2014 INTERDISCIPLINARY FACULTY RETREAT

Research Collaborations Begin with Conversations

May 15 - 16, 2014

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Sponsored by
UNL Research Advisory Board
Office of Research and Economic Development
Office of the Chancellor
Office of Academic Affairs
Institute for Agriculture and Natural Resources

Nebraska Innovation Campus Conference Center
University of Nebraska–Lincoln
Lincoln, Nebraska

Executive Summary

The 2014 Interdisciplinary Faculty Retreat provided opportunities for research faculty members to connect with other researchers from diverse disciplines, learn about future directions in research, and contribute ideas to help build new collaborative research areas.

More than 260 faculty and administrators from 56 disciplines brainstormed ideas for strategic interdisciplinary research, learned about each other's work and heard from nationally recognized speakers during the retreat. This was the first official event held at the Nebraska Innovation Campus Conference Center.

"It is fitting that the first official event at the Nebraska Innovation Campus Conference Center is aimed at fostering and supporting interdisciplinary research collaborations, which are at the core of innovation," Chancellor Harvey Perlman said in his opening remarks.

In his charge to the group, Prem Paul, vice chancellor for research and economic development, urged faculty to "connect, connect, connect. Get to know your colleagues and generate some big ideas for UNL research."

To encourage teams to develop those ideas, Paul announced the Big Ideas Seed Grant Program, offering a total of $500,000 in internal grants. Interdisciplinary teams led by tenured, pre-tenure or research faculty can compete for two levels of grants – $10,000 planning grants and $100,000 accelerator grants – in areas related to one or more of the thematic areas of the retreat.

Keynote Speakers

Guest speakers set the stage for the retreat activities, emphasizing the need for collaborative, interdisciplinary and translational research. Parag Chitnis, director of the Division of Molecular and Cellular Biosciences for the National Science Foundation, discussed investments NSF is making in research at the convergence of the life sciences, physical sciences and engineering. Rashid Bashir from the University of Illinois at Urbana-Champaign spoke on research at the interface of engineering, biology and medicine and the work of the Center for

Emergent Behavior of Integrated Cellular Systems, which he co-directs. Speaking to the audience via Skype, Kimberly Hoagwood of the New York University School of Medicine gave an overview of the challenges and rewards of translational research.

Reinforcing the key themes of the retreat, participants also heard from Colleen Gabauer, director of Purdue University's Office of Interdisciplinary Graduate Programs, speaking on the role an interdisciplinary life science research community plays in meeting the needs of stakeholders ranging from graduate students to principal investigators to employers. Eric Lyons of the University of Arizona spoke about the iPlant Collaborative, which is providing scientists with a powerful computational infrastructure for handling huge datasets and complex analyses. Cecilia Conrad, visiting from the MacArthur Foundation, briefly addressed attendees about the characteristics the MacArthur Fellows Program seeks in candidates for its "genius grants."

Thematic Discussions

Retreat discussions took place around three main themes. Each thematic session offered a variety of activities, including talks and presentations from 38 faculty from 18 departments, panel discussions, networking activities and breakout discussions. Discussion culminated in development of "Big Ideas" for collaborative interdisciplinary research that were presented by theme leaders at the closing session. The thematic areas and big ideas are briefly described below.

Theme 1. Signaling, Sensing and Imaging at the Intersection of Engineering and the Physical & Life Sciences

Scientists and engineers increasingly are exploring the frontier where biology, chemistry, physics, computer science and engineering intersect. At the same time, the development of new tools and technologies is critically important for studying the widely varying scales of biological systems, from nano-sized organisms to global ecosystems. Discussions around this theme showcased innovative new technologies and collaborative partnerships being developed by UNL faculty at this frontier.

Big Ideas

1. Create a research focus on *bio-imaging in plant and animal systems*, built upon current UNL research in cancer, infectious disease, plant genomics, plant physiology and material science.
2. Develop *predictive systems modeling across scales*, building on UNL's current strengths and existing collaborative teams in atmospheric sciences, remote sensing, climate modeling, computer science and engineering.

Theme 2. Enhancing Lives: Integrating Research and Practice across the Social, Behavioral & Educational Sciences

The goal of this thematic area was to develop a broad vision and identify specific initiatives that will leverage UNL's strengths and propel its national profile in educational, behavioral and social science research, broadly conceived. Activities in this thematic area focused on fostering transdisciplinary conceptual initiatives and empirical projects that address complex societal problems via translational research approaches.

Big Ideas

1. Strengthen *activities and expertise related to translational processes* to address contemporary societal challenges.

2. Place a priority research focus on *methamphetamine use in rural America*, given the scope of this national drug problem, expertise available at UNL and funding opportunities.
3. Leverage faculty interest and expertise in studying *at-risk youth* to build upon strengths and extensive faculty expertise in a number of related topics (e.g., bullying, social networks, adolescence, neighborhoods, substance abuse/violence, and child maltreatment).

Theme 3. Integrating Big Data into Your Research Program at UNL

The advent of big data offers unprecedented opportunities for data-driven discovery and decision-making in nearly every area of research. Realizing the transformative potential of big data requires addressing challenges in managing data and acquiring knowledge of computational methods for data analysis that may be new to researchers. This session shared the insights of faculty working with big data and the resources available at UNL for computation and analysis.

Big Ideas

1. Create a *forum for faculty to share challenges and ideas* and communicate about opportunities in big data.
2. Develop the *culture, community and tools* to enable communication and collaboration among faculty and students who work in various aspects of big data.
3. Addressthe growing need to *educate undergraduate and graduate students* in big data concepts.

Interactive Evening

Retreat attendees gathered in the conference center's banquet hall for food, drink, music and opportunities to interact and network with their colleagues. A showcase of UNL interdisciplinary centers and core facilities lined the perimeter of the hall, and tables dedicated to spontaneous interdisciplinary discussion drew a number of faculty. While some were connecting with colleagues and filling their networking passports, others toured the new Maker Space with Shane Farritor, mechanical & materials engineering.

Closing Session

The closing session included the unveiling of the report of the task force on the Social and Behavioral Sciences Research Initiative by co-chairs John Anderson, economics; David Hansen, psychology; and Kimberly Tyler, sociology.

Faculty leaders of the three thematic groups delivered their reports on the discussions and their big ideas. Shane Farritor, mechanical and materials engineering, and Stephen DiMagno, chemistry, reported on Theme 1, Signaling, Sensing and Imaging at the Intersection of Engineering and the Physical and Life Sciences. Susan Sheridan, educational psychology, and David Hansen, psychology, reported on Theme 2, Enhancing Lives: Integrating Research and Practice across the Social, Behavioral & Educational Sciences. Andrew Benson, food science and technology, and Jennifer Clarke, food science and technology and statistics, reported on Theme 3, Integrating Big Data into Your Research Program at UNL.

Introduction and Background

UNL Chancellor Harvey Perlman opened the 2014 Interdisciplinary Faculty Retreat on May 14, 2014, at the Nebraska Innovation Campus Conference Center by observing that the most competitive institutions in an era of tight budgets and limited grant funds are those that support collaborative, multidisciplinary research.

Because disciplines have their own languages and cultures, it takes time and effort to begin to understand one another and work well together. UNL already has developed ways to support interdisciplinary work, such as offering dual faculty appointments, locating faculty from different disciplines in the same space, designing laboratories to provide flexible space and creating shared core research facilities. However, the university is always seeking more ways to encourage more faculty interactions, Perlman said.

UNL's faculty retreats held over the past 12 years have helped build teams and research groups that cut across disciplines and focus on important and emerging research areas. With this retreat, UNL aimed to develop more interdisciplinary teams with big ideas, provide funding to support those ideas, and create opportunities for faculty to solve significant societal challenges.

In closing, Perlman observed that the university's research growth over the past decade has been impressive. Even with a more challenging federal funding environment, the faculty continues to succeed and help meet the institutional growth goal of reaching $300 million in research expenditures by 2018. He thanked those present for the part they played in that success and for the role they would play in continuing UNL's research growth.

Purpose and Goals

The goal of the retreat was to bring together faculty from many disciplines to learn about each other's work and identify strategic interdisciplinary research areas for UNL. Prem Paul, vice chancellor for research and economic development, welcomed participants with the challenge to use the two-day retreat to "connect, connect, connect" with new and old colleagues and to share ideas. Sessions built around three thematic areas were structured to be inclusive and encourage participation across disciplines. The retreat also offered time to relax and socialize – and have the kinds of conversations that lead to big research ideas and collaborations.

The retreat provided opportunities to

- connect with researchers from diverse disciplines
- learn about future directions in research
- contribute ideas to help build new collaborative research areas.

Vice Chancellor Paul announced the Big Ideas Seed Grant program, through which interdisciplinary teams will have an opportunity to compete for up to a total of $500,000 in internal grants. Faculty teams can apply for two levels of funding: planning grants of up to $10,000 for one year and accelerator grants of up to $100,000 over two years. Tenured, tenure-track and research faculty are eligible to serve as principal investigators on these grants. The RFP is available online.

