



Strategic Discussions for Nebraska



HIGH-TECH: The Future of Sustainable Agriculture



sdn.unl.edu



Welcome to IANR's newly designed issue of Strategic Discussions for Nebraska.

This interactive pdf contains lots of additional information so please interact and click on the **red text**,  **VIDEO** or  **SDN EXPANDED** buttons whenever you see them.

THE MORRILL ACT OF 1862

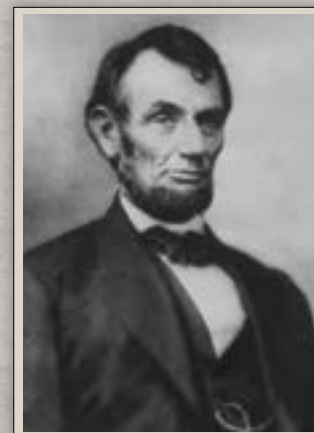
On July 2, 1862, President Abraham Lincoln signed into law the Morrill Act of 1862, sponsored by U.S. Congressman Justin Smith Morrill of Vermont. The bill established the donation of land to each state for the establishment of colleges that would provide a liberal and practical education to the industrial class, or the common person. These colleges became known as “land-grant” institutions.

Prior to the Morrill Act of 1862, higher education was available only to the wealthy. The land-grant colleges would provide instruction in the practical studies of agriculture and the mechanic arts, such as engineering.

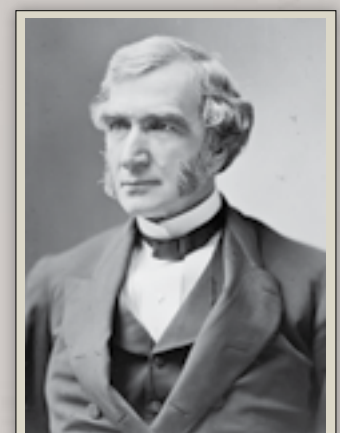
The Morrill Act of 1862 allotted 30,000 acres of public land for each sitting senator and representative in Congress to establish the land-grant colleges. Morrill could not have known the future impact this law would have in providing educational opportunities to students throughout the United States and its territories.

Today, there are more than 100 land-grant educational institutions in the United States and its territories, each focusing on teaching, research and outreach — taking new knowledge to the people.

The University of Nebraska was founded in 1869 and designated a land-grant institution under the 1862 Morrill Act.



Abraham Lincoln



Justin Smith Morrill

ABOUT STRATEGIC DISCUSSIONS FOR NEBRASKA

Strategic Discussions for Nebraska is a program in the University of Nebraska–Lincoln Institute of Agriculture and Natural Resources (IANR) whose mission is to communicate university research and to train students how to communicate research so it can be easily understood. A publication has been produced annually since 2008, each focusing on a different topic.

This year’s publication is written by a team of students, led by the faculty team of Mary Garbacz, Lisa Jasa and Dan Moser. These students learned how to research current topics in agriculture, interview university researchers and write stories that communicate complex science with clarity, accuracy and objectivity.

The students are seniors majoring in Agricultural and Environmental Sciences Communication (AESC) in the UNL Department of Agricultural Leadership, Education and Communication (ALEC) and take the SDN course as their capstone course, which brings together students’ prior coursework and developed skills and provides a learning experience that will be similar to those they will encounter in the workplace.

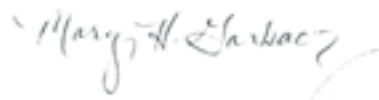
The UNL Educational Media (EdMedia) specialists provide videography, video editing, graphic design, photography and website, business and liaison services for the production of this publication.

As coordinator of Strategic Discussions for Nebraska, I express sincere appreciation for the original vision and financial support of the Robert and Ardis James Family Foundation, which founded Strategic Discussions for Nebraska in 2007.

Strategic Discussions for Nebraska now is funded by and housed in the UNL Institute of Agriculture and Natural Resources’ College of Agricultural Sciences and Natural Resources, in the Department of Agricultural Leadership, Education and Communication.

Please visit our website at *sdn.unl.edu*, where you will find not only the complete publication, but also short videos that allow you to watch and listen as the UNL researchers explain their work.

Thank you for your interest in our publication!


Mary Garbacz, SDN Coordinator
Email: *mgarbacz2@unl.edu*
sdn.unl.edu

Mary Garbacz, SDN Coordinator

STUDENT WRITERS:

- Mollie Wilken
- Emily Taylor
- Kristi Block
- Alex Wach



SPECIAL APPRECIATION

Strategic Discussions for Nebraska extends special appreciation for the vision, guidance, support and assistance of the following individuals and groups:

- Ronnie Green, University of Nebraska Vice President for Agriculture and Natural Resources and Harlan Vice Chancellor, University of Nebraska–Lincoln Institute of Agriculture and Natural Resources (*ianr.unl.edu*).
- Steven Waller, Dean, University of Nebraska–Lincoln College of Agricultural Sciences and Natural Resources (*casnr.unl.edu*).
- Mark Balschweid, Head, University of Nebraska–Lincoln Department of Agricultural Leadership, Education and Communication (*alec.unl.edu*).
- Jill Brown, Assistant to the IANR Vice Chancellor.
- University of Nebraska–Lincoln administrators, faculty and staff. We are fortunate to work with these outstanding individuals.
- University of Nebraska–Lincoln Extension, led by Charles Hibberd, Dean, and its specialists and educators, who take objective university research to the people of Nebraska (*extension.unl.edu*).
- University of Nebraska–Lincoln Agricultural Research Division (ARD), led by Archie Clutter, Dean. The ARD is the major research unit of the UNL Institute of Agriculture and Natural Resources and is the Agricultural Experiment Station (*ard.unl.edu*).
- UNL Educational Media, for the professional services necessary to produce this publication, which also is available online at *sdn.unl.edu*. Visit *edmedia.unl.edu* for more information.
- UNL Print, Copy, Mail and Distribution Services (*printing.unl.edu*) for printing, mailing and transporting these publications.

PHOTOGRAPHY CREDITS

- Nick Manes, Educational Media photographer
- Levi McPhillips, UNL Animal Science student
- Patrick Wright, Educational Media photographer

EDUCATIONAL MEDIA STAFF

- Mark Balschweid, Head, Department of Agricultural Leadership, Education, and Communication and Director, Educational Media
- Janet Owens, Business Lead
- Renee Lanik, Graphic Design
- Brad Mills, Videography, Video Editing
- Anne Moore, Desktop Publishing
- Nick Manes, Photography
- Patrick Wright, Photography
- Anita Schaepe, Lana Johnson, Pam Peters, Website Development
- Marcia Claesson, Office Support

SPECIAL THANKS TO LISA JASA AND DAN MOSER

New to Strategic Discussions for Nebraska this year was a team approach to teaching the course and producing the publication. In addition to longtime Strategic Discussions for Nebraska coordinator Mary Garbacz, Educational Media staff members Lisa Jasa and Dan Moser added their teaching and journalistic skills to enrich this year’s classroom and publications experience.

CONTACT INFORMATION:

- Strategic Discussions for Nebraska
- College of Agricultural Sciences and Natural Resources
- Department of Agricultural Leadership, Education and Communication
- 101 Agricultural Communications Building
- University of Nebraska–Lincoln
- Lincoln, Nebraska 68583-0918
- Tel: 402-472-7119
- Fax: 402-472-0025
- Email: *mgarbacz2@unl.edu*
- Website: *sdn.unl.edu*

“The University of Nebraska–Lincoln was considered the Harvard of the west in the early 1900s. We have been considered a prestigious institution in agriculture throughout our history. We are looked at as a world leader, especially in a number of the areas of technology and intensification. We are one of the world leaders in genetic enhancement of plants and genetic modification of plants. We are one of the world leaders in livestock technologies and production in livestock industries. We are building on that strong foundation.”

