to mass produce these nanostructures is key to their practical use. It’s Yongfeng Lu’s specialty.

“Carbon nanostructures have very large potential in different applications,” said Lu, Lott University Professor of Electrical Engineering.

His UNL team has developed several unique processes that use lasers to make precise carbon nanostructures. They are refining their techniques and exploring new applications for their nanostructures. Since 2003, they have earned more than $14 million in research grants.

Their laser-based production techniques can precisely control the length, diameter and properties of carbon nanotubes. Using these highly electrically and thermally conductive nanotubes, Lu’s team developed methods to improve transistors and sensors that may one day speed up computers and other electrical devices, while minimizing energy consumption and heat generation.

They also discovered how to control a carbon nanotube’s diameter from one end to the other, which alters its characteristics. Lu envisions variable-diameter nanotubes customized for specific uses.

Now they’re studying how to join carbon nanotubes to make smaller, lighter wires that carry large amounts of current for use in electric cars and other products.

Another breakthrough process creates carbon nano-onions, spherical nanostructures resembling onion layers that have unique electrical, optical and magnetic properties. Nano-onions can store large amounts of energy on their extensive surface area. Using nano-onions, Lu’s team has developed supercapacitors for high-density energy storage.

Nano-onions also have optical limiting properties, absorbing light as it intensifies. Lu’s research could lead to improved eye protection, optical sensors, satellites and other optical-dependent materials.

Lu’s team also developed a fast, single-step process using lasers to write graphene patterns on surfaces. A basic building block for other nanostructures, graphene resembles nanoscale chicken wire. Its electrical conductivity and transparency could be used in products such as LCD televisions and solar panels.

“Carbon is everywhere, so the future of electronics, photonics and many high-tech industries will not be limited by supplies,” Lu said.
Nanohybrids Promise ‘Best of Both Worlds’

Scientists are always seeking better ways to find and quantify minute things, such as toxins in the air or cancer particles in blood. UNL researchers lead a collaboration to create more powerful detection devices by combining manmade nanoparticles with nature’s inherent recognition capabilities.

Creating these “nanohybrids” requires the diverse expertise of researchers in biology, chemistry and nanomaterials engineering. A Nebraska team recently launched the UNL-based Center for Nanohybrid Functional Materials, which brings together 15 researchers from UNL, the University of Nebraska Medical Center, the University of Nebraska at Kearney, Creighton University and Doane College.

With nanohybrids, “you get the best of both worlds,” said UNL chemist Patrick Dussault, a Charles Bessey Professor, who co-leads the center with Mathias Schubert, associate professor of electrical engineering.

Nanohybrids combine nanostructures - which can be engineered to behave uniquely under certain conditions, such as when subjected to a beam of light or radio energy - with chemical or biochemical agents, such as RNA or antibodies that can bind a specific substance. This new nanomaterial can both find and reveal its target.

Materials often behave differently at nanoscales, Dussault said. Understanding the basic sensing principles of nanohybrids is a major goal of the new group. With this knowledge, researchers hope to develop tools with enhanced detection capabilities.

Potential applications include devices that more selectively or sensitively diagnose diseases or find environmental contaminants. The ability to better detect toxins in air or water also could benefit national security.

The center builds on UNL’s strength in nanomaterials. With about $7.5 million in funding from the National Science Foundation through Nebraska EPSCoR, the center is creating a new core facility and partnering with several departments to hire new faculty, enhancing UNL’s leadership in nanoscience.

The center also has begun developing partnerships with industries in Nebraska and beyond.

“I think potentially it can attract a lot of companies, big and small, to Nebraska,” said Fred Choobineh, Nebraska EPSCoR director. “It’s very creative and cutting-edge research.”
A cheaper and quicker way to detect HIV would be invaluable in fighting the HIV/AIDS epidemic worldwide. UNL chemist Rebecca Lai’s research on electrochemical biosensors may one day lead to developing a simple device for identifying HIV.

Lai’s strategy for detecting the virus is to look for the presence of HIV antibodies, proteins the immune system produces to identify and neutralize the virus by binding to viral molecules called antigens.

Many antigens change shape when they interact with antibodies. By developing a method that monitors the structural change of the antigen, Lai can detect the presence of the antibody. In the case of HIV, the presence of antibodies to HIV indicates infection with the virus.