Paul also explained that the Interdisciplinary Networking Passport included in the retreat packet was a means of encouraging participants to connect with each other. During the two days of the retreat, participants collected signatures inside the passport from 10 colleagues from a variety of disciplines other than their own and turned in complete passports at the registration desk to qualify for a drawing at the retreat's closing session. Winners received $1,000 and $500 travel vouchers and $250 technology vouchers designed to support their research programs.

Participants

More than 260 faculty and administrators from 56 departments, centers or administrative units participated in the retreat. A list of registrants searchable by name and key terms is available on the retreat packet website.

Retreat Structure

Retreat chair James Van Etten, professor of plant pathology in the Nebraska Center for Virology, provided an historical glimpse of the focus areas of prior interdisciplinary retreats and the significant outcomes that resulted. In 2006 the retreat focused on two topic areas: transportation and mathematics education, leading to development of the Nebraska Transportation Center. The 2007 retreat thematic areas were energy sciences research and recruitment of underrepresented graduate students, leading to a partnership with Nebraska Public Power District to create the Nebraska Center for Energy Sciences Research. In 2010 the theme was food, water and energy resources policy, which led to formation of the Food, Water and Energy Resources Policy Initiative and a grant from the U.S. Department of Agriculture in this area.

Van Etten introduced the three thematic areas that framed the conversations throughout the retreat:

- Signaling, Sensing and Imaging at the Intersection of Engineering and the Physical & Life Sciences
- Enhancing Lives: Integrating Research and Practice across the Social, Behavioral & Educational Sciences
- Integrating Big Data into Your Research Program at UNL.

Keynote Presentations

Keynote presentations featured speakers from outside the university who brought expertise and a broad view of science related to the retreat themes. Their presentations offered starting points for further discussion as participants moved into their focus groups.

Parag R. Chitnis

Director, Division of Molecular and Cellular Biosciences, National Science Foundation

Parag Chitnis spoke on "Investing in the Convergence of Life Sciences with Engineering & Physical Sciences" and provided an overview of the National Science Foundation's funding history and its commitment to empowering discoveries in all areas of science and engineering. In the next phase of NSF-funded research, Chitnis expects to see greater emphasis on the convergence of life, physical and engineering sciences, leading to new ideas that boost the economy.

Convergence is more than simply research at the intersections of disciplines – it involves the deliberate use of varied thinking styles to address grand challenges and is becoming an emerging paradigm for innovative research in many sectors, he said.

Chitnis calls the Age of Convergence the "Third Revolution," following the Molecular Biology Revolution that began in the 1960s and the Genomics Revolution that took root in the late 1980s. In the Convergence Revolution, we are seeing the potential in synthetic biology, which integrates elements of engineering, biology and the physical and social sciences, to design novel artificial biological pathways, devices or organisms (or redesign existing biological systems). This rapidly emerging technology can lead to solutions for long-standing problems and will advance the frontiers of our present knowledge base. The United States alone invested more than $550 million in such research between 2005 and 2011.

The NSF offers a number of funding opportunities to support research at the convergence of engineering and the life, physical and social sciences, including core activities supported through regular research grants; **EA**rly-concept **G**rants for **E**xploratory **R**esearch (EAGERs); **I**ntegrated **N**SF **S**upport **P**romoting **I**nterdisciplinary **R**esearch and **E**ducation (INSPIREs); special programs supporting Science and Technology Centers, Engineering Research Centers, and Materials Research Science and Engineering Centers; and special competitions.

Core programs constitute 90 percent of the NSF budget, and increasingly more awards (from 33 in FY11 to 102 in FY13) are going to projects that involve research at the interface of the **Bio**logical, **Ma**thematical, and **P**hysical **S**ciences (BioMaPS) and engineering. In addition, the Biological Sciences and Computer and Information Science and Engineering Directorates are making joint awards.

The NSF also employs special funding mechanisms, like EAGERs, which fund disciplinary or interdisciplinary, high-risk, high-impact research; INSPIREs, which focus on interdisciplinary, potentially transformative research; and the Ideas Lab, which is generating interdisciplinary solutions to grand challenges.

Convergence areas of special interest in 2014-2015 include Big Data science and engineering; education and workforce development; multidisciplinary collaborative teams and communities; brain research, specifically risky interdisciplinary ideas for developing new technologies; advanced manufacturing; and BioMaPS.

Chitnis cautioned that researchers should start with a grand challenge and bring the right tools to it, instead of starting with tools and going in search of a challenge.

Rashid Bashir

Abel Bliss Professor of Electrical and Computer Engineering and Bioengineering,
University of Illinois at Urbana-Champaign

Rashid Bashir spoke on "Interfacing Engineering, Biology & Medicine at the Micro & Nanoscale: From Lab-on-Chip to Building Systems with Cells," presenting an overview of the grand challenges arising from the intersection of engineering and the life sciences on both the micro- and nano-scales. Recent trends strongly suggest that biology and medicine are critical to the future of engineering; advances in biology and medicine have come (and will come) from new technologies and quantitative methods; and major challenges in society are directly or indirectly related to medicine and healthcare.

The world is seeing a greater proportion of deaths due to non-communicable diseases, such as heart disease and cancer. Because technologies like genome sequencing have become much more available to low-resource settings, we have an unprecedented opportunity to characterize the molecular signatures of human diseases, including cancers. The critical challenge – analyzing, integrating and translating that knowledge to improve human health – may be answered by systems-level thinking to combine sequence information with data from other sensors.

Bashir cited as examples the use of sensors that are 1) enabling early diagnosis in personalized health care settings, including home health care; 2) making it easier to manage individual medical, genomic and biological data and health records; and 3) changing the ways physicians are trained.

In the area of synthetic biology, scientists from the fields of microbial, mammalian and plant biology are coming together with engineers who are attempting to build with molecules and cells, with the ultimate goal of re-engineering mammalian systems. Such teams can develop around a number of grand challenges in fields ranging from genomic/individualized medicine, to global heath, neuroengineering and neuroscience, driven by the goal of conducting use-inspired basic research.

Bashir described work at a number of bioengineering-related training centers at the University of Illinois at Urbana-Champaign, including the use of biosensors in the diagnosis of HIV/AIDS; nanopore sensors to detect cancer cells; mass sensor arrays to measure physical properties of single cells; and a petri-dish-on-a-chip for bacterial culture.

He explained the focus of an NSF-supported multidisciplinary, multi-institutional Science and Technology Center called Emergent Behavior of Integrated Cellular Systems (EBICS), with the primary aim of gaining a deeper understanding of how cooperative cell behavior leads to the formation of large organized cellular structures. The ultimate goal is to create biological "machines" in which multiple cell types coordinate to perform a specified function. The center involves the work of developmental biologists, stem cell biologists, nanotechnology and fluid mechanics engineers, and modeling and systems biologists.

Bashir encouraged organizing education and research around grand challenges by combining disciplinary depth and excellence with interdisciplinary breadth. Some potential grand challenge areas include: global health, energy, sustainability, food and agriculture, technology and society, among many others. Potential models include two training and education programs he leads at UIUC: the Midwest Cancer Technology Training Center, involving faculty and students from 12 departments; and the NSF Research Trainee (NRT) program in Cellular and Molecular Mechanics and BioNanotechnology, a cross-institutional collaboration, in which disciplines such as cellular mechanics, biology and mechanical engineering are represented.

Kimberly Hoagwood

Vice Chair for Research in Child and Adolescent Psychiatry, New York University Langone Medical Center

Kimberly Hoagwood, a widely renowned expert in the field of implementation science, spoke on "Translational Science in a Policy Environment: C'est la Vie." Using examples from her experience as a clinical psychologist and as the National Institutes of Health's associate director for child and adolescent mental health research, Hoagwood described her approach to designing research projects. A focus on implementation can translate not only into interventions for clinical populations but into generalizable practices that shape our ability to implement policies effectively, assess labor market and business needs, and train the requisite workforce. Hoagwood's prime example was the Center for Mental Health Implementation-Dissemination of

Evidence-Based Practices among States (IDEAS), located at NYU and funded by the National Institute of Mental Health. It serves as a central hub, not only for researchers, but for multiple constituencies – families, providers, policymakers – engaged in health and mental health systems serving children, adolescents and their families. The goal of IDEAS is to ensure that basic and applied research informs and optimizes health care practices and health outcomes for patients.

Current research projects include

- efforts to improve family and peer support, services and interventions for patients experiencing depression or traumatic stress (known as the Peers Enhancing Practice/PEP Framework)
- school-based programs aimed at improving access to mental health services and trauma care
- studies examining the organizational conditions that shape whether initiatives designed to improve the quality of mental health care actually become adopted widely by service providers.

Hoagwood made it clear that translational or implementation science goes beyond the classic "bench to bedside" metaphor. Indeed, the triple aim is to optimize health care by creating a better experience of care for families and patients, better population health though use of proven interventions, and better business through lower health care costs.

Colleen Gabauer

Director of the Office of Interdisciplinary Graduate Programs, Purdue University Graduate School

Colleen Gabauer's presentation on "Building an Interdisciplinary Life Science Research Community: Implementing a Collaborative Program Model for Graduate Training" focused on the critical role such programs play in creating a scientific research community that meets the changing needs of stakeholders ranging from graduate students to PIs to employers.

