2017 Annual Report

IDeA EPSCoR NEBRASKA

Established Program to Stimulate Competitive Research

Teosinte (cover) and Tripsacum (this page), wild relatives of maize, grow in the lab of University of Nebraska-Lincoln Assistant Professor **JAMES SCHNABLE** with Nebraska's collaborative Center for Root and Rhizobiome Innovation (CRRI). This project's research, funded by National Science Foundation EPSCoR, includes genomic and phenomic study of how these plants have naturally adapted to environmental factors—including drought and higher temperatures—as CRRI works to understand and shape related crops' soil microbiome for productivity amid changing climatic conditions.

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NEBRASKA EPSCoR STAFF

F. Fred Choobineh – *Ph.D., P.E., Director*
Lindsey Moore – *Outreach Coordinator*
Nancy Simnitt – *Executive Assistant*
Carole Wilbeck – *Communications Specialist*
Fred Gartner – *Accounting Technician*

Nebraska EPSCoR
W192 Nebraska Hall
Lincoln , NE 68588-0557

Phone: 402-472-8946
Fax: 402-472-8948
epscor.nebraska.edu

EDITOR: Carole Wilbeck

GRAPHIC DESIGNER: Staci Nass

DIRECTOR'S MESSAGE

AS 2017 BEGAN, THE National Science Foundation announced a change: the leading letter in its EPSCoR acronym would no longer stand for Experimental, but instead: the *Established* Program to Stimulate Competitive Research.

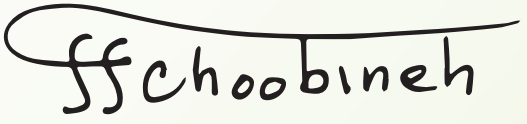
This makes sense because, after nearly 40 years of EPSCoR and nearly 25 for Nebraska as an EPSCoR state, our best programs and projects are embedded in our state's development. In Nebraska, our FIRST Awards program has helped launch more than 70 early career researchers (see the 2017 group on page 9). Our Young Nebraska Scientists program will conduct its 10th year of youth camps and summer research experiences in 2018 (see pages 12-13 for YNS updates), guiding youth to science careers. And since Nebraska EPSCoR began, more than $377 million in federal EPSCoR funding has benefited our state (for details, see inside back cover). The EPSCoR "experiment" has become an established driver of Nebraska's economy.

Yet, also in 2017, Nebraska EPSCoR/IDeA's State Committee wrote to our state's congressional representatives to express concern about proposed FY18 budget cuts and their potential impact on research and innovation in Nebraska.

Our group of experienced industry and science leaders decided to speak up against proposed reductions in the national R&D budget—to cut the National Institutes of Health (NIH) budget by 19.8 percent and the National Science Foundation (NSF) budget by 9.8 percent—and how these would harm Nebraska jobs and innovation.

For example, "(NIH's) IDeA program builds our state's science programs from grade school to graduate school, providing our future workforce," the letter explained. "We see the results of federal investments in science and research through employers of the scientific workforce that provide high quality jobs in companies across Nebraska—like LI-COR Biosciences, Ward Laboratories, Adjuvance Technologies, J. A. Woollam Company, Ground Fluor Pharmaceuticals, Epigenetics, Trak Surgical, Virtual Incision, and others."

I share key points from these letters to reiterate the importance of this funding, and results earned with it. As our State Committee's letters concluded, "These federal investments have been critical to Nebraska's research and economic success in the past few decades. We must sustain our state's momentum in science and research to build Nebraska's 21st century economy."



F. Fred Choobineh

NSF TRACK-1: NEBRASKA RESEARCH SEEKS SOIL-PLANT SOLUTIONS

The Center for Root and Rhizobiome Innovation (CRRI) Set Roots in Teamwork and Put Forth Initial Advances

WITH NATIONAL SCIENCE FOUNDATION funding of $20 million over five years, CRRI gathers 21 investigators and approximately 100 participants—from the University of Nebraska-Lincoln, University of Nebraska at Kearney, University of Nebraska Medical Center and Doane University—to study plant roots' microbiome and generate agricultural innovations that overcome challenges of increasing demand, drought and disease that threaten food supplies.

In Year 1, the CRRI Management Team completed strategic planning and established the center's website at **crri.unl.edu**. Monthly all-hands meetings continue to engage presenters from the group, including remote locations via electronic connection, to benefit cross-disciplinary problem-solving approaches.

AS CRRI'S YEAR 2 BEGAN IN MID-2017, RESEARCH PROGRESSED ON THE PROJECT'S AIM TEAMS:

- **AIM 1:** Co-leaders **James Schnable** and **Etsuko Moriyama** and colleagues study root metabolism, targeting integration of natural genetic variation and systems biology. The team started the preparation of RNA-seq libraries from diversity panel and finished the early draft assembly of Tripsacum transcriptome. They developed the root omics database for root-specific promoter identification and the preliminary ensemble transcriptome assembly pipeline.
- **AIM 2: Daniel Schachtman** and **Tessa Durham Brooks** co-lead the team that pursues linking natural chemical variation in root exudates to rhizobiomes. The Aim 2 team has worked to develop a high-throughput system for collecting and profiling root exudate samples using mass spectrometry, and screened 200+ lines of maize for diversity in exudate profiles. The team developed a simple approach for visualizing the root zone exudates' certain classes of small molecules, and generated a related manuscript for publication. They also developed a way to feed plants a carbon isotope so that specific microbes feeding on roots may be identified. The Aim 2 team collaborates with Aim 1 researchers in linking root gene expression to exudate production, and with Aim 4 researchers in understanding microbial diversity in agricultural and native soils.
- **AIM 3: Ed Cahoon**, **Tom Clemente** and team guide development and applications of root synthetic biology tools. Working with Aim 1's computational biologist, Aim 3 team members developed a toolbox of potential genetic elements for re-engineering root metabolism. They are also developing a high-throughput method to more rapidly evaluate

At the April 2017 NRIC event, speakers and informal presentations yield opportunities for regional collaborations in plant science.

synthetic biology designs, using genome editing to affect changes in root exudate concentrations by altering carbon capture in leaves, and identifying root small RNAs that are responsive to specific soil microbes. Efforts are underway to use these technologies to manipulate amounts and types of the hormone strigalactone to modify root structure and soil water and nutrient use.

- **AIM 4: Jim Alfano** and **James Schnable** co-lead the focus on plant phenotypic and rhizobiome stress responses to variations in root exudates. This team isolated root and bulk soil microbiome samples from fields with different cropping systems (one with continuous maize since the 1970s). Its greenhouse phenotyping and field experiments focused on wild type maize, a maize root hair mutant, and Tripsacum, a wild relative of maize. "We work on how root-hair mutants and wild relatives differ in their root microbiomes and plant phenotypes compared to wild type maize, and similarity between greenhouse and field for plant phenotypes and root microbiomes," said Alfano.