*Ronnie Green, University of Nebraska Vice President
for Agriculture and Natural Resources and
UNL Harlan Vice Chancellor,
Institute of Agriculture and Natural Resources*

GROWING A HEALTHY FUTURE THROUGH TECHNOLOGY, INNOVATION



Ronnie Green
University of Nebraska
Vice President
and Harlan Vice
Chancellor, Institute
of Agriculture and
Natural Resources



The need to grow food for an expected world population of more than 9 billion people is urgent and the deadline of 2050 is fast approaching. At the **University of Nebraska–Lincoln**, one of our great strengths is improving food production techniques sustainably, protecting the precious natural resources that Nebraskans hold close to their hearts.

Meeting that global need for food takes leading-edge technology and scientists from every discipline — including areas of study that weren’t even in existence 10 years ago. Those disciplines have grown out of DNA sequencing and advances in computer technology that result in the ability to process enormous amounts of research data for more exact results.

Nebraska, with its vast miles of fertile soil and underground water, is one of the few places in the world that can be a major contributor to the world demand for more high-quality food. Thanks to early predictions of an increasing population, the University of Nebraska–Lincoln has hired the talented researchers who are improving the technologies to:

- increase food production through plant and animal genetics
- use land and water efficiently
- improve human and animal health
- make food products continually safer
- improve nutrition
- reduce food waste
- assure that producers receive fair prices
- keep watch on global markets for agricultural products

This publication, ***High-Tech: The Future of Sustainable Agriculture***, is representative of the newest research at the **University of Nebraska–Lincoln Institute of Agriculture and Natural Resources** (IANR). The IANR scientists were interviewed for this publication by a team of students and faculty members involved in a senior-level course through the UNL Department of Agricultural Leadership, Education and Communication (ALEC). Students learned to write about science and technology so a general audience can understand its importance.

The UNL Institute of Agriculture and Natural Resources is ***Growing a Healthy Future*** for Nebraska and the world through its three missions of teaching, research and Extension, which are equally important and are represented in this publication. The scientists interviewed not only are researchers, but also take their research discoveries to the farm fields and ranches of the state, “extending” their research findings to the producers who will adopt the technologies. The scientists also are teachers, educating the young scientists who will solve the challenges faced by the next generation.

I hope you enjoy this publication, which also is available online at sdn.unl.edu, where you also may watch the scientists talking about their work. Click on the movie camera icon and prepare to be amazed.

Growing a Healthy Future through Technology, Innovation v
A foreword by Ronnie Green, University of Nebraska Vice President for
Agriculture and Natural Resources and Harlan Vice Chancellor, University
of Nebraska—Lincoln Institute of Agriculture and Natural Resources

FOOD and nutrition

High Technology in the Food System is Key to a Productive Globe in 2050 4
Source: Ronnie Green, University of Nebraska Vice President for Agriculture
and Natural Resources and Harlan Vice Chancellor, University of
Nebraska—Lincoln Institute of Agriculture and Natural Resources

Technology: The Right Tools at the Right Time to Solve Real-World Challenges 8
Source: Tim Carr, J.S. Tinstman Professor and Head, UNL Department of
Nutrition and Health Sciences

Groundbreaking Cholesterol Research 11
Source: Tim Carr, J.S. Tinstman Professor and Head, UNL Department of
Nutrition and Health Sciences

“Keeping Consumers Safe” Focus of Food Allergy Research and Resource Program12
Source: Joe Baumert, Assistant Professor and Extension Food Allergy Specialist,
UNL Department of Food Science and Technology

Partnering with Technology for Food Safety16
Source: Harshavardhan Thippareddi, Professor and Extension Food Safety
Specialist, UNL Department of Food Science and Technology

Regulating Allergens in Genetically Engineered Foods20
Source: Richard Goodman, Research Professor, UNL Department of Food Science
and Technology

Understanding the GI Tract to Counteract Diseases22
Source: Andrew Benson, W.W. Marshall Family Professor, UNL Department
of Food Science and Technology

Grain Quality, Fiber and Benefits for Human Health24
Source: Devin Rose, Assistant Professor, UNL Department of Food Science
and Technology

Why Study the Human Gut? We Have 100 Trillion Good Reasons26
Source: Amanda Ramer-Tait, Assistant Professor, UNL Department of
Food Science and Technology

The Ultimate Goal: Make Food Safe28
Source: Bing Wang, Assistant Professor and Extension Food Safety Risk
Assessment Specialist, UNL Department of Food Science and Technology

PLANT science

The Role of Genetic Engineering in Feeding the World32
Source: Sally Mackenzie, Ralph and Alice Raikes Professor, UNL Department
of Agronomy and Horticulture

Advances in Small-Grain Breeding are Helping to Feed the World36
Source: P. Stephen Baenziger, Wheat Growers Presidential Chair and Professor,
UNL Department of Agronomy and Horticulture

Agroecology: It’s Not Just About the Price of Corn40
Source: Chuck Francis, Professor, UNL Department of Agronomy and Horticulture

Soil — Where it all Begins42
Source: Humberto Blanco, Assistant Professor, UNL Department of Agronomy and
Horticulture

Plant Science Technology Works toward Nutrition, Sustainability46
Source: Edgar Cahoon, Professor, UNL Department of Biochemistry

Genetic Diversity — a Positive for All48
Source: Thomas Clemente, Eugene W. Price Professor, UNL Department of Agronomy
and Horticulture

Developing Climate-Resilient Crops50
Source: Harkamal Walia, Assistant Professor, UNL Department of Agronomy and
Horticulture

Breeding for Success52
Source: George Graef, Professor, UNL Department of Agronomy and Horticulture

Building More Efficient Irrigation Systems, Farm by Farm54
Source: Suat Irmak, Eberhard Professor and Extension Soil and Water Resources
and Irrigation Specialist, UNL Department of Biological Systems Engineering

Precision Agriculture: Merging Technology and Knowledge56
Source: Joe Luck, Assistant Professor and Extension Precision Ag Engineer,
UNL Department of Biological Systems Engineering

Maximizing Irrigation through Irrigation Technology and GIS58
Source: Derrel Martin, Professor and Extension Irrigation and Water Resources
Specialist, UNL Department of Biological Systems Engineering

Unmanned Aerial Vehicles Can Help Farmers Evaluate Crops62
Source: Richard Ferguson, Professor and Extension Soils Specialist, UNL Department
of Agronomy and Horticulture

ECONOMICS

Rural Futures Institute Aims for Better Future for Rural Nebraska68
Source: Chuck Schroeder, Executive Director, University of Nebraska Rural Futures
Institute

Ag Economics Extension Helps Producers Improve Techniques, Profits70
Source: Kate Brooks, Assistant Professor and Extension Livestock Economics Specialist,
UNL Department of Agricultural Economics

Market and Policy Analysis74
Source: Konstantinos Giannakas, Professor, UNL Department of Agricultural Economics

Consumer Trust a Key Component in Genetic Engineering Trends76
Source: Amalia Yiannaka, Associate Professor, UNL Department of Agricultural
Economics

ANIMAL and veterinary science

Seeking a New and Improved Rumen80
Source: Samodha Fernando, Assistant Professor, UNL Department of Animal Science

Using Genetics to Increase Feed Efficiency and Reduce Production Costs82
Source: Matt Spangler, Associate Professor and Extension Beef Genetics Specialist,
UNL Department of Animal Science

USDA-NIFA Grant Targets Reducing E. coli in Beef86
Source: Rodney Moxley, Professor, UNL School of Veterinary Medicine and
Biomedical Sciences

One World, One Health90
Source: David Hardin, Professor, UNL School of Veterinary Medicine and Biomedical
Sciences

Processed Meat Technologies Increase Value, Taste, Safety92
Source: Gary Sullivan, Assistant Professor, UNL Department of Animal Science

Building on the “Nebraska Advantage”96
Source: James MacDonald, Associate Professor, UNL Department of Animal Science

Global Commitment for a Sustainable Future98
Source: Joe Stone, President, Cargill® Global Animal Nutrition

FOOD and nutrition

"The University of Nebraska-Lincoln Department of Food Science and Technology is a non-traditional department. We focus on 'food for health' and 'food for the individual' and how food can prevent disease."