Fields represented in Purdue's interdisciplinary graduate programs run the gamut from the computational sciences to the humanities and beyond, with strongest demand in fields related to computational and life sciences, ecology, food science and nutrition.

Gabauer showcased PULSe, the Purdue University Interdisciplinary Life Science Ph.D. Program. Over the last decade, PULSe has served as an umbrella training program for students in fields as varied as biochemistry, molecular biology, neuroscience, plant biology and virology. It serves as a prime example of how Purdue coordinates interdisciplinary training programs centrally through its graduate school, even as other, equally successful interdisciplinary programs are administered via academic units.

PULSe epitomizes the type of interdisciplinary training program of interest to federal funding agencies. It involves over 200 faculty members in more than two dozen departments and provides a highly diverse group of 150-plus graduate students with ample opportunity to rotate through labs during their first year, establish strong mentoring ties with faculty in a continuously evolving set of focus areas or "training groups," and use the well-structured curriculum to develop individualized plans of study. Additional signs of how successful PULSe has become include the fact that it is one of Purdue's most ethnically diverse graduate program,

with regard to both domestic and international students, and that its retention and degree completion rates significantly exceed national and institutional averages.

Eric Lyons

Assistant Professor, School of Plant Sciences, University of Arizona

In his presentation "Data-driven Science with iPlant Cyberinfrastructure," Eric Lyons described the iPlant Collaborative, a 10-year program funded by the National Science Foundation that is now in its sixth year. Originally intended for plant science research, iPlant now encompasses all life sciences research. Primary partners are the University of Arizona, the Texas Advanced Computing Center at the University of Texas at Austin, Cold Spring Harbor Laboratory, and the University of North Carolina at Wilmington.

Lyons, who is co-PI on the project's second renewal phase, began his explanation of the iPlant Collaborative with a video animation of the dynamic molecular mechanics of a cell, noting that the blueprint for these mechanics is encoded in the genome, which may range in size from *E. coli's* 4.6 million nucelotides to 3 billion nucleotides in the human genome.

To simplify understanding of the magnitude of genome size, Lyons expressed it in terms of "Harry Potter Equivalents (HPEs)," with the total number of characters in the entire series of Harry Potter books – approximately 3.3 million – constituting one HPE, and each character representing one nucleotide. In those terms, the *E. coli* genome equals 1-1/3 HPEs; the yeast genome equals 4 HPEs, and the human genome equals 1000 HPEs, which would take about 8-1/4 years for an average person to read!

Because the cost of DNA sequencing has gone down so dramatically in recent years, the size of the GenBank has increased accordingly, so much so that biology is becoming a data-driven science, facing the key challenge of transforming genomic information into knowledge. This challenge leads to a series of "big data problems" related to data transfer, storage, analysis, visualization, metadata markup, search and discovery, sharing and collaboration, and publishing, Lyons said.

iPlant is creating solutions by providing scientists with a powerful computational infrastructure for handling huge datasets and complex analyses, essentially providing a number of services to manage the entire life cycle of data by

- developing the national cyberinfrastructure for data-intensive biology driven by high-throughput sequencing, phenotypic and environmental datasets
- providing powerful extensible platforms for data storage, bioinformatics, image analyses, cloud services, APIs, and more
- making broadly applicable cyberinfrastructure resources available across the life science disciplines (plants, animals and microbes).

Lyons said the iPlant data store is secure, scalable, reliable, redundant, high-performance and connected. Like "Dropbox on steroids," he said, its discovery environment offers multiple ways of accessing data from

a single data store without ever having to move data to the desktop. iPlant offers high-performance, multi-threaded transfers that are four times faster than regular web transfers. Data are stored on many servers at both the University of Arizona and the Texas Advanced Computing Center, both of which have access to cloud computing.

Lyons noted that iPlant's cyberinfrastructure, originally limited to solving problems relevant to plant sciences, now can provide tools that are just as useful for solving problems in all domains of life, including animals, microbes and insects. iAnimal and iMicrobe are natural extensions of iPlant that give scientists access at multiple levels to application programming interfaces (APIs), RESTful services, and web-based systems for data access, tool integration and analysis.

For more information on large scale data management, Lyons recommends the National Research Council's report, "Frontiers in Massive Data Analysis."

In essence, iPlant offers three main components: scalable hardware, software systems and knowledge in how to use it. Scientists interested in learning more about how to use iPlant can find documentation online, search or pose specific questions at ask.iplantcollaborative.org, or email iPlant for support.

Thematic Discussions

The goal of the retreat was to bring together faculty from many disciplines to learn about one another's work and identify strategic interdisciplinary research areas for UNL. Faculty from all disciplines were invited. The retreat featured nationally recognized speakers, talks and "quick pitches" by UNL faculty, panel discussions, networking activities and breakout sessions around three thematic areas.

After discussion with the UNL Research Advisory Board, three themes were chosen as UNL priority research areas, in which interdisciplinary work is essential and around which development of research teams, projects and initiatives would benefit from retreat activities. The three themes were

- Sensing, Signaling and Imaging at the Intersection of Engineering and the Physical and Life Sciences
- Enhancing Lives: Integrating Research and Practice across the Social, Behavioral and Educational Sciences
- Integrating Big Data into Your Research Program at UNL.

The sessions on the three thematic areas were structured to be inclusive and encourage participation across disciplines. A faculty leadership team for each theme, in collaboration with faculty from the disciplines involved, planned the activities for their sessions. The result was an interesting mix of activities that mirrored different approaches in the disciplines.

Research Advisory Board

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Theme 1: Sensing, Signaling and Imaging at the Intersection of Engineering and the Physical and Life Sciences

Scientists and engineers increasingly are exploring the frontiers where biology, chemistry, physics, computer science and engineering intersect. At the same time, the development of new tools and technologies is critically important for studying the widely varying scales of biological systems, from nano-sized organisms to global ecosystems. Collaborative partnerships at these intersections are generating some of the most innovative science and technologies today, yet these partnerships can be difficult to initiate and maintain.

The key to creating interdisciplinary teams is building awareness of the research taking place in the labs and in the field across campus. In initial discussions about the 2014 Interdisciplinary Faculty Retreat, James Van Etten suggested a session focused on getting scientists and engineers together to talk about their work – engineers to tell about the new tools and technologies they are developing, and scientists to tell about problems they are trying to solve and the kinds of tools that would help. This became the driving concept for this thematic area.

In subsequent meetings, faculty planners agreed that the broad area of sensing, signaling and imaging would include researchers from diverse disciplines and many cutting-edge UNL research programs, as well as faculty who are creating start-ups and working with the private sector to develop technologies. Faculty generated ideas for focus areas, external speakers, session formats and resources, such as the expertise database.

Theme 1
Faculty Planners
Jiri Adamec
David Berkowitz
Paul Black
Christopher Cornelius
Stephen DiMagno
Shane Farritor
Jiantao Guo
Jerry Hudgins
Srivatsan Kidambi
Rebecca Lai
Yongfeng Lu
Hasan Otu
Mark Riley
Jeffrey Shields
Clifford Stains
James Van Etten
Hendrik Viljoen

Shane Farritor, mechanical & materials engineering, and Stephen DiMagno, chemistry, served as co-chairs of this thematic division.

Thematic Sessions

The goal of the sessions was to facilitate the development of interdisciplinary teams with an emphasis on showcasing scientists and engineers from as many disciplines as possible in the time given. A keynote speaker was selected to kick things off, and two sessions of UNL faculty presentations were planned. Ninety-five faculty from 25 departments and units attended the sessions in this thematic area, and the 20 faculty speakers represented 11 departments, ranging from chemistry to civil engineering to agronomy and horticulture.

Keynote Speaker

Henry VanBrocklin, director of the Radiopharmaceutical Research Program in the Center for Molecular and Functional Imaging at the University of California, San Francisco, spoke on "Imag' in' ing the Future: Perspectives from Molecular Imaging."

"Imaging is all around us; we are introduced to it on a daily basis," VanBrocklin said. From ultrasounds to MRIs to weather radar, imaging allows us see the things beneath the surface and create images of the invisible

aspects of an object. Molecular imaging is an imaging science that uses non-invasive imaging modalities to understand the normal biological processes in the body. Ultrasound PET, CT and MRI are medical imaging techniques that are familiar to everyone. An incredible evolution in PET/MRI technology occurred when different modalities were combined to enhance images and make them clearer.

The field of molecular imaging illustrates the power of multidisciplinary research, VanBrocklin said. "Molecular imaging helps put all the information together, which is very powerful but it takes a village to make this happen."

Henry VanBrocklin

Molecular imaging provides a platform for collaborative research that includes integrating multi-modal imaging, simplifying probe development, working in appropriate model systems, high-end computing to handle big data, measuring outcomes to support clinical use of new modalities and agents, integrating quantitative analysis in post-image processing, and driving down costs with new innovations.

Faculty Presentations on Collaborative Partnerships and Innovative Tools and Technologies

In this series of 15-minute presentations, existing collaborative teams and scientists/engineers at UNL who are leading or working in interdisciplinary teams described their efforts.