She labels the antigen with methylene blue, a tracer molecule that accepts electrons when a specific voltage is applied. If antibodies are present, they interact with the antigens, causing a structural change and preventing the methylene blue from accepting electrons. The sensor will detect a large decrease in current in the presence of HIV antibodies. The current remains the same if no HIV antibodies are present.

“Our biggest goal is to make a handheld biosensor similar to the glucose sensor, but for the specific detection of HIV,” Lai said.

Electrochemical sensing has the potential for diverse applications, ranging from cancer detection to finding toxins, explosives or drugs in the body and in the environment.

Lai recently earned a $455,000, five-year National Science Foundation CAREER Program award, which supports outstanding pre-tenure faculty, to continue her research.

Educating young people in science and being a role model for young women and minorities in science are important facets of Lai’s career. The CAREER award also will take her into Nebraska’s classrooms. She plans to develop hands-on summer workshops in biosensing technologies for Nebraska high school teachers. The first workshops will be in summer 2011.

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“Biosensor Work Aims for Simple HIV Test

Above left: Electrochemical biosensor
Right: Rebecca Lai (left) and graduate student Jennifer Gerasimov
It’s well known that sunlight fuels plants. But exactly how plants convert photons of light into energy is unknown. Unlocking the mystery could lead to better green energy sources.

The first molecular step in conversion takes less than one-trillionth of a second, far too fast for scientists to see the process. But UNL physicist Martin Centurion has discovered a way to peer into that ultra-fast molecular world.

“This could help to get a better understanding of how to convert energy light from the sun into chemical energy,” said Centurion, who received a $600,000 Early Career Research Program award from the Department of Energy to support his work.

When a photon of light hits a molecule, whether on a plant’s leaf or in a human eye, for example, the molecule undergoes structural changes to turn that photon energy into chemical energy. For a plant, that energy becomes fuel for growth and reproduction. Eyesight depends on the converted energy traveling to the brain.

To see a structural change that lasts just one-trillionth of a second, Centurion hits gas molecules with a laser pulse, a source of photon energy, to start the molecular change. The laser also triggers a burst of electrons. When the electrons hit the molecules, they scatter. By analyzing the electron scatter, Centurion can recreate a molecule’s structure at that moment, like taking its picture.

By lengthening the timing between the laser pulse and the electron snapshot, Centurion can create a movie of the changes occurring in the molecular structure. Being able to see those structural changes will provide insight into the molecule’s function.

Understanding how the molecule converts energy may one day help scientists develop alternative energy sources.

Peering into Ultra-fast Molecular World

Building better hybrid cars, wind turbines and computers reduces global warming, but the nanomagnets used in these devices require rare earth metals. Experts in UNL’s Nebraska Center for Materials and Nanoscience (NCMN) aim to change that.

As partners in a $4.5 million Advanced Research Projects Agency-Energy grant from the U.S. Department of Energy led by the University of Delaware, UNL researchers collaborate with several universities, laboratories and companies to improve nanomagnets. The grant is funded through the American Recovery and Reinvestment Act.

Many clean energy and electronic devices rely on magnetic materials made from rare earth metals that, despite the name, are common in the earth’s crust. However, nearly all of the world’s supply of rare earth metals comes from China. Demand for these metals is skyrocketing, China is restricting exports, and the extraction process is an environmental concern.

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To better manipulate the magnetic properties, researchers are building materials at the atomic scale. The ability to precisely position every atom in a nanoparticle allows full control of the material’s magnetic properties.

This is high-risk, high-reward research. “The best magnets that we’ve got now were discovered in 1985 or so,” Sellmyer said. “We’ve made advances, but nothing that’s a big quantum leap. That’s what we want: a home run rather than a single.”

NCMN is home to one of the nation’s leading magnetism research groups and is largely funded by National Science Foundation, Department of Energy and Department of Defense grants.

NCMN director.

Developing Stronger Nanomagnets

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Peering into Ultra-fast Molecular World
The more than 70 physicists, chemists and engineers who collaborate on UNL’s nationally recognized materials and nanoscience research will soon have a new, centralized research facility.

The new Nanoscience Metrology Facility will provide much-needed research space for this interdisciplinary program of excellence, whose core facilities, equipment, labs and faculty are currently located in several campus buildings. The new facility will feature centrally located laboratories, research facilities and administrative space. Construction is under way with completion slated for 2011.