Broader impacts from CRRI include outreach that cultivates community interest in plant science underlying the world's food supply. Nebraska EPSCoR's Young Nebraska Scientists program added summer camps on Agricultural Biotechnology (for middle school students) and Soil Microbes (for high school students). CRRI faculty and students led a "Sunday With A Scientist" event for families at Nebraska's state natural history museum, with a dozen hands-on stations in the "Jungle Under Our Feet" theme. CRRI's microbiology curriculum engages students at Nebraska's tribal colleges and pilots new rhizobiome "inquiry labs" at Doane University for hands-on experiences to augment introductory biology lab courses.

CRRI funds pathways to expand the next generation of scientists, including an internship program for Nebraska post-secondary students working with industry on plant science areas including biochemistry and genetics. CRRI's first annual conference attracted 200+ attendees: faculty, students and industry representatives from the Midwest region and beyond (see sidebar).

Nebraska Research & Innovation Conference

PLANT SCIENTISTS GATHERED AT Lincoln's Cornhusker Hotel in April for the 12th annual Nebraska Research & Innovation Conference (NRIC) conducted by Nebraska EPSCoR. The NSF-funded Center for Root and Rhizobiome Innovation (CRRI) set the theme—"Predictive Crop Design: Genome to Phenome"—for this regional conference. Speakers came from 13 universities plus multi-national and startup companies, with networking for collaborations with CRRI faculty and students between sessions. The next NRIC event, also with CRRI topics, is planned for fall 2018.

TRACK 2

NEBRASKA'S ULTRAFAST PHYSICS COLLABORATION WITH KANSAS CONCLUDES WITH SUCCESSES

AS YEAR 3 OF a National Science Foundation EPSCoR "Track-2" collaboration ended in 2017, the project's University of Nebraska-Lincoln (UNL) physicists recapped final-year highlights of the Nebraska-Kansas research.

The Thrust 1 team pursued Imaging and Controlling Ultrafast Dynamics of Atoms & Molecules. For the past decade, physicists have sought ways to produce intense tabletop extreme ultraviolet (XUV) laser sources to study ultrafast dynamics in atoms, molecules, and clusters. High-order harmonic generation (HHG), a promising technique, is a 'low cost' source of XUV photons with excellent coherence and time resolution when compared to sources at large free electron laser and synchrotron facilities. Unfortunately, HHG is a low-efficiency process—but Nebraska's **Anthony Starace** led theoretical activity to increase the efficiency of HHG, especially through use of combinations of two-color (i.e., two-frequency) laser pulses. Starace's team investigated the HHG spectra produced by laser-pulse waveforms composed of a combination of time-delayed, two-color, few-cycle pulses.

"The results showed that the waveform produced when the lower frequency (fundamental) pulse is slightly delayed relative to the higher frequency (harmonic) pulse gives a higher-intensity HHG spectrum," Starace said. "The physical origin of this feature originates from higher net electric field strength in the composite laser pulse that initiates the process."

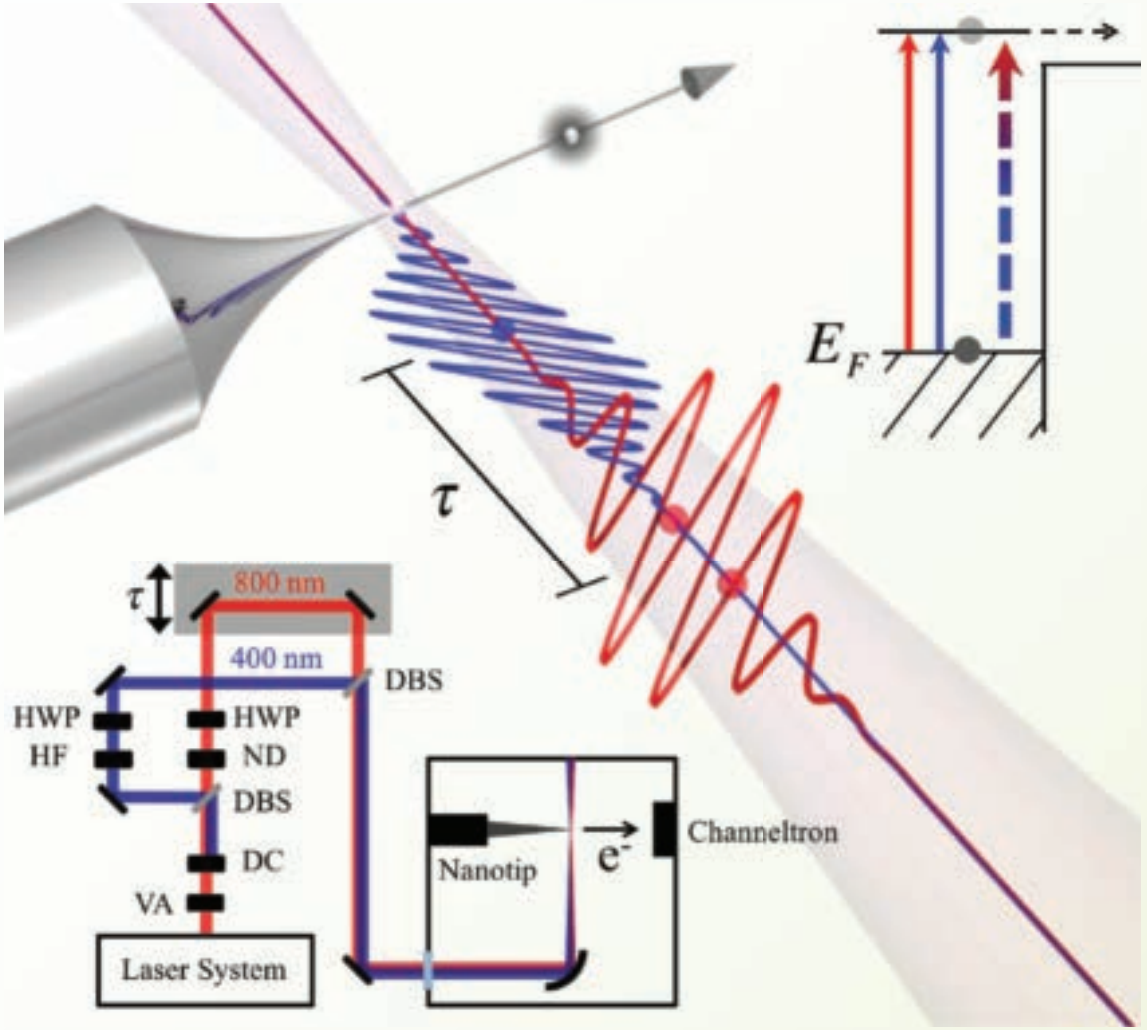
The collaboration's Thrust 2 group studied Ultrafast Electron Control by Light in Nanostructures. As nanodevices' connections need nanowires, advancing the latter components can provide proof-of-principle tests for new and innovative electronic and optoelectronic applications. To study the coupling of light to electron currents and then develop optical control and read out, a UNL-Kansas State University (KSU) team grew free standing nanowires long enough to allow optical access at multiple locations, including at junctions.