Rebecca Lai, chemistry, and **Mathias Schubert, electrical engineering,** gave an overview of the Nebraska Center for Nanohybrid Functional Materials, a multidisciplinary center funded by Nebraska EPSCoR. CNFM includes 19 investigators from six Nebraska colleges and universities working in engineering, chemistry, physics, biology and pharmaceutical sciences. The center targets the discovery and exploitation of new sensing principles based on the combination of 3-D ordered nanostructures and chemical or biochemical sensing elements. The goal: developing new and more powerful sensors and separation devices. CNFM provides facilities and equipment to faculty and students to enable this work, including the Glancing Angle Deposition (GLAD) chamber to create thin films. A recent NSF grant will fund development of iGLAD, which will enable the group to make structures that are more controlled and well-defined.

Judith Burnfield, Nebraska Athletic Performance Lab and Madonna Rehabilitation Hospital, and **Carl Nelson, mechanical and materials engineering,** spoke about their collaboration, which began in 2006 based on their shared interests. Nelson wanted to help real people in his research on the medical application of robotics, and Burnfield had the perfect project: a training system to help people with physical disabilities regain walking capacity and physical fitness. Their collaboration produced ICARE, the Intelligently Controlled Assistive Rehabilitation Elliptical, an enhanced version of an elliptical machine. It's now being manufactured and sold in 80 countries.

Their latest project is in robot-assisted ultrasound diagnostics focused on specific types of Achilles tendon injury. This ties together clinical processes with automated post-imaging processing to look at images of the tendon and identify damage. Burnfield and Nelson both emphasized that teamwork between researchers and patient-care experts is essential in projects like theirs. They are interested in potential collaborators for work in musculoskeletal and tissue biomechanics, sports equipment design and assessment, and experimental and computational research.

Angela Pannier, biological systems engineering, works in the area of tissue engineering, with the goal of developing functional tissue substitutes to replace tissues and organs damaged by injury or disease. Her affiliations with UNL's Center for Nanohybrid Functional Materials, UNMC's Regenerative Medicine Program and Center for Drug Delivery and Nanomedicine, and the USDA Meat Animal Research Center (MARC) have provided collaborations and conversations that have led to innovative tissue engineering techniques for *in vitro* tissue models. She has been designing and characterizing alginate hydrogels for use as scaffolding materials for building tissue.

One of her first collaborations began at a retreat with UNL's animal science department, in a lunchtime discussion with Jeremy Miles from MARC about the problem of embryonic loss in pigs. Working with Miles, Pannier found that encapsulating pig embryos in alginate hydrogels helped the embryos secrete estrogen during the critical first 12 days of pregnancy. Other projects include using hydrogels for engineering bone growth plates, characterizing protein and cell adhesion on biomaterials and exploiting biomaterial interfaces for improved non-viral gene delivery. Pannier's thoughts on interdisciplinary collaborations:

- The first step is learning something from one another.
- Focus on the simplest things you do together, like writing a conference paper.
- Be creative.
- Embrace the concept of a "little bet" – several little bets will result in learning and innovation.

Edward Harris, biochemistry, and **Srivatsan Kidambi, chemical & biomolecular engineering**, believe that the point of research is to pursue collaborative actions – research is now a network. Their collaboration began informally in the lunch line during new faculty orientation, when they were talking about research and found they had overlapping interests in work dealing with the liver. Kidambi's research focuses on *in vitro* models for engineering living tissues from the brain and liver; Harris studies the biochemistry of the liver, including heparin catabolism, endocytosis and fatty liver. Their interests met in studies of liver sinusoidal endothelial cells and culture optimization of primary cells.

The collaboration grew as others came on board, from psychology, chemistry, biochemistry and medicine. They now have a UNL interdisciplinary grant, are working on re-submission of an NIH proposal, and have set their sights on larger center and program grants at NIH. They are preparing papers for publication and training graduate and undergraduate students in interdisciplinary research and have been invited to give talks at symposia. Their key messages on collaboration:

- Collaborations are symbiotic, they can't be parasitic – every lab must contribute.
- Start small and then grow. It is kind of like dating – wedding planning occurs when writing a grant together, then the official marriage follows.

Daniel Schachtman, agronomy and horticulture, works in the area of improving crop yields under stress, studying the mechanisms that enable crops to adapt to stressful soil conditions like low nutrient levels, drought and salinity. He is leading a large multidisciplinary team studying the continuum of plant-soil-microbe interactions, including how plants control interactions with soil microbes, how microbes contribute to plant productivity, and how microbes improve soils and enhance nutrient availability. This systems approach requires many disciplines: plant genetics and physiology, mycology and bacteriology, soil chemistry and ecology. Engineers and chemists will develop new sensing and monitoring technologies, and computer scientists and statisticians will work on integrating and visualizing the mass of data generated.

Mehmet Can Vuran, computer science and engineering, and **Suat Irmak, biological systems engineering**, have combined their expertise to tackle one of the most pressing issues facing the world today: how to make irrigation, which is used to produce 40 percent of the world's food, more sustainable and efficient. Vuran developed the technology for a wireless underground sensor network that could communicate real-time soil

Suat Irmak and Mehmet Can Vuran

moisture data and teamed with Irmak, a leading irrigation expert, to test real-world applications of the technology. Irmak's irrigation research site at UNL's South Central Agricultural Laboratory was ideal for early research and development; now the technology is being tested and demonstrated at more than 1,000 farms in Irmak's Nebraska Agricultural Water Management Network.

The team, which also includes computer scientists Stephen Reichenbach and Xin Dong, has received funding from an NSF Innovation Corps award for developing and marketing the technology. Vuran founded Wildsense LLC, which has a licensing agreement with NUtech Ventures, the nonprofit corporation responsible for commercializing UNL research. Wildsense received an NSF Small Business Innovation Research Phase I grant to continue developing and marketing the sensor network. Vuran expects a product to be ready within a year.

Shannon Bartelt-Hunt, civil engineering, recounted how her collaboration with Jason Bartz from the Department of Medical Microbiology and Immunology at Creighton University began with a phone call and the question "What would happen if we...?" It started small in 2006, with basic questions. There was no grand plan, no funding attached, just the desire to study prion diseases, fatal neurodegenerative diseases of animals, particularly chronic wasting disease in deer. Bartelt-Hunt viewed this project from an engineer's environmental perspective. The infectious prion protein enters the environment through shedding from an infected host or carcass decomposition, or is released through urine and milk. Not a lot is known about what happens when prions enter the environment, but they do attach to the soil. The team's research question became: "How do ambient environmental processes (such as wetting/drying) influence persistence and fitness of soil-bound prions?"

Their collaboration enabled them to couple information on environmental behavior with information on biologic effects. To date, the team has co-authored 12 papers and two book chapters; one doctoral dissertation is completed and two dissertations are in progress. They have had good success leveraging individual PI funding from NSF, NIH and USDA. Bartelt-Hunt emphasized what it takes to develop a good collaboration:

- Take the time to learn each other's language, meet, talk and read outside your own discipline.
- Begin with simple questions, not based on dollars only.
- Recognize that collaboration is a long-term commitment requiring trust and sharing of ideas, resources, equipment and student advising.
- It takes a leap of faith to be successful.
- Above all, it is extremely rewarding.

"Quick Pitches" by Faculty on Their Research and Innovations

In the spirit of entrepreneurship and start-ups, nine UNL faculty members from diverse disciplines gave five-minute "quick pitches" about their innovative research and identified ways others might fit into it.

Harkamal Walia

Harkamal Walia, agronomy and horticulture, described his work on imaging/plant phenotyping to find rice varieties that will be productive under drought, flood and salinity stresses, which are expected to increase with climate change.

David Hage, chemistry, spoke about "adventures in analytical separation" techniques that could be useful in many types of research. He highlighted high-performance affinity chromatography, affinity micro-columns, multidimensional separation methods, chromatographic immunoassays and flow-based biosensors.

Stephen DiMagno, chemistry, gave a quick pitch on the idea of making pre-cursors of a pre-formed drug and labeling them with isotopes, building on his work with radiofluorination methods to improve production of radiopharmaceuticals for use in positron emission tomography (PET).

Art Zygielbaum, School of Natural Resources, described a new technique using the spectrum of visible light reflected from plants to detect plant water stress.

Jun Wang, earth and atmospheric sciences, pitched the newly-formed, interdisciplinary Initiative for Integrated Earth Observation and Modeling, an approach for research related to future prediction or decision-making.

Deborah Brown, School of Biological Sciences, spoke about vaccination strategies against pathogens that escape antibody detection, such as influenza strains that quickly mutate.

Shadi Othman, biological systems engineering, described his e-incubator system for growth of a tissue construct that allows for in vitro magnetic resonance imaging of the tissue.

Karrie Weber, earth and atmospheric sciences, explained her work on the role microorganisms play in catalyzing chemical reactions in soils, sediment and groundwater, especially how they influence uranium and water quality oxidation.

Shane Farritor, mechanical & materials engineering, pitched the work of his two companies, Virtual Incision, a partnership with surgeon Dmitry Oleynikov of UNMC, which makes tiny robots that are inserted inside the body and used during surgeries, and MRail, a train car with sensors, lasers and cameras to measure track stiffness to improve maintenance and safety.