*"We are just now starting to understand what the human gut does. You might ask 'what does the human gut have to do with human health?' The answer is **everything**."*

*Rolando Flores, Ph.D.
Head, UNL Department of Food Science and Technology*



HIGH TECHNOLOGY IN THE FOOD SYSTEM

is key to a productive globe in 2050

by Mollie Wilken



“Sustainable intensification — use of high technology for the food system — is the answer to the challenge as we move forward for a very productive and healthy globe in 2050.”

—Ronnie Green, University of Nebraska Vice President for Agriculture and Natural Resources and UNL Harlan Vice Chancellor, Institute of Agriculture and Natural Resources

“NEBRASKA IS ONE of the greatest breadbaskets of the world; it is one of the most productive environments for food production and a world leader in the production of food products and food byproducts,” according to Ronnie Green, University of Nebraska Vice President for Agriculture and Natural Resources. But with the gift of productivity, there is responsibility, Green said.

“Investing in the institution for the long-term future is one responsibility. These investments have a huge impact around the world, not just in what is produced, but also in the knowledge that is gained,” he added.

By 2050, the global population is expected to increase by 40 percent. Green, who also is Harlan Vice Chancellor for the University of Nebraska—Lincoln Institute of Agriculture and Natural Resources, said UNL research is focusing on

ways the university can be a global leader in sustainable agriculture.

Green said sustainable agriculture requires the use of technology, innovation in agriculture and food systems, and more efficient food production to be able to form the system of using fewer resources per unit of production.

“Use of the very best high technology for the food system is the answer to that challenge as we move forward for a very productive and healthy globe in 2050,” he added. “If we do not do these things, we won’t have the resource base we need long-term. We won’t increase the sustainable ability to feed humanity,” Green said.

Resource issues and food insecurity may go hand in hand with political insecurity. Uprisings in Mediterranean countries — called the Arab Spring — started in 2010 and were related to food prices and availability, Green said,

NEBRASKA RANKS:

- ➔ First in commercial red meat production
- ➔ Second in all cattle and calves, all cattle on feed
- ➔ Third for corn grain production, corn exports
- ➔ Fourth for land in farms and ranches, net farm income
- ➔ Fifth in agricultural exports, soybean production and exports

—Nebraska Department of Agriculture

and resulted in the fall of political systems in that region of the world.

THE CHALLENGE FOR TODAY’S YOUNG PEOPLE

There is no way some developing countries can meet the food need with the production capacity they have, Green said.

A challenge for people who will be at the peak of their careers in 2050 — today’s young people — will be meeting that global food demand, he said. In the last 15 years, the world has become more and more connected through news, social media and the Internet. Now, food, communication and technology travel faster from country to country. “When something happens across the world, the rest of the world is affected immediately. Therefore, the challenges ahead need to be faced in a global mindset,” Green said.

Green said the resources UNL has and the technologies it produces will continue to yield products to be distributed around the world to help meet this demand.

AGRICULTURAL TECHNOLOGY NOW AND IN THE FUTURE

The University of Nebraska is a world leader in agricultural technology, notably in the areas of genetic enhancement and modification of plants, plant and livestock technology, and livestock genetics that help make Nebraska the top producer of red meat in the U.S., Green said.

BUT IT ISN’T ENOUGH TO LOOK AT TODAY

“We have to be able to sit today in 2014, look out into that future and say ‘How well equipped are we as a university to meet the needs that are ahead?’” Green said. “We must be a world leader.”

Strategic planning is ensuring that the university is using technology wisely, deploying it appropriately and ensuring it is scientifically and environmentally sound to produce high quality, nutritious and safe food, Green said. Included is planning for the research and extension programs on approximately 40,000 acres of University of Nebraska land across the state, Green said.

Future development areas of the UNL Institute of Agriculture and Natural Resources include the Gut Function Initiative in the UNL Department of Food Science and Technology, Green said.

The multidisciplinary team of scientists is working to better understand the ecology and microecology of the gastrointestinal system, or gut, in humans, cattle, swine and poultry. One goal is for cattle to be fed non-traditional feedstuffs to produce the same high-quality beef that is produced using traditional feeds. If the research proves successful, cattle one day might not compete for human feedstuffs. Investments in areas such as this will lead to big payoffs for people and resources worldwide, Green said.

WHAT IS SUSTAINABILITY?

Sustainability means continuing to use resources for the benefit of humankind, yet not depleting or decreasing the quality of those resources, Green said.

“Think of it as a system of resources that we produce food within; do we leave that system as good as we found it, or better, in the future?” Green said. The farm and ranch are the foundation of agriculture, but agriculture includes everything that goes into the production and delivery of food products and co-products that are used in everyday life, he said.

In addition to natural resources sustainability, economic competitiveness also is a factor. “Food production has to happen in a way that supports

itself and supports the food production system economically in the global context,” Green said.

GLOBAL MINDSET

The majority of the population growth will be in developing parts of the world. In these regions there are not enough resources, energy or technology for the country to thrive agriculturally or economically. Ninety percent of this global growth is occurring in two regions of the world; 49 percent in sub-Saharan Africa and 41 percent in Southeast Asia. Therefore, the university, the breadbasket where innovation, technology and knowledge can be gained and shared around the world has the duty to think on a level that will help these regions, Green said.

By expanding innovation at the university and sharing knowledge and advancements with other countries, UNL can help countries around the world produce as much healthful and abundant food as possible.

OTHER COUNTRIES’ INVESTMENTS

Other countries also are making investments to meet the challenge of producing enough food for a population of 9 billion, Green said. These countries are known as the BRIC countries — Brazil, Russia, India and China. All are making investments in agricultural innovation and education.

Brazil is similar to the United States, with a large natural resource base, similar population size and the ability to innovate and produce and export for the world. Embrapa, Brazil’s federal research arm, is one of the country’s major assets in accomplishing this successful production.

Food security is a concern in China, Green said. China is making land investments in other parts of the world to use for food production, especially in Central and South America and Africa. These investments are being made because China’s population is greater than its land and water resource capacity, he added.



“Sustainability means continuing to use resources for the benefit of humankind, yet not depleting or decreasing the quality of those resources.”

— Ronnie Green

China, Brazil and India also are making investments in education by sending students abroad to U.S. and European universities. These students increase their knowledge and capacity for innovation, and take that knowledge and implement it in their home countries, Green said.

Russia is in a state of rebuilding its infrastructure after the collapse of the Soviet Union, Green said. As a country, it is making investments in capacity and production to close the yield gap and to bring the food closer to where the people are.

“We have to use less,” Green said. “We don’t have more resources. We have to be smarter and use those resources sustainably for perpetuity.”