Construction was made possible by a $6.9 million grant from the National Institute of Standards and Technology (NIST), funded by the American Recovery and Reinvestment Act, to cover nearly half of the $14.8 million cost. Private donations and university funds will fill the rest. NIST is a non-regulatory agency in the U.S. Department of Commerce.

UNL is home to one of the nation’s top nanomagnetism research groups. Materials scientists, nanoscientists and engineers from across UNL collaborate through the Nebraska Center for Materials and Nanoscience, and in UNL’s National Science Foundation-funded Materials Research Science and Engineering Center focused on nanomagnetics and spintronics.

"Knowing the structure of nanomaterials is extremely important," Sellmyer said. "When you make particles that small, they can have extremely important properties. When you make particles that small, they can have extremely important properties. When you make particles that small, they can have extremely important properties. When you make particles that small, they can have extremely important properties. When you make particles that small, they can have extremely important properties. When you make particles that small, they can have extremely important properties. When you make particles that small, they can have extremely important properties. When you make particles that small, they can have extremely important properties. When you make particles that small, they can have extremely important properties. When you make particles that small, they can have extremely important properties. When you make particles that small, they can have extremely important properties. When you make particles that small, they can have extremely important properties. When you make particles that small, they can have extremely important properties. When you make particles that small, they can have extremely important properties. When you make particles that small, they can have extremely important properties. When you make particles that small, they can have extremely important properties. When you make particles that small, they can have extremely important properties. When you make particles that small, they can have extremely important properties. When you make particles that small, they can have extremely important properties. When you make particles that small, they can have extremely important properties. When you make particles that small, they can have extremely important properties. When you make particles that small, they can have extremely important properties. When you make particles that small, they can have extremely important properties. When you make particles that small, they can have extremely important properties. When you make particles that small, they can have extremely important properties. When you make particles that small, they can have extremely important properties. When you make particles that small, they can have extremely important properties. When you make particles that small, they can have extremely important properties. When you make particles that small, they can have extremely important properties. When you make particles that small, they can have extremely important properties. When you make particles that small, they can have extremely important properties. When you make particles that small, they can have extremely important properties. When you make particles that small, they can have extremely important properties. When you make particles that small, they can have extremely important properties. When you make particles that small, they can have extremely important properties. When you make particles that small, they can have extremely important properties. When you make particles that small, they can have extremely important properties. When you make particles that small, they can have extremely important properties. When you make particles that small, they can have extremely important properties. When you make particles that small, they can have extremely important properties. When you make particles that small, they can have extremely important properties. When you make particles that small, they can have extremely important properties. When you make particles that small, they can have extremely important properties. When you make particles that small, they can have extremely important properties. When you make particles that small, they can have extremely important properties. When you make particles that small, they can have extremely important properties. When you make particles that small, they can have extremely important properties. When you make particles that small, they can have extremely important properties. When you make particles that small, they can have extremely important properties. When you make particles that small, they can have extremely important properties. When you make particles that small, they can have extremely important properties. When you make particles that small, they can have extremely important properties. When you make particles that small, they can have extremely important properties. When you make particles that small, they can have extremely important properties. When you make particles that small, they can have extremely important properties.
Harnessing Nanotechnology’s Potential

From medicine and electronics to energy and the environment, nanotechnology promises to change our world. Researchers at UNL’s Materials Research Science and Engineering Center (MRSEC) are exploring how to harness this nanopower.

More than 20 UNL physicists, chemists and engineers collaborate to study new magnetic structures and materials as small as one-billionth of a meter. Understanding the properties and performance of nanomaterials is a key step toward using them to create advanced technologies, said physicist Evgeny Tsymbal, MRSEC’s director.

For example, physicist Christian Binek studies magnetism for use in spintronics, which exploits the spin of electrons in addition to their conventional electrical charge. This could lead to exponentially smaller, faster and more powerful computers and electronic devices.

Multidisciplinary collaboration is essential, Binek said. “We are combining materials that don’t happen in nature, which might be causing a chemical reaction that produces unwanted results. For a chemist that may seem obvious, but for a physicist, if we aren’t talking, it may be a painful learning curve.”

MRSEC researchers share equipment as well as expertise. For his research, physicist Axel Enders built an ultrahigh-vacuum chamber to exclude oxygen when creating nanomaterials and a unique low-temperature scanning tunneling microscope that makes atoms of nanostructures visible. Both aid broader MRSEC research.