To study the motion of electrons in nanowires, Nebraska's **Herman Batelaan** led a team within the collaboration that has performed pump-probe experiments on these wires. Because the ballistic and spin currents have ranges smaller than 100 nanometers (nm), smaller than the spatial extent of the laser focus, new techniques were

In an experimental setup from Batelaan's laboratory, a tungsten nanotip is irradiated by two-color fields (800 nm and 400 nm). (Top Right) multicolor quantum channels (dashed arrow) open up as the two-color pulses overlap. (Bottom Left) a Mach-Zehnder interferometer controls the time delay of the 800 nm pulse. Source: W. C.-W. Huang, M.Becker, J. Beck, and H. Batelaan, "Two-color multiphoton emission from nanotips," New J. Phys. 19, 023011(2017)

needed. The UNL-KSU team turned to laser-induced electron emission from nanotips and nanowires. The nanowires were made at KSU and successfully transported for optical experiments at UNL. The electron-emission induced by laser light was found to be caused by combinations of slow thermal, fast tunneling, and fast multi-photoemission. Since the slow emission can mask the faster signal that the group sought, for nanotips they found a convenient way to achieve ultrafast, femtosecond control of electron emission: by sending two laser pulses of different colors with a variable time delay between them onto the nanotip. When both pulses are present, the electron-emission yield doubles—and was the first observation of two-color multi-photon emission from a nanotip, providing a roadmap to future advances in ultrafast electron optics.

As the project term ended, the collaboration's Nebraska group had produced more than 20 journal publications, trained 17 graduate students, and resulted in two new technologies/techniques and one new patent.



Framing courses use NICC's South Sioux City lab room, equipped with teleconferencing capabilities for connecting with students at Little Priest Tribal College.

TRACK 3

CHEMISTRY CURRICULUM BUILDS AT NEBRASKA TRIBAL COLLEGES

IN 2017, THE NATIONAL Science Foundation (NSF) EPSCoR-funded Track-3 project, "Framing the Chemistry Curriculum," solidified its course offerings at Nebraska's tribal colleges in Year 4 of the 5-year project. The project established introductory chemistry courses at northeast Nebraska's Little Priest Tribal College (LPTC) and Nebraska Indian Community College (NICC), where chemistry courses had not been offered for several years.

Chemistry courses are a gateway to many STEM careers, including medical professions—in which tribal college students may seek to serve their communities and the greater good—said **Mark Griep**, the "Framing" project's principal investigator and associate professor of chemistry at the University of Nebraska-Lincoln (UNL).

Griep congratulated **Bev DeVore-Wedding**, the UNL Ph.D. student who helped develop and deliver the "Framing" courses (see interview at right), on defense of her dissertation—a case study connected with the project. She will be a postdoctoral researcher for the remainder of the project, Griep said, "to further disseminate our findings to other tribal colleges."

Griep and DeVore-Wedding learned their journal article—"The Sharing Cycle of Science Learning: Connecting Community Topics to Tribal College Science Lab Courses," which they co-wrote with **Janyce Woodard** (LPTC), and **Hank Miller** (NICC)—earned acclaim. Published in the Great Plains Quarterly's Spring 2016 issue, the article received the Center for Great Plains Studies' 2016 Frederick C. Luebke Award, for the year's best article published in the journal.

This Track-3 team also created a three-minute video, "The Sharing Cycle of Science Learning," as part of the 2017 STEM For All Video Showcase, funded by NSF (**bit.ly/STEMvidNE**). Among more than 170 videos entered for advancing Science, Technology, Engineering and Math (STEM) projects, Griep said this Nebraska video gained 1,694 views from the website's total of 35,763 video views, or 4.7% of all the video views.

Science Sharers

Interview with Bev DeVore-Wedding, Ph.D.

HOW MANY STUDENTS HAS THE FRAMING CURRICULUM SERVED?

In 2017 we had 7 students in our NICC and LPTC chemistry classes. Between the two schools, with each location having enrollment of about 180 students, over three years of offering the courses we've had a total of 15 students.

HOW ARE THE FRAMING COURSES' CHEMISTRY TOPICS TAUGHT WITH COMMUNITY THEMES?

Water is an overriding theme. We talk about molecular structure, polarity, solutions, ions, acids/bases—and these all connect to water.

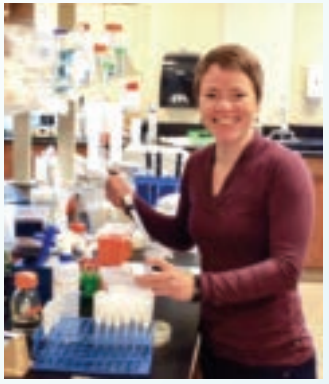
Water quality and purification labs and soil quality labs enable students to connect community and chemistry. Starting with a density lab, we use the corn and beans part of the Three Sisters Gardening story to talk about food, water, and soil quality.

I adapted "Adopt an Element" to "Adopt a Molecule": for students to learn more about a chemical in their environment—foods, air, water—basically, they choose the molecule.

HOW DOES THE CHEMISTRY COURSE CHANGE OVER TIME?

(Looking ahead) we will focus more on food sovereignty and chemistry connections. Cooking food can be used to show chemical changes as well as generate discussions about calories, quality of food sources, disease, etc.

FIRST AWARDS

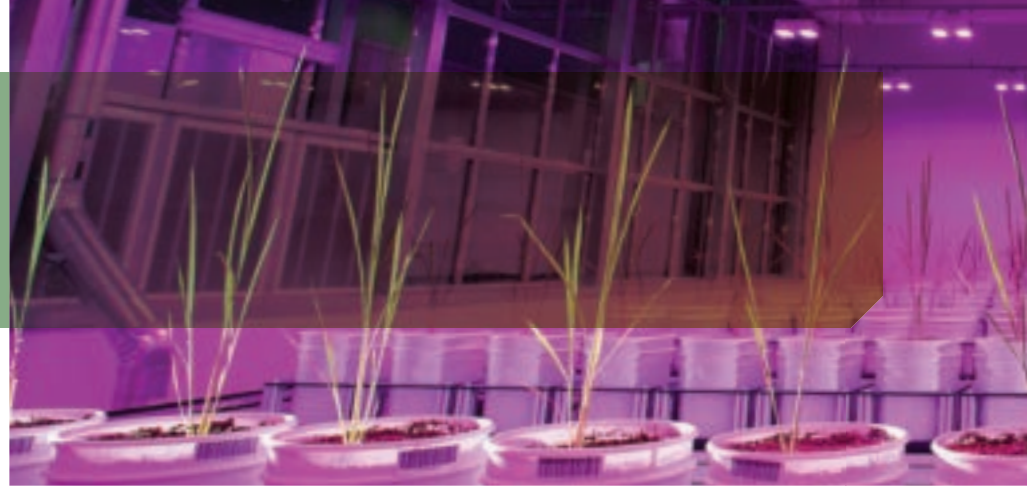


Nebraska EPSCoR's FIRST Award is a CAREER builder

A SIGNIFICANT STEPPING STONE in a scientist's early career path is that initial substantial grant. Especially in today's challenging environment for science, technology, engineering and math—the STEM fields—such an award is vital to start a laboratory, recruit students, and establish a viable research area. Nebraska EPSCoR boosts in-state candidates of merit with its annual FIRST Award program: simulating the rigorous application process for National Science Foundation CAREER Awards, and providing expert reviews for finalists' proposals—plus $25,000 for recipients' further submission efforts.