TECHNOLOGY: THE RIGHT TOOLS

at the right time to solve real-world challenges

by Mary Garbacz



“Sustainability, applied to agriculture, means growing crops in a responsible way so the soil can be used year after year. Are we creating minimum impact on the environment? In the area of nutrition, sustainability might mean ‘Can we grow enough crops to feed a growing world? Can we feed healthy foods to developed countries?’ These are questions of sustainability with regard to nutrition and health.”

—Tim Carr, Professor and Head, UNL Department of Nutrition and Health Sciences

TIM CARR WORKS AT THE INTERFACE of food production, nutrition, and human physiology that enables him to understand how humans and animals function, and what affects their health. He also speaks in easy-to-understand terms about technologies, such as genetic engineering, and about the research that will produce more food and reduce the incidence of both genetic and lifestyle diseases. Carr, the head of the University of Nebraska–Lincoln Department of Nutrition and Health Sciences, looks at the past, present and future of the science of health. The challenges are different, based on whether people live in developed countries or in developing countries.

ALSO DIFFERENT ARE THE DEFINITIONS OF TECHNOLOGY AND SUSTAINABILITY

Sustainability for someone in a developed country like the United States, Carr said, may be whether the food supply is healthy — that the food delivers an adequate amount of essential nutrients without too much starch, fat or unhealthy ingredients that could cause obesity. On the other hand, sustainability in a developed country may simply be whether the people have enough food to meet their basic caloric requirements, regardless the composition of the food. Even if there already is enough food for the world, the infrastructure is not in place to get the food where it needs to be, or possibly to refrigerate or store foods so they stay safe to eat.

“These are the types of things we enjoy and take for granted in developed countries,” he said. “These are the systems that are lacking in developing countries.”

Technology, Carr said, is just using tools. “In food and nutrition, we’ve been using technology for thousands of years,” he said. “The first person to select a plant because it had better growing capabilities over another plant was using technology. We make a big deal out of technology, but it’s just using the right tools for solving the right problems.”

WHAT IS GENETIC ENGINEERING?

Technology tools have allowed scientists to genetically engineer plants, sometimes called genetic modification.

A plant’s DNA determines its inherited characteristics. It is that DNA that scientists alter, Carr said. Through the process, the DNA is changed to produce desirable characteristics, such as drought tolerance or pest resistance.

Genetic engineering takes place when a scientist takes the DNA of a plant — for instance, a corn plant — and

splices in a gene from the DNA of another organism that carries a desirable trait.

“What happens, for example, if corn, which uses a lot of water — what if we were to splice in a gene from a drought-resistant organism so that corn becomes more drought-resistant? That is an example of taking a desirable characteristic from a natural organism and putting it into another natural organism and creating a beneficial product,” Carr said.

In agriculture, there always is the worry about whether there will be enough water to grow the world’s food, or whether there will be an infestation of insects, or whether crops will survive under adverse conditions.

“If we can fortify, or make our crops stronger and more viable, then this is the best outcome of genetic engineering,” Carr said.

One of the first genetically engineered crops is cotton, which has been engineered to be pest-resistant and drought-resistant, Carr said. Cotton is used in textiles and its seeds are used for oil and animal feed.

The most common genetically engineered food products are soybeans, corn, cottonseed oil and canola oil, Carr said.

“Many years have passed since the first (genetically engineered crops) have been produced, and we’re not seeing negative impact — only positive — with regard to agricultural production,” he said.

“When we employ genetic engineering, only very small changes have been made in the recipient DNA with the new gene that has been spliced in. The new ‘recombinant DNA’ is not inherently risky. There is nothing that the DNA itself can do to cause harm,” Carr explained.

Regulation is focused on the products that are made as a result of the genetic engineering process, Carr said. They are tested and regulated in the same way as traditional crops are regulated. The government did not initiate the first “policing,” or regulatory processes of genetically engineered products, Carr said. The initial conferences took place in the 1970s and 1980s and involved experts doing the research.

“It was to their credit that led to the federal regulatory process,” he added.

GENES, DIET AND HEALTH: “FOOD FOR THE INDIVIDUAL”

One area of primary interest, epigenetics, is at the molecular level, Carr said.

“Epigenetics focuses on what happens when the gene or the DNA is already in place and we eat something, or we have some environmental factor go into the body,” Carr said. “How might that influence how that DNA is regulated or how that gene is regulated?”

The understanding of genes and the relationship between genes, diet and health outcome is an area of leading research at UNL, in the Nebraska Gateway to Nutri-genomics program, Carr said. The Nebraska Gateway to Nutri-genomics was started by Janos Zemleni, UNL professor of molecular nutrition in the Department of Nutrition and Health Sciences, and has grown into a multidisciplinary program including more than 40 researchers who study the interaction between nutrition and genes. The goal of the research is to be able to analyze an individual's DNA to determine how specific foods might be able to prevent diseases such as diabetes, stroke, heart attack and cancer, as well as birth defects. This “food for the individual” concept would be based on the composition of specific foods and how those nutrients can improve the health or prevent disease in a specific person.

Millions of dollars in grant funding have been awarded to the Nebraska Gateway to Nutri-genomics, Carr said, which has led to a number of collaborative research projects that are in the process of implementation. Many publications of research findings have resulted from the work of the nutri-genomics researchers, he said.

“We are leading the charge here at UNL in the nutri-genomics area,” Carr said.

NEW PLANS, NEW FACULTY

“It's easy to rally around good ideas,” Carr said, including the plan for the UNL Institute of Agriculture and Natural Resources' initiative to move forward with new areas of research and with the hiring of faculty members in several areas, including stress biology and healthy humans. Focus groups studied the needs, the multidisciplinary possibilities, and the hoped-for outcomes. As faculty members retired or moved from UNL, the position descriptions were rewritten to reflect the future.

In the healthy humans area, Carr said, the strategy is to look at the food environment, health and well-being, behavior, obesity research and other related areas. Six job descriptions emerged from that strategy, including elements of several UNL departments: Nutrition and Health Sciences; Child, Youth and Family Studies; Agricultural Economics; Food Science and Technology; Biochemistry; “and whoever else wanted to come to the table,” Carr said. “We wanted to look at a common theme that ran through this ‘healthy humans’ business.”

That common theme would involve the economic impacts of people's food choices, family and social settings that cause someone to eat certain foods, the impacts of eating those foods, and obesity — whether it is an issue and whether it can be prevented.

“There are so many things embedded,” Carr said. “We realized that this goes well beyond the Institute of Agriculture and Natural Resources. This is such a perfect example of how collaborations begin around a solidifying idea.”

Five faculty members in the healthy humans area have been hired; a sixth will soon join UNL. The progress continues; a second phase of hiring for the future is beginning.

➔ **“IN THE DEPARTMENT OF NUTRITION AND HEALTH SCIENCES,** we have invested a lot of time and energy in teaching. It is important that we train students these days to be comfortable with ambiguity to live in a world of gray. Not everything is black and white. Issues such as sustainability have no single answer and the students need to be able to work through the issue of sustainability in ways that their parents or grandparents didn't have to think about. In our department, we believe that the training begins in the classroom. It begins with hands-on learning, experiential opportunities for the students to feel the issues, to work through the issues, to not always feel compelled to have the single answer but perhaps to have a variety of answers, all of which could be correct and applicable to the situation. At UNL, we are focusing mostly on the teaching of students, the classroom activities of our teachers, and building a stronger network of educational experiences.”



CARR HAS SPENT 30 YEARS researching the mechanisms that regulate cholesterol transport, or how cholesterol moves around in the body. This research is the science that has led to today's knowledge of cholesterol and ways to control its excess.