Breakout Discussion

The size and diversity of the Theme 1 group was reflected in the key issues that emerged and in the discussion of potential big ideas. The discussion quickly became focused on facilities and equipment, which was not surprising given the theme of signaling, sensing and imaging, with an emphasis on available vs. needed capabilities. Many faculty said it is difficult to know what equipment and capabilities are available on campus and advocated for a website/database for sharing this information. Some suggested a need to centralize coordination and management of facilities. Capabilities for handling big data and for integrating image

capture in informatics were mentioned. All agreed a workshop on this topic would be valuable.

Communication and making connections with potential collaborators were mentioned frequently. An expertise database was suggested, along with faculty group meetings organized around topics and an electronic whiteboard for posting issues and problems.

Paul Black

Big Idea Areas for Development

Bio-imaging in Plant and Animal Systems

This area would build on current UNL research in cancer, infectious disease, plant genomics, plant physiology and material science. A core facility that would provide equipment for molecular and organism-level imaging in plants and animals would enable discovery of new targets for imaging. This facility would fill a need, because currently most samples are sent out of state for imaging. Imaging capabilities should include small scanners that would enable scientists to know in "real time" the nutrients within a plant. Such a facility would fill gaps in awareness about current capabilities and equipment, address the difficulty of coordinating across facilities and generate ongoing support for facilities. It also could support new collaborative work on big projects that could increase UNL funding and attract collaborators from the public and private sectors.

Predictive Systems Modeling Across Scales

UNL's current strengths and existing collaborative teams in atmospheric sciences, remote sensing, climate modeling, computer science and engineering address this area. An approach that integrates data and modeling, including visualization, data management and software engineering, is appropriate for projects related to decision-making or predicting the future. Gaps to be addressed include current limited knowledge of the strengths on campus and existing collaborations (both internal and external) and definition of problems to study that would match UNL strengths.

Next Steps

In regard to both big ideas, follow-up discussions or workshops would serve to clarify research objectives and focus, identify potential cross-disciplinary collaborators, open up new areas of funding for UNL, and lead to potential new collaborations with other universities and the private sector.

Theme 2: Enhancing Lives: Integrating Research and Practice across the Social, Behavioral and Educational Sciences

The goal of this thematic area was to develop a broad vision and identify specific initiatives to leverage UNL's strengths and propel its national profile in social, behavioral and educational science research, broadly

conceived. The focus of these discussions was to foster transdisciplinary conceptual initiatives and empirical projects that address complex societal problems via translational research. Sixty-eight faculty from 27 departments and units participated in this thematic area. David Hansen, psychology, and Susan Sheridan, educational psychology, served as co-chairs for this theme.

Theme 2
Faculty Planners
John Anderson
Kirk Dombrowski
David Hansen
Ming Li
Julia McQuillan
Susan Sheridan
Kimberly Tyler
Regina Werum

Structure and Highlights

Kimberly Hoagwood, one of the plenary speakers, addressed translational research in her talk. Her implementation science research provided valuable examples and background for discussions related to this theme.

Session 1: What is Translation? Overview, Examples, and Discussion

The first session provided an opportunity to discuss the translational research process. Translation was selected as a unifying theme, given its importance across a wide variety of research areas focused on solving complex problems with human dimensions. Any areas whose goals relate to human application and intervention may benefit from a translational research agenda – in particular, research in health, mental health, education, transportation and the environment, among others. Translation also was deemed a valuable retreat focus because it requires interdisciplinary collaboration; both translation and collaboration are increasingly expected and essential for funding opportunities.

The notion of translation has been around for many years. Its origins are in health research, particularly biomedical research, supported by the National Institutes of Health. Descriptions of translation have evolved as understanding of the process has grown. Figure 1 (adapted from Khoury et al., 2007), presents an overview of the phases of translational research discussed at the retreat. This commonly referenced model is used by a variety of agencies, including the Institute for Translational Health Sciences and the DHHS Agency for Healthcare Research and Quality. Our version was modified by shifting the language of the model away from a focus on health research only to a broader focus that addresses translation across a variety of research contexts with human application.

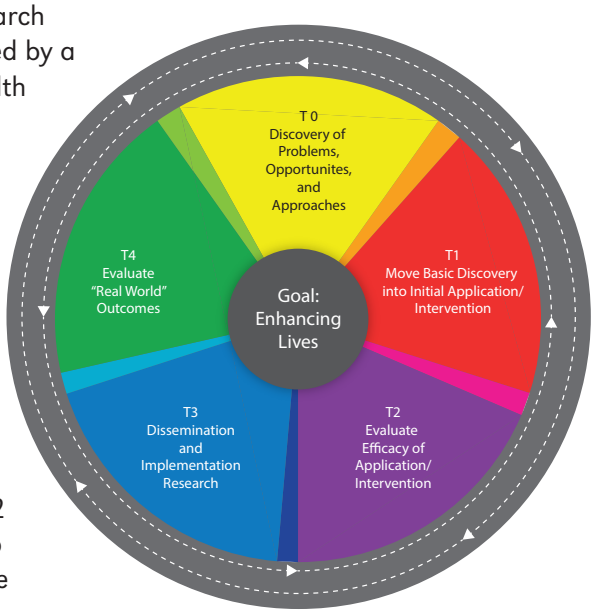

Figure 1. Phases of Translational Research. Adapted from: Institute of Translational Health Sciences (https://www.iths.org/about/translational) and Khoury, M. J., et al. (2007). The continuum of translation research in genomic medicine: How can we accelerate the appropriate integration of human genomic discoveries into health care and disease prevention? *Genetics in Medicine, 9*, 665-674.

Translation provides a valuable conceptual framework for moving research into practice. Early discussions of translation focused on the area labeled T1 in the figure (often called "bench to bedside"), which would include, for example, moving basic pharmacology research into tests on a limited number of research patients. This was followed by the T2 phase ("bedside to practice"). A typical T2 objective might be to determine the effects of a drug treatment on patients in practice settings.

Translational models were expanded over time to acknowledge the complexity of the process. For instance, it is apparent that developing a treatment does not ensure it will be implemented correctly, widely disseminated and adopted by practitioners. That can be a slow and painstaking endeavor. T3 and T4 were added to

address the multiple steps associated with implementation, dissemination and sustainability. T0 has not been included in all representations of translation, because it has not traditionally been thought of as a translation phase (it is "the bench" in "bench to bedside") – but it is valuable as a key part of the overall process and the foundation for the integration of basic research and applied practice.

Some discussions of translation describe it as a *continuum* (moving from T1 to T2 and so on). This circular representation was chosen because it conveys the multidirectional nature of translation. As research knowledge is acquired, it informs phases before or after it, influencing future research.

To facilitate discussion of translation research, Susan Sheridan and Carolyn Pope Edwards described the development of their research collaboration to address the problem of school readiness for impoverished children. In a presentation titled "Getting Ready for Translation: A Case Example" they explained that their interests came together when their individual concerns about school readiness intersected with a major

David DiLillo, Victoria Molfese, Ming Li, Judith Burnfield, Laurence Rilett, Kirk Dombrowski

federal grant opportunity offered by the Interagency School Readiness Consortium. Allied fields, such as developmental psychology, school psychology, special education, social work and health, identified concepts that invited synthesis, making it particularly timely and exciting to come together. Sheridan and Edwards discussed their previous and current randomized controlled trials, as well as next steps for their relational

family engagement "Getting Ready" intervention. They illustrated the phases of translation research, from basic research identifying the problem through dissemination and adoption.

The session concluded with lively Q&A discussion moderated by Kirk Dombrowski. Questions addressed the translational research process, initial consideration of the value of interdisciplinary translational research programs and the challenges of pursuing them. The importance of considering translational goals throughout all phases of research and systematically evaluating translation efforts were discussed.

Carolyn Pope Edwards and Susan Sheridan

Session 2: Translation at UNL: Panel Discussion with Audience Participation

The second session provided examples of translation research activity at UNL via a moderated panel discussion, followed by questions and comments from the audience. Panel participants were

- **Julia McQuillan, sociology**, panel moderator
- **David DiLillo, psychology**, Substance Abuse & Violence Initiative
- **Victoria Molfese, child, youth and family studies,** Nebraska Center for Research on Children, Youth, Families & Schools
- **Ming Li, psychology,** Neuroscience and Behavior Program
- **Judith Burnfield, Nebraska Athletic Performance Laboratory,** Madonna Rehabilitation Hospital
- **Laurence Rilett, civil engineering,** Nebraska Transportation Center
- **Kirk Dombrowski, sociology,** Minority Health Disparities Initiative

The panel illustrated the potential for translational research at UNL. Brief presentations by the panelists described research on intimate partner violence (DiLillo); preschool learning (Molfese); antipsychotic drug treatment (Li); transportation challenges (Rilett); improving human performance, safety, and well-being (Burnfield); and community-based participatory research (Dombrowski). Moderated discussion with the panelists and audience focused largely on enhancing interdisciplinary collaboration, including strategies and challenges (e.g., facilitating communications about opportunities, expertise and resources available; developing opportunities for collaborative relationships to grow organically).