CONGRATULATIONS TO FIRST AWARD RECIPIENTS ANNOUNCED IN 2017

- **Dr. Vitaly Alexandrov**, Chemical and Biomolecular Engineering, University of Nebraska-Lincoln (UNL)
- **Dr. Hamid Bagheri**, Computer Science & Engineering, UNL
- **Dr. Shudipto Dishari**, Chemical and Biomolecular Engineering, UNL
- **Dr. Anna Selmecki**, *(above)* Medical Microbiology and Immunology, Creighton University
- **Dr. Daizaburo Shizuka**, School of Biological Sciences, UNL
- **Dr. Ryan Wong**, Biology, University of Nebraska at Omaha
- **Dr. Alex Zupan**, Mathematics, UNL



NEBRASKA RESEARCHERS BEGIN TRACK-2 COLLABORATIONS

In August 2017, the National Science Foundation announced eight Track-2 awards including three with Nebraska scientists. NSF EPSCoR's Track-2 program funds multi-state, four-year projects fostering interdisciplinary collaboration.

HARKAMAL WALIA, ASSOCIATE PROFESSOR with University of Nebraska-Lincoln's Department of Agronomy and Horticulture, is the principal investigator with the group that will study *Comparative Genomics and Phenomics Approach to Discover Genes Underlying Heat Stress Resilience in Cereals*. UNL is the lead institution for the $5,783,738 project which also involves Arkansas State University and Kansas State University researchers—plant physiologists, quantitative geneticists, computational biologists, biochemists, engineers, informaticians, and precision agronomists—aiming to create the foundational knowledge needed to improve wheat and rice yields under stressful environments.

Trends at the global-, regional-, and farm-level point to an increase in minimum night temperatures that is significantly higher than the rate of increase in maximum day temperatures. Increases in night temperatures significantly decrease the grain yield and quality of major crops such as rice and wheat, which together provide over 50% of the caloric intake for humans worldwide. To ensure global food security, the need is urgent to improve crop resilience to high night temperature stress-induced yield and quality losses.

This project is building genome to phenome linkages using automated image-based phenomics approaches in combination with transcriptomics and metabolomics applied to wheat and rice diversity panels. Genes and pathways discovered from this approach will be functionally tested for their role in improving the temperature resilience in rice and wheat.

UNL School of Biological Sciences' **Jay Storz**, **Colin Meiklejohn** and **Kristi Montooth** are UNL faculty with *Using Natural Variation to Educate, Innovate, and Lead (UNVEIL): A Collaborative Research Network to Advance Genome-to-Phenome Connections in the Wild*. Colleagues from the University of Montana lead the $4 million UNVEIL project, to address fundamental scientific questions that are relevant to local adaptation and conservation of wild populations. The team, including early career faculty and students, will use newly developed genomic technologies to understand the genetic basis of traits that influence the survival of wild animals and plants in changing environments.

UNVEIL research aims to advance understanding of how organisms cope with environmental challenges, and generate fundamental knowledge about how complex traits arise from variation in genomes—with implications likely extending to conservation biology, agriculture, and medicine. Engaging an interdisciplinary group of philosophers, geneticists, wildlife biologists, and natural resource managers, this project will help form guidelines for

(From left) **HARKAMAL WALIA** works in the Plant Phenotyping Facility at Nebraska Innovation Campus; UNVEIL's **COLIN MEIKLEJOHN**, **JAY STORZ** and **KRISTI MONTOOTH** meet in a lab at University of Nebraska-Lincoln's Manter Hall; and **JIM VAN ETTEN** studies viruses in microbes with aquatic and agricultural impacts.

the application of genomic information to conservation—for example, to help determine when and how genomic interventions should be used.

Nebraska's **Jim Van Etten**, William Allington Distinguished Professor of Plant Pathology, is a co-PI on G2P in *VOM: An Experimental and Analytical Framework for Genome to Phenome Connections in Viruses of Microbes*. This $5,999,124 project's team—including scientists from University of Delaware (lead institution), University of Hawaii, and Roger Williams University—will study how viruses in soils, sediments, and water environments infect microbes and impact ecosystems. The details of the viral-microbe interactions are largely unknown, and this project seeks to advance the ability to predict the phenomic features of the viruses of microbes (VoMs) from genomic data.

G2P in VOM will focus on viruses that infect marine and freshwater phytoplankton, and viruses that infect a bacterial group that forms a symbiosis with important legume crops—most notably, soybeans. Global phytoplankton populations create vast stores of biomass that support the nutritional needs of larger aquatic organisms, and sustain half of the oxygen within earth's atmosphere. Enhanced understanding of genome to phenome links within phytoplankton viruses will aid in improving models that predict the impacts of excess carbon and nutrients on ecosystems.

Better understanding of genome to phenome connections for viruses infecting bacterial symbionts of legumes could eventually lead to new technologies for improving the productivity of critical agronomic crops such as soybeans. The project team's faculty, postdocs and students will collaborate on research, share best practices and mentoring, plus prepare educational materials and provide summer camp opportunities for middle and elementary school students.

YNS' NEW CAMPS DIG INTO THE ROOTS OF CROP PRODUCTIVITY

IN SUMMER 2017, NEBRASKA EPSCoR added new camps—on Soil Microbes, and Agricultural Biotechnology—to its Young Nebraska Scientists' schedule.

The new camps represent the Center for Root & Rhizobiome Innovation (CRRI), a research collaboration spanning several Nebraska universities. With funding from the National Science Foundation (NSF), CRRI scientists from the University of Nebraska-Lincoln (UNL), University of Nebraska at Kearney (UNK), University of Nebraska Medical Center and Doane University conduct lab and field research to study root exudates, soil diversity, organisms' genetics and more. CRRI also does outreach to help the public understand the work.

UNL Biochemistry's **Karin van Dijk** hosted the camp for high school students, *Life Underground: The Unseen Power of Microbes*, and UNK Biology's **Paul Twigg** and **Julie Shaffer** led a middle school camp about how research can help farmers have better crop yields. Both of these camps will return in 2018.