“The most intriguing discovery we've made over those 30 years is that cholesterol has only one escape route from the body, and that's through the digestive tract,” Carr said. Every cell in the body makes cholesterol; if cells didn't have that capacity, we wouldn't survive, he added. However, if the body makes too much cholesterol, it can accumulate in areas where it's not desirable to accumulate, such as in the arteries of the heart or the arteries of the brain, causing heart attack or stroke. Figuring out how the excess cholesterol gets out of the body has been the main focus of his research, Carr said.

“What we have discovered is that what we eat can help promote the losses of cholesterol in the digestive tract,” Carr said.

Most people are familiar with the cholesterol in the blood — the HDL, or “good cholesterol,” and the LDL, which is the “bad cholesterol,” but few people understand that cholesterol is a vital component in the body, Carr explained.

When cholesterol gets into the digestive system, most of it comes from the liver, not from the diet, Carr said. The liver releases the cholesterol into the digestive tract so it can be excreted from the body. Figuring out how to promote the liver cholesterol to get into the digestive tract so it gets out of the body has been the challenge, he said.

“Drug companies have spent billions of dollars to try and figure out how to do that with a drug. We prefer the food approach, which is to identify which foods we consume that can latch onto the cholesterol and prevent it from being reabsorbed back into the body so it can be excreted,” he explained. “The events that happen in the digestive tract have been the focus of our research.”

The foods that latch onto the cholesterol are plant-based foods; foods that are rich in vital chemicals that have a similarity to cholesterol, he said.

“When chemicals are alike, they tend to associate with each other and so when we eat our fruits and vegetables like we should, we're not only adding all the vitamins and antioxidants and all the great things that can promote health, we're also allowing cholesterol to be excreted from the body and that allows our blood cholesterol to go down,” Carr said.



Tim Carr

KEEPING CONSUMERS SAFE

focus of the Food Allergy Research and Resource Program

by Mary Garbacz



“Sustainability in a food allergy realm enables the food industry to be able to sustain the food safety aspect of their processes, technology and training to sustain the safety of the allergic consumer.”

—Joe Baumert, Assistant Professor, UNL Department of Food Science and Technology and Co-Director, Food Allergy Research and Resource Program

PEANUTS. EGGS. MILK. FISH. Crustacean shellfish. Tree nuts. Soy. Wheat. These are known as the “Big 8” allergens. People who have food allergies already know that it can be dangerous — even fatal — to come into contact with a food that causes an allergic reaction. They may not know that University of Nebraska–Lincoln researchers are using the latest technologies to make the world safer for them through advancements in allergen controls and sanitation practices in processing facilities; development of sensitive detection methods; and identification and characterization of new allergenic proteins.

Food allergies continue to be an area of public health and food safety concern. In fact, an estimated 5 percent of the world population is thought to suffer from food allergies, affecting infants and children at an even higher rate.

Joe Baumert is a UNL assistant professor in the Department of Food Science and Technology and is co-director of the Food Allergy Research and Resource Program (FARRP). FARRP was founded in 1995 by the

late Sue Hefle, UNL associate professor of food science and technology, and by fellow co-director Steve Taylor, UNL professor of food science and technology. Funding came from a group of about 10 food industries, with the mission of conducting research to advance the knowledge of food allergens and assisting with food allergy-related food safety issues. Food allergy research, Baumert said, requires funding and time. Unfortunately, he added, federal funding for research on more applied aspects of food allergen research was limited in 1995 and continues to be limited today. Food allergen research and management is costly, and no individual company could afford to fund the needed research alone; so the group formed and funded FARRP to collectively tackle this area of food safety concern. More than 80 food industries now contribute to funding the work of FARRP scientists, who are finding ways to contain allergens in food production facilities and extending research information to companies around the world. The U.S. Department of Agriculture also provides funding to study the improvement of allergy detection methods.

“The emphasis we have is really providing the food industry with the best tools and knowledge of control of food allergens so they can keep their consumers safe,” Baumert said.

Scientists in FARRP have three main missions: research, outreach and teaching. Baumert said the research focus may reflect a number of topics related to food allergens, in both basic and applied research. Outreach includes training that food industries can use immediately, as well as workshops and conferences. The teaching mission, Baumert said, involves a number of graduate students — both master’s-level and doctorate-level — who conduct research as well as introduce undergraduate students to food allergen research through the Undergraduate Creative Activities and Research Experiences (UCARE) program at UNL.

PROTEINS AS ALLERGENS

People who are allergic to foods generally are allergic to the proteins found in those foods, Baumert said. Research focuses on what makes these proteins allergenic by studying their biochemical structure, as well as detecting allergens in food products or on food contact surfaces found in the food industry.

“We’re trying to ensure that packaged food products are properly labeled and can be safely consumed by food allergic individuals,” Baumert said.

The research scientists in FARRP use an enzyme-linked immunosorbent assay technology, abbreviated ELISA, to very specifically detect proteins from allergenic sources. “We can monitor whether those allergens are present in a finished product that could be a concern for an allergic consumer, or whether that (food production) company has a sufficient cleaning protocol to remove those allergens,” Baumert said.

The ELISA technology has been in use for 10-15 years, but newer technolo-

gies hold promise as alternative or confirmatory methods that can complement the ELISA methods commonly used by the food industry. Mass spectrometry is finding its way into food allergy research, as an additional tool to characterize food allergens. It also can provide the quantitative data to better detect allergens in certain applications.

“We also are looking at the area of food allergen thresholds,” Baumert said. An allergen threshold is the minimum amount of specific proteins for an allergenic source an allergic person can consume before he or she has a reaction. Those thresholds could be used by food industry and regulators to help the allergic consumer with more specific labeling of foods.

FOOD ALLERGY OR FOOD INTOLERANCE?

Food allergy and food intolerance both fall into the realm of “adverse reactions to foods or food sensitivities,” Baumert said, but there are differences.

Food allergy involves the immune system and more specifically, the IgE antibodies (immunoglobulin E) in the body, which are a key part of the immune system’s response that causes an allergic reaction. Allergic reactions can include respiratory, gastrointestinal or skin reactions, depending on the allergen and the individual.



Joe Baumert

“The labeling system provides consumers with more accurate information about what allergens may be in the package, but unfortunately as the law was written, it also gave the food industry a ‘zero threshold’ standard to work toward.”
— Joe Baumert

“Food allergies aren’t that different from other allergies, like hay fever — they have the same type of immune response; however, the symptoms associated with food allergies can be more severe, even life-threatening,” Baumert said. Food allergy just happens to be the body viewing proteins as foreign to the body, and the body needs to attack to get rid of them. “It’s an immune response to get rid of those particular proteins,” he explained.

Food intolerance, Baumert said, can bring about an adverse response to ingestion of a particular food, but an immune response does not take place. “Lactose intolerance is an excellent example of a pretty prevalent intolerance that is seen throughout the world,” he said. A person who is intolerant of lactose — milk sugar — lacks enzymes to metabolize lactose. Reactions to food intolerance generally are not fatal, but can be uncomfortable.

LABELING

The Food Allergen Labeling Consumer Protection Act of 2004 (FALCPA) was enacted by the U.S. Congress, mandating that food products must have clear labeling of allergens. “For example, if you had something such as ‘casein’ listed on the label, milk-allergic individuals would not always know that was derived from a milk protein,” Baumert said. FALCPA requires the declaration of food allergens in common English terms so they are easy to identify by allergic consumers. The example of “casein” would require the declaration of “milk” on the packaged food label and alert milk-allergic consumers that the product contains a milk-derived ingredient (casein).