Session 3: Academic Crowdsourcing: Our Chance to Solve Wicked Problems Using Translation

The third session provided opportunities to interact around various societal issues of concern. The notions of academic crowdsourcing and wicked problems were selected to convey a focus on the need for creative, interdisciplinary solutions for problems that are very difficult to solve because of their scope and complexity. Participants could join 20-minute discussions on up to three of seven topics:

- How can we identify and rectify the causes and (often unintended/unanticipated) consequences of growing social inequality? (*Julia McQuillan*)
- How can we design, create and maintain sustainable and equitable environments that optimize human safety, health and wellbeing? (*John Anderson*)
- How can we ensure that children and youth have the opportunity to develop into healthy, productive members of their community? (*Susan Sheridan*)

- How do we address the causes and consequences of risky behavior (e.g., drug use and addiction) in rural and urban America? (*Kirk Dombrowski*)
- How can our social/behavioral/educational research address concerns about optimizing national security, broadly defined (political, economic, cyber, other)? (*Kevin Smith, Kurt Preston*)
- How do we improve quality of life for people who are experiencing various types of chronic disadvantage (e.g., disability, poverty, mental illness)? (*Ming Li*)
- How do we reduce the occurrence and consequences of the many forms of aggression and violence experienced in homes, schools and neighborhoods? (*David Hansen*)

For each topic, the following questions were discussed:

- What does translation have to do with this problem?
- What assets do we have at UNL to address this specific problem?
- What opportunities do you envision for addressing this specific problem?
- What gaps/shortages come to mind?

Key strengths, opportunities, and challenges across the three rounds of table discussions were reviewed at the beginning of the next session.

Jody Koenig Kellas

Session 4: Where Do We Go from Here – and How Do We Get There?

The fourth session provided a review of what had been learned from the various presentations and discussions and to brainstorm opportunities to pursue. Sherri Jones (special education and communication disorders) and Eric Thompson (economics; Bureau of Business Research) served as moderators for the discussion.

UNL's major strengths and potential opportunities in the seven topic areas explored in Session 3 were briefly reviewed. Common strengths noted included many UNL programs, centers and initiatives that offer expertise and infrastructure supports: Nebraska Center for Research on Children, Youth, Families and Schools (CYFS); Center for Brain, Biology and Behavior (CB3); Public Policy Center (PPC); Nebraska Transportation Center (NTC); Cooperative Extension (e.g., 4-H); Minority Health Disparities Initiative (MHDI); and Substance Abuse and Violence Initiative (SAVI). Additional strength lies in the many partnerships and connections with state and community agencies (e.g., schools, mental health and social service agencies) that want to collaborate with the university on services, evaluation and research.

The university's Cooperative Extension platform provides the opportunity to collaborate with and disseminate information to those in the field. The breadth of existing faculty expertise and datasets on campus available for addressing such complex societal concerns was noted, from basic research in animal laboratories, to research on applications and interventions with humans, to policy endeavors.

Common challenges include lack of awareness of potential collaborators, concerns about the value of interdisciplinary publications in promotion and tenure processes, lack of communication between the many departments and centers that do related work, and lack of faculty time (due to existing commitments) to increase interdisciplinary collaboration and pursue new opportunities.

Strategies for encouraging interdisciplinary work include: access to planning/seed grant funding to stimulate team building for pursuit of external funds; hosting an interdisciplinary seminar series to bring investigators together to interact around issues of common interest; and increased communication among researchers (e.g., web portal to post ideas and to network). Greater expertise for understanding the translation process as a research question is needed, along with additional leveraging of community members as collaborators to help continually build translation into the research activities and potential solutions.

Cecilia Conrad, MacArthur Foundation

After reviewing the ideas generated in Session 3, the discussion focused on generating "big ideas" to pursue. The moderators led the discussion based on the following themes:

- Opportunities: What interdisciplinary, translational research topics/questions could we address here at Nebraska? How might they lead to external funding?
- Strengths: What expertise and resources do we have for pursuing that research?
- Gaps: What expertise and resources do we need?

Big Ideas for Development

The participants and processes of this retreat track generated three "big ideas" to pursue for advancing the social, behavioral and educational sciences at UNL. These endeavors have the potential for broad, interdisciplinary impact, and to bring together researchers across the translational research spectrum, from basic lab research to development and evaluation of interventions in real world settings, dissemination into common practice, and adoption as policy.

Translational Processes

To advance UNL and our many research strengths focused on addressing contemporary societal challenges, we need to significantly strengthen our activities and expertise on translational processes. We have many organized, productive research teams with theory and content expertise addressing societal problems that require translation. This includes centers and initiatives across the social, behavioral and educational sciences, such as CYFS, CB3, PPC, NTC, MHDI, and SAVI. It also includes collaborators in the community and throughout the state, such as the Nebraska Department of Health and Human Services and Madonna Rehabilitation Hospital. In addition, a growing number of UNL teams that include social and behavioral scientists are pushing the boundaries of interdisciplinarity with research projects at the intersection of civil engineering and national security.

These existing centers and initiatives, and the infrastructure supports they have in place, provide great opportunity to coalesce critical mass to advance our study of translation processes. Existing and emerging relationships with end users (practitioners, systems, policy makers) also provide a solid basis for moving forward and advancing our translation efforts.

The major gaps identified include limitations in methodological expertise needed for investigating translation processes and building translation into our intervention, implementation and dissemination efforts. Translational expertise has traditionally resided in medical schools, with a focus on pharmacology and health applications. There has been limited attention to the intellectual problem of translation within the social, behavioral and educational sciences, though there is a clearly an established need to do so.

Advancing our expertise in translational processes would significantly impact our funding success across a number of areas. Existing research programs focused on addressing societal problems would be strengthened by access to additional expertise in translation. Investigators interested in studying translation processes would have many opportunities to investigate translation within the context of existing, productive UNL research programs. Funding could be accessed from many agencies (e.g., National Institutes of Health, National Science Foundation, National Institute of Justice, Department of Education, Department of Defense, Department of Homeland Security), as translation research is inherently interdisciplinary, innovative and cross-cutting, with broad economic and policy implications.

Methamphetamine Use in Rural America

Given the scope of this national drug problem, expertise available at UNL, and funding opportunities, another priority "big idea" is methamphetamine use in rural America. UNL has many strengths and resources in this area, including current faculty research across a number of disciplines. Addressing this problem requires research coverage from biomolecular, medical, behavioral, human systems and applied disciplines. It connects with research programs from a variety of fields, including adolescent development, families, social service systems, legal systems, rehabilitation services, rural education, and behavioral health. Our varied rural strengths and resources also provide opportunities for productive research on this topic (e.g., Cooperative Extension, National Center for Research on Rural Education).

Gaps identified include the challenges commonly associated with bridging activities across research programs and different disciplines and centers, including building a critical mass, finding faculty time and leadership, and facilitating communication. Developing a priority research emphasis on rural methamphetamine use would advance UNL's research growth goals by building interdisciplinary teams to pursue a problem with significant federal funding opportunities (e.g., National Institute on Drug Abuse). This also brings together and leverages a variety of currently siloed research activities, such as basic research in animal labs, clinical research evaluating interventions, and legal and policy analysis.

Youth at Risk

The third priority theme identified via this track of the retreat was youth at risk. Existing strengths identified include faculty interest in violence and gangs, and extensive faculty expertise in a number of related topics (e.g., bullying, social networks, adolescence, neighborhoods, substance abuse/violence and child maltreatment). There is also significant community interest in the state (including Lincoln) in partnering with UNL researchers to better understand and address the problem of at-risk youth. In addition, there are many opportunities for investigating this topic in Nebraska, including studying links between immigration/refugee populations and gangs, as well as rural populations and gangs. Our proximity and relationships with Native populations are also seen as an advantage, as are our existing centers and initiatives that research topics related to at-risk youth (e.g., CYFS; Center for Child and Family Well Being; 4-H work with adolescents). Potential gaps for advancing this area include the challenge of bringing together the needed expertise across the diversity of faculty researchers and lack of clarity about whether there is a critical mass of expertise and interest in developing a more specific research focus. The problem of at-risk youth is seen as highly fundable, including opportunities within the Department of Education, National Institute of Justice and the National Institute of Child Health and Human Development.

Next Steps

Translation is crosscutting and inherently multidisciplinary. Expanding our translational research expertise and activities is a logical next step for advancing research across the social, behavioral and educational sciences. Success at translation is critical for addressing complex societal concerns, advancing our research and obtaining external funding.

An interdisciplinary translation working group will be created. Faculty teams will be encouraged to pursue "Big Ideas Seed Grants" announced at the retreat (i.e., planning grants or accelerator grants). These may be focused across the priority themes noted above or in complementary areas that arise from post-retreat discussions. The working group will develop further plans and activities for strengthening translational research at UNL. This may including developing an inventory of existing resources and activities related to translation, as well as systematic analysis of gaps in our expertise and resources.

A colloquium or seminar series may be developed to bring faculty together to learn more about translation, engage with each other and help grow collaborative teams. These may be broadly-focused on translational processes, or more specifically on translation in the context of more focused research problems (e.g., rural methamphetamine use, youth at risk). The working group will also explore pursuing an NSF Research Coordination Networks grant or similar funding mechanism that will provide support for strengthening coordination and communication of research and training activities around the translation theme.