The middle schoolers' AgBiotech camp took place at York Public Schools, with Twigg and Shaffer guiding hands-on science activities indoors and outside, to share deeper understanding of the crops nearby and our food sources.

The Microbes camp took advantage of UNL facilities and expertise at the Beadle Center, as well as Nebraska Innovation Campus, with its robotic greenhouse for extensive plant testing, and the Dairy Store at East Campus, where food and agricultural research is a growing strength.

(Top) YNS Microbes Camp students gather around an electrophoresis machine at UNL's Beadle Center. (Below) At Ag Biotech Camp in York, UNK biologists lead hands-on science sessions.

YNS HIGH SCHOOL RESEARCHERS GROW THEIR STEM

YNS High School Researchers **LUKE SCHROEDER** (left) and **DANNY TRAN** (right) meet with Doane University's **TESSA DURHAM BROOKS** to analyze root growth data for CRRI research.

CRETE HIGH SCHOOL SENIORS Luke Schroeder and **Danny Tran**, and sophomore **Sam Ragorshek**, were Young Nebraska Scientists' High School Researchers working for Doane University's Biology Department Chair and Associate Professor **Tessa Durham Brooks** as part of her team with Nebraska's Center for Root & Rhizobiome Innovation (CRRI).

Their research focused on how nitrogen supplements affect corn plants' root exudate growth. Durham Brooks developed a measurement method for living seedlings using ninhydrin paper as a blotting sensor, with image scanning of the plants at intervals (3, 5 and 7 days) showing root growth pattern. Danny was eager for summer work that paid him to do computer coding--an area he'd explored in high school, but hadn't thought of applying in a biology setting. Durham Brooks said using coding to answer questions from data is an important part of modern biology. Doane Bio had a coding camp in early summer for its undergrads; Danny was unable to attend but taught himself Python to help to analyze the images scanned of the root growth timepoints.

All summer, the YNS trio attended Doane Bio's weekly code review sessions, presented their work at a department meeting, and helped prepare a paper about the ninhydrin innovation, which was submitted for publication in a science journal. Being published was another good surprise, Danny said and added, "The science experience is worth a lot."

AT SUNDAY WITH A SCIENTIST, FAMILIES EXPLORE 'JUNGLE UNDER OUR FEET'

(Above) A team of CRRI researchers (faculty and students) hold a banner decorated by visitors to a plant science event with families at Morrill Hall. UNL's **JOSH HERR** is standing directly under the elephant's left tusk. (Right) During the event, CRRI lab technician **LINDA NGUYEN** helps children understand how acid and base pH affect soil.

In September nearly 200 visitors to Morrill Hall, the University of Nebraska State Museum of Natural History, dug into the root issues of how plants grow—with help from Center for Root and Rhizobiome Innovation (CRRI) scientists.

CRRI's **Josh Herr**, UNL Assistant Professor of Plant Pathology, led the multi-lab experiences with table stations that helped families examine plant DNA, root exudates, bacterial diversity, and more. Guests who visited all the stations took home a plant seedling as well as increased understanding of plant growth processes. Based on exit interviews, some attendees were happy just "getting to find bugs in the dirt and looking at them with a microscope!" Thank you to all participants!

NEBRASKA EPSCoR ADDS PHYSICS MOBILE LABS

FOR NEARLY A DECADE, Nebraska EPSCoR's mobile lab kits have traveled to high school classrooms across Nebraska, helping provide biology learning for rural students to access Advanced Placement course work. Nebraska EPSCoR saw a need in our state's schools—especially some rural locations—for equipment in hands-on learning of lab science, and gathered kits with instructions for teachers to lead. The biology materials proved popular, and more recently physics became a new frontier in mobile labs.

NE EPSCoR Outreach Coordinator **Lindsey Moore** (a former high school science teacher) worked with UNL Physics and Astronomy Associate Professor **Brad Shadwick** to develop equipment and curriculum for students to experiment with hands-on demonstrations that convey lessons about force and motion.

Also advising on the Physics Mobile Labs were Wayne State College's **Adam Davis**, associate professor of physics, and **Sally Harms**, professor of science and science education; their participation was funded through Nebraska EPSCoR's program to connect the state's small colleges with its collaborative research projects.

To test the mobile labs, a dozen teachers from across Nebraska gathered for a five-day Physics Teachers Institute that used the materials. The teachers gave valuable feedback, including input for alignment with new state science standards, and then extended the learning to a larger group of teachers attending a one-day workshop at the end of the Institute.

Joe Haschke, a physical sciences teacher with Columbus Lakeview High School, said the Physics Mobile Lab is an excellent hands-on set-up for generating images students use to collect data—making measurements easier so the students can more readily learn concepts, such as accelerating momentum and rotational inertia.

(Top) Nebraska high school physics teachers test new mobile labs by Nebraska EPSCoR. (Below) Students with Nebraska College Preparatory Academy (NCPA) use the Physics Mobile Labs.

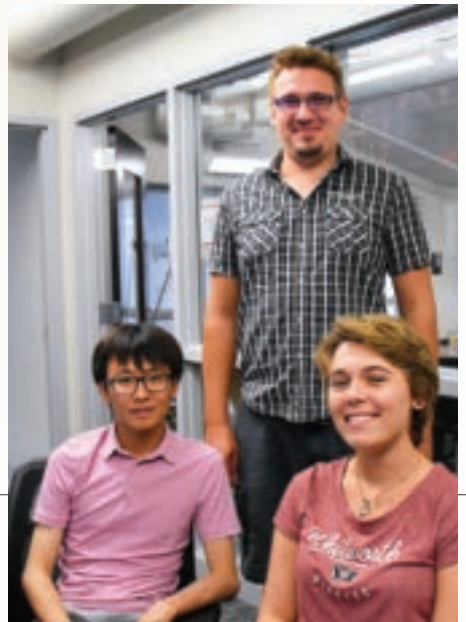
NEBRASKA EPSCOR HOSTS UNDERGRADUATES FOR PRODUCTIVE SUMMER

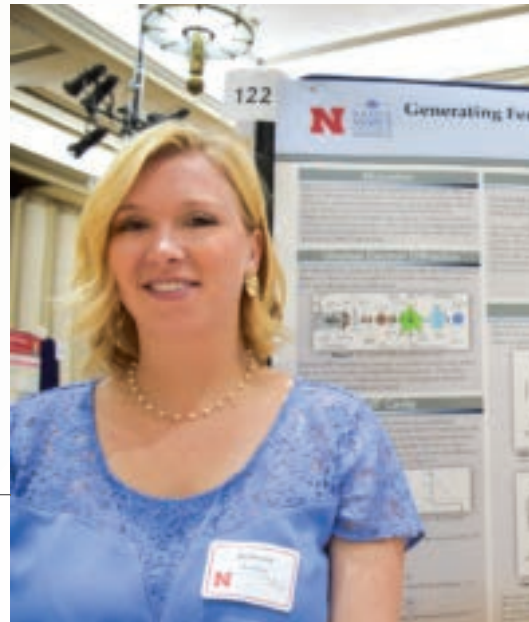
A SELECT GROUP OF students from throughout the nation worked in the University of Nebraska-Lincoln's 2017 Summer Research Program. Several were placed as Research Experiences for Undergraduates (REU) participants, funded through the National Science Foundation, with Nebraska EPSCoR projects—including Track-1 (Center for Root & Rhizobiome Innovation) and Track-2 (Atomic, Molecular and Optical—or AMO—Physics) groups.