The labeling system provides consumers with more accurate information about what allergens may be in the package, but unfortunately as the law was written, it also gave the food industry a “zero threshold” standard to work toward, Baumert said. “Zero is a very low number that can never be proven with 100 percent certainty. If it’s derived from that particular allergen, it has to be labeled,” he said.

“What the FALCPA law does not dictate is how much cleaning the food industry must use to ensure safety,” he added. A completely risk-free product is operationally difficult to achieve, so labels can include advisory statements, such as those that state “may contain ...” or “processed in a facility ...” Such labels limit the amount of food choice that an allergic consumer has since they are widely used by the food industry today, Baumert said.

Baumert hopes the future holds a determination of a reasonable industry threshold or action level that can receive regulatory endorsement around the world. That reasonable threshold, Baumert believes, will be safe for the allergic consumer and achievable by food processing facilities. “We feel quite confident we have sufficient threshold data for the priority food allergens now,” he said. “Hopefully with the implementation of thresholds we can open up a lot more product choice for allergic consumers while providing safer food products.”

THE FUTURE

Allergy to peanut is prevalent and potent, Baumert said, so it is a main focus of FARRP research. Consumers hear about severe reactions and deaths through media reports, so peanut allergy likely is the most-publicized food allergy. However, research focuses on the entire range of food protein allergies.

Clinical researchers are looking for ways to cure food allergy, Baumert said, but current research appears that desensitization, rather than full tolerance can be achieved at the moment. Medical doctors specializing in food allergies are trying to build tolerance in allergic individuals by very slowly introducing peanut, milk or egg into the diet and desensitizing the allergic individual over time. Although full tolerance does not seem achievable at this point (an allergic consumer may not be able to freely eat an entire peanut butter sandwich), desensitization may build enough tolerance to the allergen so the individual could have a little less risk if he or she consumes a product that contains a trace of peanut, for example. ***This type of clinical work is in its experimental stages, and it is very important that the introduction of the offending allergenic food should only***

be done under the supervision of medical personnel who specialize in food allergy, with ready access to emergency care if needed.

COLLABORATIONS, CONTRIBUTIONS

Scientists in FARRP work with other researchers at the University of Nebraska–Lincoln in biochemistry and microbiology and in the Gut Function Initiative (GFI). The GFI collaboration studies gluten proteins which cause celiac disease, Baumert said.

In addition, FARRP scientists work with clinicians around the world — throughout the U.S., in Europe and in Australia. Baumert and Taylor are the only U.S. collaborators in a European Commission-funded framework project studying thresholds, risk assessment, management of allergies and detection of allergies in the food industry. The work of FARRP scientists is respected throughout the world, Baumert said.

Baumert and Taylor focus solely on the food industry, while colleague Rick Goodman looks at assessing safety of

biotechnology products. “Biotech and biotech crops are probably the safest crops in the world because they go through so many safety steps through the development process. By the time they get to production, they have been looked at many different ways,” Baumert said.

The FARRP organization includes Taylor, Baumert and Goodman as its three faculty members, as well as 11 graduate students and a laboratory staff of more than 20 individuals. FARRP laboratory technicians provide analytical services to food industries, including assessing the industry’s level of risk and analysis of raw ingredients and finished products, as well as helping the food industry with assessing cleaning protocols. Other FARRP staff members work with outreach, including training and workshops; coordinate research projects with clinical partners; or conduct basic or applied research that will help to further advance knowledge of food allergens, all of which directly help the food industry and have made the University of Nebraska internationally known for its expertise in food allergies, Baumert said.

INFO
bytes

If you or your child has a food allergy, you’ll need to be careful to avoid allergic triggers.

This means careful menu planning, avoiding cross-contamination and reading food labels for alternative ingredient names to make sure you are aware of any “hidden” triggers.



PARTNERING WITH TECHNOLOGY

for food safety

by Dan Moser/Mary Garbacz

Based on an interview by Emily Taylor



“All along the chain, everyone who handles food has the responsibility to ensure the safety of the product and if they can, improve it.”

—Harshavardhan Thippareddi, Professor, UNL Department of Food Science and Technology, and Extension Food Safety Specialist

FOOD SAFETY IS A DIVERSE FIELD, and includes chemistry, microbiology, engineering, meat science, veterinary science, food production, food processing and consumer education. Multidisciplinary scientific and industry partnerships, along with the newest technologies developed by the scientists, help ensure a safe food supply for the world.

It requires coordination, vigilance and communication.

“When somebody consumes a product that we make, as a food processor, we need to absolutely make sure that the product is safe, because we are affecting the lives of other people,” said Harshavardhan Thippareddi, University of Nebraska–Lincoln professor of food science and technology and Extension food safety specialist.

“All along the chain, everyone who handles food has the responsibility to ensure the safety of the product and if they can, improve it,” Thippareddi said.

The U.S. has one of the best food safety programs in the world, compared to other countries such as Canada, those in Europe and other developed countries, Thippareddi said — but it requires ongoing research, as well as the cooperation of producers, processors and consumers who prepare foods at home.

Nebraska, as a top producer of beef in the U.S., has benefited from research into safe beef production and processing. The U.S. has the best and the safest beef available anywhere in the world, Thippareddi said, adding that the food safety risk is very minimal when another country chooses to import products from the Midwest.

“The eventual goal — the long-term goal of our research — is to improve public health,” he said. “The short-term goal is to improve the safety of these specific products of economic importance to Nebraska and to processors and producers, and to make sure the food they produce is safe.”

EXTENSION/OUTREACH

Thippareddi assists food processors every day, offering input on improving processes and product safety. He also conducts workshops frequently, in Nebraska and around the world. Even though U.S. food safety is among the best, that is not true of some developing countries. That is especially important when those countries export food products to the U.S. Thippareddi often travels to those countries to conduct workshops so processes, testing and food safety requirements meet the food safety requirements of the U.S. so products being imported into the U.S. are not turned away at the U.S. port of entry due to quality issues, he said.

Thippareddi’s current work with the meat processing industry includes the scope of livestock production and

products. His work with the poultry and egg industry, for example, involves the egg processor, the shell processor and liquid egg and dried egg processors as they improve their processes and the safety of their products. “They consult with me on a daily basis, as does the beef industry here in Nebraska and across the U.S.,” he said.

The food industry in the U.S. and in other countries uses Hazard Analysis and Critical Control Points (HACCP), which is a system of preventive measures that can assure the safe production of food products. It is based on technical and scientific principles that ensure product safety from farm to table. HACCP can be applied to production, meat slaughter and processing, shipping and distribution, food service and in-home food preparation. The University of Nebraska–Lincoln holds HACCP workshops; visit <http://food.unl.edu/meatproducts/safety> for more information.

FOODBORNE ILLNESS: CAUSES

Several different pathogens, parasites and viruses cause foodborne illness outbreaks, Thippareddi said, but are largely controlled due to continued research and educational outreach to producers, processors and consumers. In order of the number of illnesses they cause, they are: *Salmonella*; *Escherichia coli* O157:H7 and six other types of Shiga toxin-producing *E. coli* (STEC); *Listeria monocytogenes*; *Clostridium perfringens*; and *Clostridium botulinum*.

Thippareddi and his colleagues not only study the characteristics of the foodborne pathogens, bacteria and viruses that cause foodborne illness and their behavior in foods, they also develop predictive models for use by industry and communicate this information to producers, processors and consumers.