“Collaborating with others is very inspiring. Now, we can do things that any one of us could not do alone. MRSEC is one of the reasons I came to UNL,” said Enders, who recently won a prestigious National Science Foundation CAREER award.

Established in 2002 with a $5.4 million NSF grant, MRSEC received an $8.1 million, five-year renewal grant in 2008. Its research, which focuses on quantum and spin phenomena in nanomagnetic structures, has garnered international attention.

MRSEC’s research has potential applications in advanced computing, data storage, energy production, handheld electronic devices, sensors and medical technologies. The center also has a strong education and outreach program and collaborates with industry, national laboratories and scientists internationally.

“Our long-term goal is to be the leading interdisciplinary center for integrated research and education in nanomagnetism,” Tsymbal said.
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Determined to Make a Difference

It’s a remarkable journey from an uncertain childhood as a Sudanese refugee to UNL graduate student and Fulbright grant winner. For Nithal Kuwa, it’s the path to her dream of improving African health care.

Kuwa is in Zambia studying HIV drug resistance in children. This follows her master’s degree research with Charles Wood, UNL molecular virologist and AIDS researcher who directs the Nebraska Center for Virology. She’ll graduate in December 2009. For her Fulbright, Kuwa is working with researchers in Wood’s lab in Zambia and volunteering at a local counseling and testing center.

“What I am going to do will be important for the development of better drug regimens for children,” Kuwa said.

As Wood’s graduate student, Kuwa studied immune response to a herpes virus that often causes an aggressive cancer in HIV/AIDS patients. Wood studies HIV and HIV-associated viruses, focusing on transmission and their roles in immunosuppression and cancer development. Through his lab and clinic at the University of Zambia, Wood works closely with local scientists on HIV/AIDS.

Born in Sudan at the beginning of its civil war, Kuwa spent most of her childhood living in Ethiopia and Kenya before arriving in Lincoln, Neb., in 2000 as a teenager with her mother and siblings.

She excelled academically. During college she was so moved by her summer volunteering in a Sudanese hospital she decided to one day return to Sudan to help. Following her Fulbright experience, she plans to pursue a doctorate in public health.

“I hope that my being there and seeing their faces will give me motivation to put even more into my work,” Kuwa said. “Hopefully in the future, I’ll make a difference in someone’s life.”

UNL faculty are aggressively pursuing funding available through the American Recovery and Reinvestment Act of 2009 to expand their research and scholarship, and to help stimulate the nation’s economy.

The stimulus package, which provides unprecedented funding for research, infrastructure and education, is designed to jumpstart the economy and create or retain jobs. Prem Paul, UNL vice chancellor for research and economic development, said stimulus funding will lead to new technologies and information with short- and long-term economic benefits. “Money spent on research creates and retains jobs.” Paul said. “These dollars will be spent in Nebraska and will truly have multiple benefits for our economy.”

UNL faculty are successfully competing for stimulus funding, Paul said. Examples of early success included:

- A $375,670, two-year grant from the National Institute of Allergy and Infectious Diseases to Charles Wood, professor of chemistry, for research to enhance his team’s functional annotation screening technology by nuclear magnetic resonance spectroscopy (FAST-NMR) assay. Perfecting this tool will help researchers determine the function of proteins identified by gene sequencing and their therapeutic potential in developing new drugs.

- A $360,000, three-year grant from the National Science Foundation to Jeffrey Burt, professor of mechanical engineering, to establish a Research Experiences for Undergraduates (REU) program in nanomaterials and nanoscience. Sponsored by the Nebraska Center for Materials and Nanoscience, this REU will build on UNL’s research strengths in nanotechnology. It will bring to campus students from colleges and universities that lack a strong research emphasis, especially those in the upper Midwest, as well as students from underrepresented groups for 10 weeks of intensive research with UNL faculty.

- A $300,002, three-year NSF grant to Li Tan, assistant professor of engineering mechanics, for research exploring how best to produce free-standing nanoparticle fibers that could be used to make far more efficient organic photovoltaic cells.

Stimulus Bolsters Research

A $735,670, two-year grant from the National Institute of Allergy and Infectious Diseases to Robert Powers, associate professor of chemistry, for research to enhance his team’s functional annotation screening technology by nuclear magnetic resonance spectroscopy (FAST-NMR) assay. Perfecting this tool will help researchers determine the function of proteins identified by gene sequencing and their therapeutic potential in developing new drugs.