Joining UNL scientists' labs, the undergraduates learned skills that enhance their capabilities for future research careers, and presented their scientific advances with host labs in posters at UNL's Summer Research Symposium. In addition to stipend, room and board, the undergraduates enjoyed professional development and memorable social events including visits to Omaha's Old Market, and canoeing and camping on Nebraska's Niobrara National Scenic River.

In the lab of UNL Biochemistry's **Tomas Helikar**, **Alyssa LaFleur** from Whitworth University deepened her basic understanding of MATLAB software while developing multiscale models of differential equations to explore aspects of immune systems. In Helikar's lab, part of the NSF EPSCoR-funded CRRI project, she benefited from working closely with postdoctoral researcher and computational biologist **Kenneth Wertheim**. A junior with majors in math and biochemistry, LaFleur said it was fascinating to see Helikar teams address projects and she plans to use her new skills to keep building models that serve research. She realizes there are many opportunities for this work to help biologists accelerate drug discoveries or generate more efficient vaccines.

Rebecca Hoehne's time at the UNL Department of Physics & Astronomy was a way to return to Nebraska, where her family lives, while making progress in her five-year dual degree program at Saint Mary's College and the University of Notre Dame. At UNL, she worked on an aspect of dissociative electron attachment (DEA), designing a pump concept to study high vs. low energy electrons, and focusing on system damage caused at varied speeds. "At the low energies it has been proposed that the electron will be attracted to the molecule, eventually raising the potential energy and thus causing the breaking of bonds," Hoehne said. "What I am looking at in my simulations is to achieve sub-atomic resolution...in order to study the effects of the low energy electrons." Working on theoretical simulations with physicist **Martin Centurion**'s group for the NSF EPSCoR Track-2 project was meaningful in her efforts to earn a Bachelor of Science and a Bachelor of Science in Engineering, Hoehne said, because it combines three fields she is passionate about. Refining her model's temporal resolution from 2.43





From left, postdoc **KENNETH WERTHEIM** and Assistant Professor **TOMAS HELIKAR** helped **ALYSSA LAFLEUR** gain skills in computational biology during her REU experience at Nebraska. **REBECCA HOEHNE** displayed her poster at Nebraska's Summer Research Symposium after her summer's work.

LIZ LASKOWSKI studies optics and high-intensity laser physics at Nebraska's Diocles Lab, thanks to summer research experiences via Nebraska EPSCoR.

picoseconds to 100 femtoseconds was a challenge, and one that increased her understanding of the processes involved.

Liz Laskowski, who studies materials science at University of Wisconsin-Eau Claire, had attended Nebraska's WoPhyS (Women in Physical Sciences) conference and presented her research on smart polymers. During WoPhyS, she toured UNL's Archimedes Lab and was encouraged to try for an REU at Nebraska. She was excited for the opportunity to explore new areas and see what graduate level research might look like at a Big Ten school. With Track-2's **Don Umstadter** and team in the Diocles Lab, she used optical techniques to measure the phase shift caused by gases and densities, then applied that measurement to reconstruct density profiles of gases and plasmas.

"In a broad sense, (we study) how the phase of light changes after passing through a gas or plasma for communication purposes—radios, tvs, and satellites all depend on it," she explained. "In a more focused sense, a lot of applications depend on laser-photo ionization of a neutral gas. Being able to measure plasma density profile, with femtosecond and micrometer resolution (in real time!) would be invaluable to applications such as plasma wakefield acceleration. The plasma density measurements I took this summer showed that this could be achievable with further improvement of experimental set up, and the group will continue working towards that goal. I can't wait to see what they find!"

Laskowski said her REU time was "incredible" and added: "Every day I was challenged to reach far into what was unknown to me, and encouraged to dig deeper until I understood it at a fundamental level. [The REU experience at Nebraska] introduced me to the beautiful world of optics and high-intensity laser physics, and I hope my future studies will relate to this field."

"I felt wonderfully supported, encouraged, and welcomed my entire time here at UNL, and I am so grateful to have had this opportunity," said Laskowski—who returned to present research at her third WoPhyS event in November 2017.

EPSCOR PROGRAM BOOSTS SMALL-COLLEGE FACULTY-STUDENT RESEARCH TEAMS

TEAM SCIENCE AND TECHNOLOGY are more than buzzwords for a Nebraska Wesleyan University (NWU) biology student and faculty member, who ramped up their science capabilities at the University of Nebraska-Lincoln in summer 2017. A Nebraska EPSCoR program funded their opportunity to work in a research university setting.

NWU Assistant Professor **Adrianne Prokupek-Pickett** and rising senior **Dan Novinski** learned computational biology skills by working with the Center for Root & Rhizobiome Innovation (CRRI). They temporarily joined the lab of CRRI's **Etsuko Moriyama**, who specializes in bioinformatics with UNL's School of Biological Sciences.

"For a smaller college faculty and student, I think it was a good opportunity to learn through UNL's Holland Computing Center," Moriyama said. "At the beginning of the summer, I encouraged them to attend HCC's workshops where they obtained accounts and learned some basic commands and how to use their resources."

Moriyama and Prokupek-Pickett agreed that the NWU pair would bring their own data, which was not plant-related, but Moriyama said, "Our bioinformatics method can be applied to data from any organisms, (so) it actually was a chance to work on something (my group had) never seen and test how our method can be applied to non-plant data. We hope to continue our collaboration."

Prokupek-Pickett said the experience was "invaluable to my course development" and added: "A very important component of this summer research was being able to bring an undergraduate student along with me. The student and I worked side by side on this data, having a chance to interact as colleagues (instead of teacher-student) while we navigated the complex procedures. The student continued the final analysis steps with me during the fall."

Novinski can now add "building a snake's transcriptome"—the sum total of all the messenger RNA molecules expressed from the genes of an organism—to his résumé. His role was similar to participants in a "Research Experiences for Undergraduates" (REU) program, but in this case he had the benefit of working closely with a faculty member from his own college.

Nebraska EPSCoR Outreach Coordinator **Lindsey Moore** praised the partnership: "Nebraska EPSCoR works to enhance the STEM education pipeline in our state, and created this visit program to add opportunities for teams comprised of a small college faculty member and undergraduate student. Our program focuses on primarily undergraduate schools and provides research experiences related to science, technology, engineering, and math. Our goal is to increase the pool of potential students pursuing careers in these areas, and we see these experiences are opening students' eyes to further possibilities, solidifying their interests, and making connections for their future progress in STEM. The faculty involved augment their careers and build professional relationships."