SHIGA TOXIN-PRODUCING E. COLI (STEC) RESEARCH

Foodborne illness can be mild or quite serious. It also can mean the end of a food company. Thippareddi noted that in 1997, Hudson Foods, then a state-of-the-art company based in Columbus, Nebraska, had to recall 20 million pounds of ground beef — two months’ worth of product — because a sample of one day’s production tested positive for *E. coli* O157:H7. The company went bankrupt as a result.

“Assuring the safety of beef is very important, especially for Nebraska, as beef is a critical component of the

state economy — the production as well as the processing sides,” Thippareddi said.

Nebraska’s strength in beef production and processing led scientists from the University of Nebraska–Lincoln and 15 other educational institutions and food industries to apply for grant funding from the U.S. Department of Agriculture to study Shiga toxin-producing *Escherichia coli* (*E. coli*), or STEC. The group was awarded \$25 million in funding over a five-year time period; the researchers are now initiating the third year of research focused on controlling not only *E. coli* O157:H7, but also six other serotypes of STECs.

The STEC team’s research addresses the risk mitigation strategies, from production and processing to consumer handling of meat products, (Read about the researchers’ work at <http://www.stecbeefsafety.org>.)

Progress has been made in methods of detection of STEC organisms, Thippareddi said. Researchers discovered that methods being used were not adequately sensitive or specific, so they have developed new techniques to improve detection methods. The USDA Food Safety and Inspection Service (FSIS) has reported greater prevalence of STECs in veal cuts and ground veal. The research team has focused on developing interventions that can be used during veal slaughter and identified options for their use during processing. Those interventions already have been implemented in veal processing to reduce risk, he said.

“Some of the work we have done so far has been



Harshavardhan Thippareddi



CONSUMER RESPONSIBILITY FOR FOOD SAFETY

Consumers are responsible for the safe storage, handling and preparation and cooking of food products once they are purchased, Thippareddi said. Consumers can minimize the risk of foodborne illness by:

- ➔ Refrigerating meat, fish, eggs and produce immediately so pathogens don't have the opportunity to grow.
- ➔ Keeping fresh produce separate from raw meat, fish and eggs, including use of separate utensils and cutting boards.
- ➔ Cooking meat, fish and eggs to the correct temperatures; a good resource is: <http://www.foodsafety.gov/keep/charts/mintemp.html>. Even though the risk of *E. coli* is very low, cooking it to an internal temperature of 160° F can destroy the organism if it happens to be present.
- ➔ Sensitive populations, like children, pregnant women, the elderly and those with compromised immune systems may wish to take extra care, as foodborne illness risks are greater for these individuals.

instrumental in providing input to regulatory agencies like the U.S. Department of Agriculture's Food Safety Inspection Service," he said. "The publications that we have generated are used by several of the food industry food processors and are a basis for their food safety management system or food safety plan development — and assuring the safety of the food products," Thippareddi explained.

"We need to continue research, we need to continue to develop programs so we can reduce the prevalence of the STECs in the beef supply," he said. The research will continue and the methods will improve, including adding a food safety curriculum for children from kindergarten through high school, as well as in higher education. "We want to disseminate this information through educational activities as well as extension activities," he said.

"If I, as a consumer, don't consider those risks and don't understand those risks, I can mishandle the products and cause a foodborne illness," Thippareddi said.

"We try to put that (responsibility) on the processor, but I think we also need to understand that as a consumer we have that responsibility as well. I am the one feeding myself and my family, so I need to be careful about how I handle the product, how I cook the product and how I serve the product," he said.

THE SUSTAINABLE, GLOBAL FUTURE

The need for feeding more than 9 billion people by 2050 requires careful management of water and other resources, but there are other needs as well.

"We need to improve our ability to properly store, handle, and process and prepare these products," Thippareddi said. Products will have to be stored for extended periods of time in the future, so it will be necessary to ensure they are safe at the point of consumption.

If you look at the U.S. compared to the rest of the world, the number of people getting sick from foodborne illness in the U.S. is relatively small, Thippareddi said. That shows the industry is doing an excellent job in ensuring a safe product, but at the same time, researchers, producers and industry must continue to work to make products continually safer.

"There's always room for improvement," he said.

INFO bytes

E. coli O157:H7 is one of many of kinds of the bacterium *Escherichia coli*.

Although most types of *E. coli* are harmless and live in the intestines (guts) of healthy humans and animals, the O157:H7 type produces a powerful toxin that can cause severe illness.

REGULATING ALLERGENS

in genetically engineered foods

by Kristi Block



“We use simple scientific principles to evaluate food safety of things like genetically modified crops.”

—Richard Goodman, Research Professor, Food Allergy Research and Resource Program, UNL Department of Food Science and Technology

SPECIFIC PROTEINS are the major cause of food allergies that affect 2 to 8 percent of the world population. Food allergies range from mild to severe in susceptible individuals, causing reactions from mild skin rashes to death. The most common allergenic foods are peanuts, tree nuts and shellfish.

Developing methods to screen for proteins with the potential to cause allergic reactions for people with food allergies is important to the development of genetically engineered foods and to the health and safety of consumers.

Richard Goodman is a research professor in the Food Allergy Research and Resource Program (FARRP) at the University of Nebraska–Lincoln. Goodman’s work focuses on food safety as it relates to allergens, as well as building research processes for regulators to assure the United States’ food supply is safe for people with food allergies.

An allergy is an inappropriate immune response that causes someone to become sick after eating, touching or breathing something that is harmless to most people, Goodman said. An allergen is a substance, usually a protein, present in a plant (such as pollen) or animal (milk, egg, fish) that induces an allergy, he explained.

Goodman studies foods that cause allergies, develops testing methods for potential allergens, tests foods provided by food companies for allergens, studies cross-reactivity of similar proteins and updates an allergen database of known allergens for developers of genetically engineered foods.

The question needing to be answered, Goodman said, is “What are the potential risks of proteins that would be

produced by a new genetically engineered crop?” For all proteins, researchers consider whether the protein is a toxin or an allergen, he said. If there are reasons to believe that an allergen or toxin could have been introduced in the development process, then both the developer and the scientist would be asked by regulatory agencies to conduct specific tests to evaluate whether that was true, Goodman added.

If the new protein is an enzyme, Goodman and his fellow researchers would determine whether there could be safety issues for new substances made by the enzyme.

Novel genes that have been introduced in genetically engineered crops are genes that are already present in some organisms in the environment. The function of the protein is already understood.

The gene is added into a plant that has thousands of genes. And it is tested to ensure it functions correctly, Goodman said.

EVALUATING POTENTIAL ALLERGENS

The allergy evaluation process has been improved in accuracy. “It’s evolved in accuracy as we have learned more about allergy in the past 15 years and that allows us to focus on realistic risks of food allergy from commonly consumed foods,” Goodman said.

His research focuses on the risks related to food allergy. “We consider the source of the gene, the sequence of the protein produced by that gene, and if there are other things that would lead you [us] to suspect the protein is going to cause allergies,” Goodman added.

Several methods are used to determine the risk of an allergen. One method is the digestibility of a given protein in pepsin, which is a digestive enzyme. “There is a rough correlation between the stability of proteins in pepsin and the likelihood they would be a food allergen,” Goodman said.

ALLERGENONLINE.ORG

The Food Allergy Research and Resource Program established an online allergen database used in the risk assessment of genetically engineered crops and in the development of novel protein ingredients in foods, Goodman said.