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Credits

The 2008-2009 Annual Report is published by the University of Nebraska-Lincoln Office of Research and Economic Development. More information is available at http://research.unl.edu or contact: Prem S. Paul, Vice Chancellor for Research and Economic Development, 311 CamHil Administrator Building, University of Nebraska-Lincoln, Lincoln, Nebraska 68588-0433, (402) 472-3123, ppaul2@unl.edu

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Innovation, collaboration and economic development are linchpins in an ambitious vision for the Nebraska Innovation Campus, a private-public research partnership at UNL.

This long-term project is in the initial planning stages. It will build UNL's research capabilities, strengthen private-public collaborations, attract businesses that create jobs and expand Nebraska's economy.

The Nebraska Innovation Campus is planned for about 250 acres adjacent to UNL and near downtown Lincoln on land that now houses the Nebraska State Fair. Support for the project has grown since UNL officials unveiled the concept in late 2007. The Nebraska Legislature approved plans to move the state fair to Grand Island, Neb., freeing up most of the land by 2010 for research campus development.

"The modern economy is based on innovation. Many private-sector companies prefer to locate adjacent to or on a university campus where they can collaborate with university scientists and engage university students," UNL Chancellor Harvey Perlman said.

"We have a unique opportunity to create such an environment that will allow Nebraskans to benefit from the economic development value of our research."

Officials envision a research campus with public and private research and technology space where entrepreneurs and private companies work closely with UNL researchers and students. The campus concept proposes up to 1.6 million gross square feet of mixed-use space that private companies and UNL will develop as demand increases and private and public funds become available.

"Innovation Campus will facilitate converting research inventions into products for the marketplace that enhance Nebraska's economy," said Prem Paul, vice chancellor for research and economic development.

Demand for research space is growing along with UNL's research enterprise. Several current or planned projects will begin to address this critical space shortage, providing state-of-the-art facilities and improving infrastructure. Here's a rundown:

**Physical Sciences Building:**
In early 2010, physics and astronomy faculty will move from cramped labs and offices in three older buildings to the new $37 million Physical Sciences Building. Construction is under way on the four-story, 121,000-square-foot building to house laboratories and offices for physics and astronomy faculty along with teaching labs, lecture halls and classrooms.

**NanoScience Facility:**
Construction of the adjacent NanoScience Facility will begin when the Physical Sciences Building is complete. The $13.5 million facility will provide 32,500 square feet of laboratory, core facilities and administrative space for College of Engineering and College of Arts and Sciences researchers who collaborate through UNL's Nebraska Center for Materials and Nanoscience.

**Whittier Renovation:**
A $23.6 million phased renovation is transforming the historic Whittier Building into space for two major research centers – the Nebraska Transportation Center and the Nebraska Center for Energy Sciences Research. The first phase, slated for completion in late 2009, will provide about 26,000 square feet of laboratory, office and meeting space for faculty, staff and students affiliated with these two new centers.

**Whittier Building**

**Physical Sciences Building**

**Projects Aim to Ease Research Space Shortage**
Summer Programs Share Nanoscale Research

Understanding why a component in cow’s milk makes mice skinny may one day help people lose weight, too.

Scientists have long known that mice fed a diet containing just 1 percent conjugated linoleic acid, or CLA, a fatty acid produced by a microbe in cows’ stomachs, lose 50 percent to 80 percent of their body fat. With help from a National Science Foundation EPSCoR grant, UNL plant scientist Michael Fromm and animal scientist Jess Miner are discovering how CLA causes such dramatic weight loss at the molecular level. It’s part of broader nutritional genomics research.

“It’s very complex,” said Fromm. “But the advent of genomics technologies, sequencing the mouse and human genomes in particular, has given us a chance to really understand the mechanisms of these nutritional effects.”

They compare gene expression changes in mice fed a CLA-rich diet with those on a normal diet using microarray analysis, which measures expression across the entire genome at once. They’ve learned that CLA prevents the body from absorbing fat and glucose and increases fat burning.

In summer 2007, the program’s fifth year, more than half the teachers and professors were women or minorities. Organizers hope the participating teachers return to their classrooms and inspire young women and minority students to consider careers in materials science.