Nebraska Wesleyan University student **DAN NOVINSKI** was part of a small college team that joined a CRRI lab at UNL for the summer.

SMALL COLLEGE AND UNIVERSITY UNDERGRADUATE RESEARCH AWARDS

JOHN KYNDT
College of Science and Technology, Bellevue University
"Optimizing Algal Cultivation for Biofuels Using Low Value Sugars and Wastewater"

ALLEN THOMAS *(see story at right)*
Department of Chemistry, University of Nebraska at Kearney (UNK)
"Alpha-Substituted Phenylalanine Analogs to Probe the Activity of LAT1 Transporter Substrates"

AUSTIN NUXOLL
Department of Biology, University of Nebraska at Kearney
"Antibiotic Tolerance in Polymicrobial Biofilms"

CHRISTOPHER HUBER
Department of Chemistry, Doane University
"New Directions in Groundwater Pollutant Remediation Through Hot Electron Transfer"

BRYAN DREW
Department of Biology, University of Nebraska at Kearney
"The Monardella (Lamiaceae) Story: Unraveling a Recent Radiation"

BRETT SCHOFIELD
Department of Biology, Doane University
"Development of a System to Induce Specific DNA Compaction at Any Native Locus"

Small College, Big Horizons

IN SEPTEMBER, UNK CHEMISTRY'S Allen Thomas received a National Institutes of Health (NIH) R15 AREA grant of $399,000 for three years of research on "Identification of New LAT-1 Transporter Substrates for Drug Delivery": medicinal chemistry pursuing better uptake across the blood-brain barrier (BBB), to potentially improve brain tumor treatment. This NIH research builds upon the work by Thomas and his team with funding from Nebraska EPSCoR's Undergraduate Research Experiences at Small Colleges and Universities.

Thomas' group seeks to exploit one of the BBB's natural mechanisms for transporting amino acids, the LAT-1 transporter protein, to use it for drug delivery into the brain. The EPSCoR funding enabled Thomas' team to prepare isomers of phenylalanine analogs for further testing of substrates. Thomas said, "A turning point for this project was when (UNK Chemistry undergraduate student) **Brooklynn Venteicher** made a key discovery, that substitution with an isobutyl group could best be accomplished by alkylation with isobutyl triflate, as less reactive electrophiles failed to react."

Thomas noted that the structure-activity relationship (SAR) from the EPSCoR-funded project serves in a paper that he and his team are preparing for submission to the Journal of Medicinal Chemistry in Spring 2018. "Thanks to the generous funding by Nebraska EPSCoR and the University of Nebraska at Kearney," Thomas added, "I have been able to generate sufficient preliminary data to obtain an NIH R15 AREA grant"—all helping to get Thomas' research group launched at UNK.

NIH IDeA

Nebraska INBRE Funds Pipeline for Student Training to Combat Bio-Threats with Army Medical Research

IN FALL 2017, UNIVERSITY of Nebraska at Omaha (UNO) students began a path toward research careers to combat infectious diseases globally. The University of Nebraska Medical Center (UNMC) and the U.S. Army Medical Research Institute of Infectious Diseases (USAMRIID) established a collaboration providing advanced opportunities.

After a rigorous selection process, students enter the Bioinformatics Research Education Pipeline (BREP) during their second year at UNO. They work with USAMRIID on projects throughout their undergraduate curriculum, leading to a senior summer internship at USAMRIID as part of the Army's College Qualified Leaders (CQL) program.

Upon graduating from UNO, BREP students enter UNMC's graduate program with topics on combatting Zika and Ebola viruses, treating staph infections, responding to anthrax exposure, and analyzing large-scale biomedical data. BREP students also benefit from UNMC's new Global Center for Health Security: training and research infrastructure working against infectious disease and bioterrorism threats.

The BREP program, funded by the National Institutes of Health's IDeA Network for Biomedical Research Excellence (INBRE) program and USAMRIID, "offers students the unique opportunity to do specialized research," said UNMC and UNO Chancellor **Jeffrey P. Gold**, M.D., who praised the BREP collaboration. The partnership also enables future research opportunities for faculty at UNMC and UNO, as well as for USAMRIID scientists to teach courses at UNMC.

BREP is "giving Nebraska students experience in top-notch Department of Defense infectious disease research laboratories, and simultaneously infusing the USAMRIID workforce with our wonderful students," said **Ken Bayles**, Ph.D., BREP mentor and associate vice chancellor for basic science research at UNMC. Bayles is also a member of Nebraska EPSCoR's State Committee.

*Learn more about the DANSON project at http://bit.ly/DANSONprojectUNL and http://bit.ly/DANSONprojNASA.

NASA NEBRASKA EPSCOR

Detecting Neutron Radiation: The Adventures of Solar Neutrons

by Peter Dowben and Nicole Benker

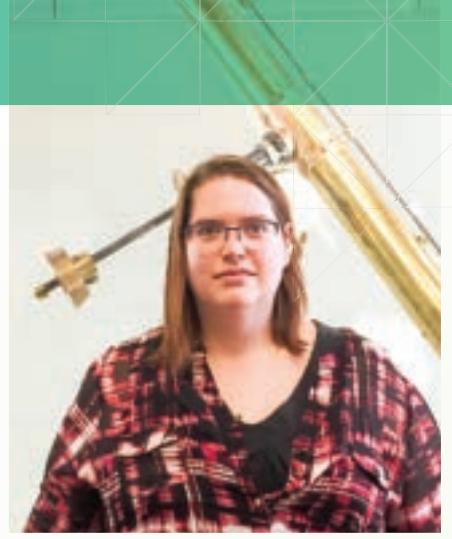
NEUTRON RADIATION FROM THE sun can damage satellites and harm astronauts in space. But unlike electrons and protons, neutrons don't have any electric charge. Neutrons can pass through many kinds of solid objects without being scattered or absorbed. This makes it difficult to build devices to detect them, so special materials are needed that absorb neutrons and leave a measurable signature when they do.

Researchers at the University of Nebraska-Lincoln (UNL) are working on this challenge, with funding through Nebraska NASA EPSCoR, and studying the effects of solar neutron radiation on two types of materials on the International Space Station (ISS). The Nebraska researchers use detectors made of very stable compounds containing boron-10 and lithium-6, which readily absorb neutrons far better than most other elements. Since neutrons from the sun are too energetic to be "caught" by the detectors, researchers reduced that energy first: with a neutron moderator that "steals" energy from neutrons passing through the material.