Theme 3: Integrating Big Data into Your Research Program at UNL

Theme 3
Faculty Planners
Andrew Benson
Jennifer Clarke
Aaron Dominguez
David Swanson
William Thomas III

The advent of big data offers unprecedented opportunities for data-driven discovery and decision-making in nearly every area of research. To realize the transformative potential of big data, researchers need to address challenges in managing data and acquiring knowledge and expertise in recent computational methods for data analysis that may be new to them.

Big data is a big subject and may mean different things to different faculty depending on their disciplines and perspectives. It is, by its nature, interdisciplinary; teams often form organically and involve a subject matter researcher working closely with a quantitative scientist (statistician and/or mathematician) and often a computer scientist, depending on the application. The Theme 3 session shared the insights of faculty working collaboratively on projects involving big data and information about the various resources available at UNL for computation and analysis.

This theme was selected not only because it is a current hot topic in all fields, but because it has been a major focus at UNL for several years. The faculty and administration have recognized the growing need for information skills, for both students and faculty, and are tackling the question of how to provide informatics training. The result was the Computational Sciences Initiative (CSI), focused on growing and strengthening teaching and research in this critically important area. Jennifer Clarke, CSI director, and Andrew Benson, a leader in the UNL Big Data Initiative, led development of the session on Big Data.

The core planning team for this session outlined areas of discussion for the retreat, ideas for speakers and session formats addressing the following ideas:

- the big data future for biology and other disciplines now dealing with huge datasets for the first time

- the need to educate faculty about the excellent computational/analytic resources available at UNL and how to access them
- the importance of collaborations and how to build collaborative networks
- opportunities for faculty to learn about the Computational Sciences Initiative and share their ideas
- opportunities for training and educating undergraduate and graduate students in computational sciences.

Thematic Sessions

Activities in this thematic area had two main goals:

- to provide examples of how UNL faculty are integrating big data into their research programs
- to educate faculty about the computing and analytic resources available for research at UNL and how to access and make the best use of them.

More than 80 faculty from over 25 disciplines attended the sessions in this thematic area, and the 10 faculty speakers represented six departments ranging from history to computer science and engineering to food science and technology.

Ian Fisk

Keynote Speaker

Ian Fisk from the Fermi National Accelerator Laboratory spoke on "Advances and Improvements in Big Computing." Fisk has extensive knowledge of big data from his experience working on the Large Hadron Collider, where he helped set up the first prototype Tier-2 analysis facility to commission the Worldwide LHC Computing Grid. He drew the distinction between "big data" and big computing, saying that the class of problems we tend to think of as "big data" are not as common in science as big computing problems. Physicists have large and unwieldy datasets, but they tend to be focused and frequently come from controlled sources, he said.

Fisk showed the huge growth in the generation of data involved in high energy physics research. In the late 1950s, two or three scientists working in a group produced kilobits of data recorded in notebooks. By the 2010s, more than 3,000 scientists were collaborating, producing petabytes of data recorded on tapes and disks. The challenge then became how to share these data. The solution: the Worldwide Large Hadron Collider Grid.

Fisk compared the LHC Grid to Netflix, the single largest user of bandwidth in the U.S. Netflix delivers streaming video content to about 20 million subscribers. The LHC Grid has a smaller number of clients, less distribution and higher bandwidth per client, he said, but Netflix has much less data to deal with. The grid is a globally distributed system, combining services to enable computing clusters to be used for processing and storage so physicists can solve big computing problems.

"There was no technical reason all the computing could not be located in one place, but we have more support and more resources this way," Fisk said.

Faculty Presentations on Integrating Big Data into Their Research and Computing Resources Available for Research

Half-hour presentations by faculty described their experiences with big data and UNL computing resources.

Aaron Dominguez, physics & astronomy, described the model that the Large Hadron Collider (LHC) project provides for how to organize people around big data. Dominguez is part of the UNL team on the Compact Muon Solenoid (CMS) project, one of the two large particle detector experiments at the LHC. The team has played an important role in building the LHC detectors and analyzing data that come from the experiments. Dominguez described the culture developed by the high energy physics community that has enabled them to pursue "really big ideas requiring really big machines," huge datasets and worldwide collaborations of scientists. Even though this culture has grown somewhat organically over time, Dominguez said it is clear to him that they couldn't have accomplished this physics at this point in history without the culture they have adopted. How do you organize more than 2,000 physicists on a project that has no real boss with real authority to hire and fire? Dominguez asked. By convincing them that the idea is so good that all voluntarily agree to pursue it. "Credibility becomes the currency of the realm," he said.

This huge network does have a structure – a CMS Management Board and a CMS Constitution. But most important is communication among the physicists distributed across the globe, which requires thousands of national and institute meetings each year. Researchers have found a "common cause" model for technical coordination that has delivered a detector capable of tracking billions of particles per second to within 10 microns. To make this work, the physicists have developed many web-based tools: good video conferencing, agenda servers, document databases and other tools. But the physics is the main focus and that is what has driven development of such a huge project.

"We have had to self-organize in a way that respects each individual researcher's self-interest, while remaining open to criticism and change," Dominguez said. "Being immersed in this culture daily, I rarely think about it, but it has led to some truly great accomplishments."

Andrew Benson, food science and technology, spoke on the changes in biological research driven by the advent of next-generation DNA sequencing and the huge amounts of data it generates. Biologists have to understand how big data or data-driven science relates to research programs at UNL, then create the environment and the culture that enables data management, processing and analysis, Benson said. Using UNL's Gut Function Initiative as an example, he described building a team of experts in gut microbiota, mouse genomics, statistics, bioinformatics, and information technology and database programming. Within three years the team switched to a new next generation sequencing platform, and the amount of data generated per sample grew 1,000 times. "Then we developed complete dependence on the Holland Computing Center infrastructure," Benson said.

Benson discussed key lessons he learned in the process of conducting interdisciplinary research involving big data at UNL. A first, crucial step is to define the big research questions so everyone understands what is being pursued and the overall framework. Then research questions, approaches, and front-end experimental designs should be designed collaboratively. Sharing postdoctoral researchers, students and staff among laboratories is a great way to develop interdisciplinary knowledge and capabilities in data science and to increase collaboration, Benson said. Training students in data skills, such as Perl programming, bioinformatics and statistics, also is a great investment. Most important is developing truly collaborative relationships with programmers and those who work with big data. "Everyone on the project needs to benefit," he said.

William G. Thomas III, history, brought his perspective as a leader in digital research in the humanities to the challenge of big data. The integration of big data in humanities scholarship often results from big questions whose answers will require large-scale collaboration, Thomas said. A project that requires a massive

historical collection of individual-level data may present opportunities for big data in the humanities. Humanities centers can be a particularly viable way to address these projects.

A key area of big data research in the humanities is the Internet. The analysis of social media and mass digitization projects, such as digitizing all of a renowned writer's work, are examples. Humanities scholars may face the challenge of access to data due to privacy concerns and data embargoes, Thomas said. A pedagogical perspective is a good starting point to enhance the integration of big data and humanities scholarship. Students from many disciplines, including the humanities, need to learn skills for analyzing and interpreting data.

William Thomas III

David Swanson, computer science and engineering and director of the Holland Computing Center, gave a comprehensive overview of the computing facilities and capabilities available at UNL and examples of interesting inter-disciplinary collaborations around big data. The Holland Computing Center provides high performance computing and data storage for faculty and students throughout the University of Nebraska system. Its 16 full time staff members include applications specialists, systems administrators and computing research personnel. One of the services they offer is to help faculty develop computing that will enable their research. HCC encourages faculty from any discipline to come to them with their computing needs and ideas. Faculty can get started on their own big data challenge by setting up an account with HCC or arranging a meeting with HCC staff, Swanson said.

An example, Swanson said, is the collaboration between Steve Kolbe of UNL's Johnny Carson School of Theatre and Film and Adam Caprez of HCC to develop a rendering farm – a high performance computer cluster built to render computer-generated imagery typically used for visual effects in movies. In the realm of really big data, Swanson described a collaboration aimed at providing real-time maps and visualizations of down-scaled regional climate data. "Model simulations of climate change generate large amounts of output – really big data," Swanson said. Faculty from HCC, earth and atmospheric sciences, and computer science and engineering have been collaborating to continue to develop MapMaker, a program to display and analyze output from regional climate models.

Jennifer Clarke, food science and technology and director of the UNL Computational Science Initiative described the CSI as a university-wide program of excellence for developing expertise and resources in Big Data and data science. "In my opinion, 'big' or 'large' data is a relative term," Clarke said. "What is large to me, or you, or a random faculty member or student on campus, may be small to financial analysts on Wall Street or at credit card companies." It is the relative size, not the absolute size, that is important, and even relatively small data can be a challenge to analyze, she said. This is where informatics, the science of information, becomes important. Skills in informatics help researchers get from data to knowledge when the data are large, noisy and complex.

Today it is very easy for scientists to collect huge amounts of data but much more difficult to turn that data into answers to interesting questions. Most scientists were not trained to handle complex data and are not prepared to analyze it, Clarke said. Finding answers to interesting questions and addressing critical challenges now involves collaborating with information scientists and learning to communicate across disciplines. This is driving an unprecedented demand for information skills. How do we train individuals in these skills? Clarke asked.