Visiting students and teachers work on a variety of nanomaterials research projects, including investigating ferroelectric properties, x-ray diffraction and making nanoscale clusters of atoms, which can be used in various technologies, such as hard disk drives. UNL physicist Steve Ducharme said the fellowships spark ongoing collaborations and encourage students to consider graduate school.

For example, a professor and her student took their knowledge of nanoscale clusters back to the University of Wisconsin-Platteville and involved other students in making clusters and investigating potential applications. To Kirby, that demonstrates the program’s success.

Unraveling CLA’s Role in Weight Loss

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They compare gene expression changes in mice fed a CLA-rich diet with those on a normal diet using microarray analysis, which measures expression across the entire genome at once. They’ve learned that CLA prevents the body from absorbing fat and glucose and increases fat burning.

In summer 2007, the program’s fifth year, more than half the teachers and professors were women or minorities. Organizers hope the participating teachers return to their classrooms and inspire young women and minority students to consider careers in materials science.

Visiting students and teachers work on a variety of nanomaterials research projects, including investigating ferroelectric properties, x-ray diffraction and making nanoscale clusters of atoms, which can be used in various technologies, such as hard disk drives. UNL physicist Steve Ducharme said the fellowships spark ongoing collaborations and encourage students to consider graduate school.

For example, a professor and her student took their knowledge of nanoscale clusters back to the University of Wisconsin-Platteville and involved other students in making clusters and investigating potential applications. To Kirby, that demonstrates the program’s success.

Visiting school teachers, undergraduate students and their professors get a macroscale immersion in nanoscale research through summer programs at UNL’s Materials Research Science and Engineering Center (MRSEC).

The center fosters collaboration among UNL physicists, chemists and engineers to advance nanomaterials research. Education and outreach is part of the National Science Foundation-funded center’s mission. Each summer, its 14 faculty members invite middle and high school teachers, and student-professor teams from four-year colleges to participate in MRSEC research.

“We’re inviting folks to gain some new skills, learn some new things and to take what they learn here back home to disseminate to their students, some of whom will become scientists or engineers,” explained Roger Kirby, chair of the Physics and Astronomy Department who heads the summer outreach programs. “We’re building for the future.”

MRSEC’s summer programs give participants the chance to work closely with UNL scientists and engineers on cutting-edge research in nanomagnetics. One program brings five middle and high school teachers to UNL for eight weeks; another invites six students and their professors from smaller colleges for fellowships ranging from two weeks to two months.
Talk about your gilded cage. UNL scientists studying gold’s structure at the nanoscale discovered hollow cage-like structures made of pure gold atoms.

Research by UNL chemist Xiao Cheng Zeng, graduate research assistant Satya Bulusu and colleagues revealed the first freestanding hollow cage structures composed of clusters of pure metal atoms. They are the metallic equivalent of buckyballs, the hollow carbon clusters made famous partly by their catchy name. Their findings were featured on the cover of the Proceedings of the National Academy of Sciences in May 2006.

Unlike carbon buckyballs, which contain 60 atoms, the golden hollow cages are composed of 15, 16, 17 or 18 atoms and can hold an atom inside. Scientists might someday be able to harness these nanocages to carry useful guest atoms for medical or industrial purposes.

Zeng’s team was the first to combine quantum chemistry calculations with a powerful computerized search technique to identify previously unknown nanoscale structures and substances. With the help of UNL’s PrairieFire supercomputer, researchers generated many theoretical fingerprints of the gold clusters’ structure.

UNL researchers worked with physicist Lai-Sheng Wang of the Pacific Northwest National Laboratory and Washington State University. Wang’s team provided spectral data or fingerprints of the gold clusters, made by smashing gold with a laser beam. Clusters containing different numbers of atoms produce a unique spectral fingerprint.

By comparing spectral and theoretical fingerprints, UNL researchers identified the structures of the 15-, 16-, 17- and 18-atom gold clusters. “We were shocked when we first saw these,” Zeng said. “No one expected the cage structure.”

Zeng’s team is studying the golden hollow cages’ potential to carry nanomaterials and their prospects as catalysts to speed chemical processes.

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“We were shocked when we first saw these. No one expected the cage structure.”

Xiao Cheng Zeng

Above: Xiao Cheng Zeng (right) and graduate research assistant Satya Bulusu.
Opposite: An illustration shows a hollow nanocage made of 17 gold atoms.