The **UNL Detector for the Analysis of Solar Neutrons** (DANSON*) experiment's lithium tetraborate crystals and boron carbide diodes were encased in a neutron-moderating polycarbonate that was then placed on the International Space Station (see adjacent image). **Peter Dowben**, UNL Charles Bessey Professor of Physics and DANSON project principal investigator, said, "Placing the detectors at different depths allows us to determine the energy of the neutron radiation we capture—we can infer that neutrons captured deeper in the moderator must have had higher starting energy, since they were able to penetrate further into the material."

UNL Physics & Astronomy undergraduate **Nicole Benker**, who served as project manager and payload developer, said UNL's neutron detector was aboard the ISS from October 2016 to March 2017. Since the DANSON experiment's return to UNL, the research team is looking for radiation damage to the structure of the crystals and comparing the electronic characteristics of the diodes from before and after their journey. It is clear that there is a great deal of radiation in space and the neutrons coming from the sun are fairly energetic.

The researchers hope to apply what they learn from this experiment to help advance the development of small, effective neutron detectors for use on Earth and in space. Dowben added, "By examining the distribution of neutron captures in our moderator, we also hope to catch a glimpse into the nuclear fusion processes that fuel our sun."



(Top) **NICOLE BENKER**, (Middle) **PETER DOWBEN**, (Bottom) The UNL Detector for the Analysis of Solar Neutrons (DANSON) cube was affixed to the International Space Station (ISS).

NSF EPSCoR CO-FUNDING

In 2017, National Science Foundation co-funding brought $4.011 million to Nebraska; $1.4 million of the year's total was from NSF EPSCoR. Recipients were:

CRAIG ALLEN, PI; **NANCY SHANK, DIRAC TWIDWELL, SEBASTIAN ELBAUM, FRANCISCO MUNOZ-ARRIOLA**, Co-PIs | University of Nebraska-Lincoln (UNL): Nebraska Cooperative Fish & Wildlife Research, Public Policy Center, Agronomy & Horticulture, Computer Science & Engineering, and Biological Systems Engineering | NRT-INFEWS: Training in Theory and Application of Cross-scale Resilience in Agriculturally Dominated Social Ecological Systems

ALEXEI GRUVERMAN | UNL Physics and Astronomy | Domain Wall Engineering for Novel Nanoelectronics

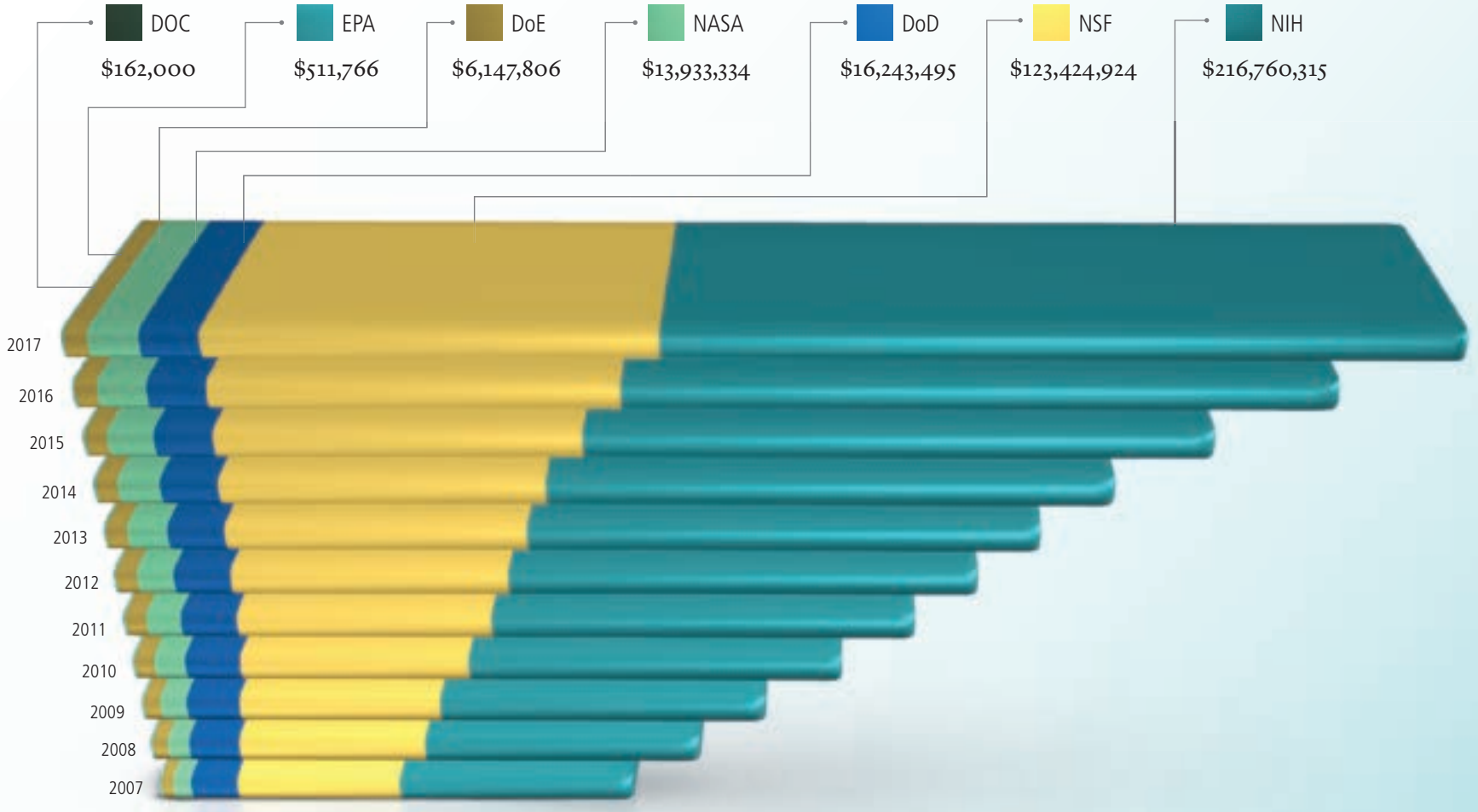
YULIYA LIERLER, PI; **MIROSLAW TRUSZCZYNSKI**, Co-PI | University of Nebraska Omaha (UNO) College of Information Science & Technology | RI: Small: Automated Optimization of Programs and Processing Tools in Answer Set Programming

BRIAN RICKS | UNO College of Information Science & Technology | CHS: Small: A Perceptual-based Approach to Improve Synthetic Crowds

REGINA WERUM | UNL Sociology | Collaborative Research: How Military Service and Benefits Shape STEM Career Trajectories

TOTAL FEDERAL EPSCoR FUNDING IN NEBRASKA

NEBRASKA BECAME AN EPSCoR state in 1991 and has successfully competed for more than $377 million in federal research funding. This chart shows funding by agency and the cumulative growth of funding over time, from 2007 through 2017.



Nebraska EPSCoR
University of Nebraska
W192 Nebraska Hall
P.O. Box 880557
Lincoln NE 68588-0557

2017 State EPSCoR/IDeA Committee Members

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epscor.nebraska.edu
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