David Swanson, Aaron Dominguez, William Thomas III, Jennifer Clarke, Andrew Benson, James Schnable, Juan Cui, Hasan Otu

The CSI is charged with answering this question. CSI was established to

- enable interdisciplinary and basic research at UNL in Big Data
- advocate for and develop Big Data resources and expertise on campus
- serve as the Big Data liaison between UNL and industry partners
- develop both graduate and undergraduate curricula in data science.

Interdisciplinarity is key to the CSI's work, which focuses on developing mutually beneficial collaborations between big data scientists and other scholars.

Five-Minute Introductions from Faculty in Diverse Disciplines about Their Work in Computational Sciences

Recently hired faculty in diverse disciplines gave five-minute introductions about ways their work relates to and relies on computational sciences.

Juan Cui, computer science and engineering, spoke on her work in high throughput "-omics" techniques: genomics, proteomics and metabolomics, especially in the area of cancer research. She currently is working with colleagues at UNL and UNMC on a mitochondrial protein study, dietary microRNA regulation network and a genome evolution study to identify the cancer driver.

Juan Cui

Hasan Otu, electrical engineering, described learning gene interaction networks using external knowledge and experimental data. This is an extension of his work in bioinformatics focusing on macromolecular sequence analysis, microarrays, biomarker discovery, genetic variations and systems biology, analyzing high throughput biological data within the context of networks.

James Schnable, agronomy and horticulture, described his work in computational biology focused on the comparative genomics and gene regulation of grasses, including maize, sorghum, setaria and panicum.

Massimiliano Pierobon, computer science and engineering, works in the engineering of molecular communication systems and networks in biology, with a current focus on modeling and engineering biological systems stemming from cellular metabolic pathways. In the 2014 fall semester he is teaching a new course, "Molecular and Nanoscale Communications."

Interactive Panel Discussion about UNL Computational Sciences Resources

A panel discussion that invited participation from session attendees began with questions submitted by attendees during Session 2 and coalesced around three main topics: exposing undergraduate and graduate students to big data concepts, increasing awareness of big data issues among faculty, and enhancing communication regarding big data needs. Panelists were

- **Steve Goddard, computer science and engineering**
- **David Swanson, computer science and engineering**
- **Jennifer Clarke, food science and technology**
- **Andrew Benson, food science and technology**

Exposing Undergraduate and Graduate Students to Big Data Concepts
The group addressed various ideas for exposing students to big data concepts, beginning with the need to develop related coursework. A first step would be to add a computational component to 100-level courses, which also would help students understand how computational courses would benefit them in the future. Another mechanism suggested was an undergraduate club focused on the grand challenges of the 21st century – an interdisciplinary group extending beyond the honors students community. A similar club for graduate students would facilitate cross-disciplinary collaborations among graduate students, who tend to get trapped in their niches. Recruiting undergraduate students to work in laboratories that use or focus on big data also was suggested. The "best and the brightest" undergraduates could be recruited from the 100-level courses.

The question was raised whether it is necessary to expose "non-computationally oriented" students, such as those majoring in journalism and the humanities, to big data issues, and if so, how it should be done. The consensus was that these students should take a methodology course on informatics, which would include a

laboratory component. Faculty seemed to agree that students should not be able to opt out of computational learning, and this might also pave the way for a big data component in the Lincoln Public Schools curriculum.

Increasing Awareness of Big Data Issues among Faculty Members
Discussion centered on the idea that one reason some faculty members are averse to learning about big data issues is that big data is perceived as a risky or scary area. To demystify the field, a useful first step would be to identify some big data-related core themes that are common across many fields. Comments suggested a lack of awareness among faculty of available resources or which resources are most appropriate for faculty big data needs. A survey was suggested as a beneficial first step for faculty to understand their big data needs, weaknesses and challenges. Support from upper administration for big data efforts and interdisciplinary collaborations was urged.

Enhancing Communication Regarding Big Data Needs
One idea to encourage communication was a walk-in, "open house" environment, supported by dedicated space for the CSI, where students and faculty would be encouraged to gather and engage in conversation about needs and issues related to big data. A message board also was proposed, but some felt this would be ineffective because there is no incentive to participate. The "open house" would allow people to seek solutions to their immediate problems, such as programming issues, and allow them to collaborate on long-term projects or prolonged problem solving.

The importance of developing truly collaborative partnerships surrounding big data was discussed. Relationships should not be about non-experts approaching experts to solve problems that are of little interest to the experts, but rather true collaborations where everyone benefits professionally. Developing interdisciplinary projects around grand challenges and training students in each other's laboratories were discussed as ways to help develop truly collaborative projects involving big data.

There was agreement about the need to communicate to university administrators how important core facilities are to research endeavors at UNL. The consensus was that it would be helpful for UNL to employ people who are charged with educating the university community and the public about the vital role of core facilities such as the UNL Center for Biotechnology.

Big Ideas for Development

Three broad big idea themes emerged from the topics generated in the panel discussion.

Culture, Community and Communication

Developing a culture and community and tools for communication among faculty and students who work in various aspects of big data should be a priority at UNL. This community would be diverse and interdisciplinary and focused on developing truly collaborative partnerships of benefit to all the partners. Developing interdisciplinary projects around "grand challenges" would build the community and benefit the university. An "open house" space where faculty and students could gather and informally exchange ideas and needs about big data was proposed. This would also be the place to seek solutions to problems, such as programming issues, and to develop collaborations.

Forum for Sharing Challenges and Opportunities

Many faculty expressed a need for some sort of forum for sharing their challenges and ideas and communicating about opportunities in big data. This could be as simple as a message board or a more elaborate online collaborative space.

Faculty networking between sessions

Education

Educating undergraduate and graduate students in big data concepts is a major need at UNL. Some suggestions:

- Add a computational component to 100-level courses to introduce big data concepts to students in many disciplines.
- Modify existing courses, including labs and homework, to incorporate big data.
- Form undergraduate and graduate student clubs focused on grand challenges for the 21st century that will require computational skills and management of big data.
- Recruit undergrads to work in labs that deal with big data.
- Create an informatics course for students from fields that are not computationally-focused.

Next Steps

As follow-ups to the retreat discussions, faculty are urged to attend the Big Data Symposium, Nov. 8-9, 2014, and pursue development of the education components discussed.

Networking Activities

The retreat offered many opportunities for faculty to network, connect and learn about their faculty colleagues and resources available on campus. The retreat also offered time to relax and socialize – and have the kinds of conversations that lead to big research ideas and collaborations.

Faculty Database

Prior to the retreat, the Office of Research and Economic Development created a searchable database to make it easier for faculty with similar research interests to find one another. When faculty registered for the retreat, they were asked to submit a brief description of their research interests and five key words related to their research. Using this information, the ORED created a database searchable by name, department or key words. It's also possible to click on a keyword and see a list of retreat participants who used the same key word – a great way to facilitate networking at the retreat.

Jordan Soliz and Michael Scheel

Interactive Evening

Retreat attendees gathered in the Banquet Hall for food, drink, music and opportunities to interact and network with their colleagues. A showcase of UNL interdisciplinary centers and core facilities filled the perimeter of the Hall, and tables dedicated to spontaneous interdisciplinary discussion drew in faculty.

Shane Farritor shows off the Maker Space

Networking Passport

The evening provided a great opportunity for participants to fill their retreat "networking passports" with signatures of colleagues from other disciplines. Those who filled a passport with at least 10 signatures of colleagues from other departments or disciplines became eligible for "lucky research awards" of $1000 and $500 research travel vouchers and $250 technology vouchers. At the drawing at lunch the next day, 20 faculty and postdocs won a total of $10,000 in awards to further their research.

Maker Space Tour

Shane Farritor, professor of mechanical & materials engineering and founder and faculty adviser of the UNL Maker Club, gave a tour of the new 17,000-square-foot Maker Space located in the Innovation Commons. The space will provide an environment for students to work with each other building projects using 3D printers, laser cutters, woodworking, sewing, electronics and metalwork, Farritor said. Students aren't the only Maker Space users. Anyone will be able to get a membership and use the Maker Space's facilities for their own enrichment.

Farritor started the Maker Club in February 2014, and more than 200 students, staff, faculty and community members turned out for the first meeting. The club promotes student-initiated projects that fuse engineering, art, design and technology. In a few short months the Maker Club has grown to be the largest student club on campus, with more than 500 members.

"If students want to be successful after college, they have to be special. They have to be creative. They have to be innovative. And they have to be interdisciplinary," Farritor says. Setting up a student-run maker space on campus helps students extend their own skills, while helping others to do the same.

Leslie Hawley

Research Centers, Core Facilities and Related Groups Participating in the Interdisciplinary Showcase

Bureau of Sociological Research (BOSR)
Center for Biotechnology
Center for Child and Family Well-Being
Center for Digital Research in the Humanities (CDRH)
Center for Entrepreneurship
Center for Extreme Light Research
Center for Plant Science Innovation (PSI)
National Strategic Research Institute (NSRI)
Nebraska Innovation Campus (NIC)
Nebraska Educational Telecommunications (NET)
NUtech Ventures
Rural Futures Institute
Survey, Statistics and Psychometrics Core Facility (SSP)
University Libraries

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