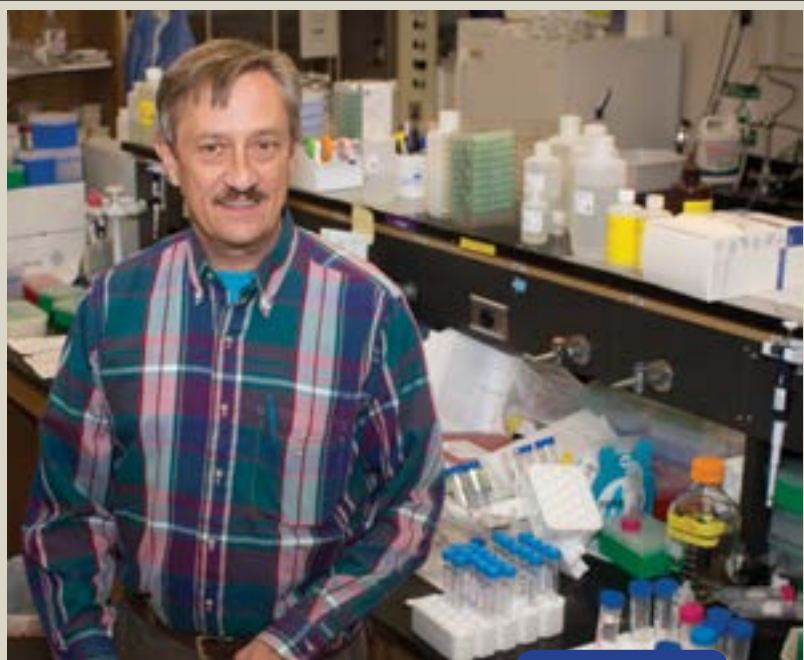
“The (AllergenOnline) database is reviewed by an international panel of allergy experts who look at the sequences of proteins that scientists may claim are allergens and evaluate the published information that says this given protein is really an allergen,” Goodman said.

The database is updated yearly. Scientists who work in large biotechnology companies, researchers, and others can search the database for a gene being considered for use in the development of a genetically engineered crop and compare the similarity of that gene to known allergens, Goodman said. If the gene is similar to a known allergen, it will not be used, he added.

REGULATIONS TO PREVENT ALLERGENS

In 1992, the U.S. Food and Drug Administration (FDA) established guidelines — not laws — that outline the tests that should be done on new products before the developer presents the new product to the FDA for approval. It is a voluntary pre-market approval process, Goodman said. Before the new product’s regulatory information is passed on to the FDA, the developer can show the FDA the tests that will be conducted based on the guidelines, and ask if the FDA believes additional testing is required. Developers of genetically engineered plants know the FDA will require data to approve the safety of the genetically engineered crop. If this process is not followed, Goodman said, the FDA can force a recall of all products related to that crop. A recall can cost millions of dollars, Goodman added.

On an international level, the CODEX Alimentarius Commission was established as a body within the United Nations, bridging the Food and Agricultural Organization and the World Health Organization, and



Richard Goodman

charged with developing guidelines for food safety, Goodman said. A group of internationally recognized scientists viewed as experts in the areas of allergy and toxicology developed the guidelines for an international food safety evaluation process, with adoption in 2003. A common set of guidelines has assisted international food trade. Each country may have its own laws regarding food safety evaluations, but the CODEX provides a more uniform international guideline. This has been important for the growth of biotechnology and genetic engineering, Goodman explained.

FUNDING

Goodman’s research is funded by major biotechnology companies, the United States Environmental Protection Agency (EPA), the Grand Challenge 9 initiative from the Gates Foundation and USAID, and the USDA Foreign Agricultural Service Borlaug program.

DEFINITIONS:

Allergy — an inappropriate response that causes someone to become sick after eating, touching, or breathing something that is harmless to most people.

Allergen — a substance, usually a protein, present in a plant (such as pollen) or animal (milk, egg, fish) that induces allergy.

EVERY HUMAN IS BORN with a sterile gastrointestinal (GI) tract, according to Andrew Benson, professor in the Department of Food Science and Technology at the University of Nebraska–Lincoln, but the GI tract soon becomes colonized by complex groups of organisms. Abnormalities can be produced in this growth and can make people susceptible to specific diseases. Benson is working with a team of scientists to study gut function with the ultimate goal of changing unhealthy assemblies of microorganisms to benefit human health.

People in developing countries have different GI tract development than those in developed countries like the United States, Benson said. People who live in developed countries show higher incidences of diseases like obesity, heart disease and inflammatory bowel disease. By understanding these diseases, Benson's team will develop strategies that can affect people not only in the U.S., but around the world.

"Organisms outnumber you. You're 90 percent microbes. There's a lot of interest in this area right now. I think there's going to be a lot of potential for... health applications to animal health and productivity and food production," Benson said.

Therapeutic foods, or foods that can benefit health, are likely to result from the Gut Function Initiative research team.

The team includes microbiologists, immunologists, nutrition scientists, nutritionists, biometricians, statisticians, computational scientists, animal geneticists and veterinary

microbiologists. Their research discoveries will ultimately allow them to develop foods that could benefit health and in some cases be considered a therapeutic type of food. Benson expects to develop diets that will lead to healthy assemblages and the healthy functions of the microbiome in the GI tract.

UNDERSTANDING THE GUT

The scientists approach the research from three different angles: discovery of microbial factors; host factors; and the dietary influences.

On the microbial side, *Lactobacillus reuteri*, which is related to *Lactobacillus* species used to produce cheese and yogurt as well as silage, is one organism that has been dissected down to the molecular level to identify its main components that allow it to colonize the GI tract of different types of animals, Benson said.

"It is a species that has some populations that are host adapted, meaning that they prefer to replicate in one host animal versus another and we have learned what genes contribute to that host adaption process," Benson said.

This process was carried out to understand *Lactobacillus*' genes and how those genes promote adaptation in a specific animal.

On the body side, Benson's team has learned that the human genetic makeup contributes to shaping the composition of the microbiome, or the collective types and functions of the microorganisms in the system. "The organisms that can actually colonize your body depend in part upon your individual genetic makeup," Benson said.

The diet can also interact with body genetics. "Dietary manipulation can potentially overcome some of the effects of host genetics," Benson added. Human genetics may have an indirect effect on diseases, he said. For instance, if a person is more prone to developing inflammatory bowel disease, it could be in part related to his or her genetic susceptibility to abnormal colonization in the GI tract, Benson said.

With dietary changes, the team has been able to see that detectable changes in the microbiome can occur when one single compound is introduced to the diet. These are compounds that specific groups of organisms can consume in the GI tract, but a person's tissue cannot consume. Something as simple as crackers can be used to introduce one type of compound into the diet, Benson said. Doing that could significantly change the microbiota composition in a person for a short term, he added.

CHANGING AGRICULTURE AND FOOD PRODUCTION

"We want to have the agriculture production community gather around us taking some of the discoveries that we have and incorporate that into their production systems," he added. Understanding the microorganisms of plants and animals is on the horizon. Discovering how to manipulate plants to have an increase or decrease of a specific compound might be in the future as well, and both of these have the potential to impact production.

Technology is an asset to the Gut Function Initiative team. The technology is used to count all the microorganisms in the GI tract. Technology also can be used in the food production industry. Benson sees an understanding of the microbiome of the food production system as important because it contributes to food quality and it can be used as a signature of safety characteristics.

WHERE IT BEGINS

The first stage of the research is to understand how the microorganisms assemble. "We are still at the stage of trying to define the process itself," Benson said. "We are trying to understand what governs the assembly process, what governs it in normal situations and what goes wrong that leads to these abnormal assemblages," he added. One current study revolves around using diet to change the composition and function of the microbiota, which refers to the names of all microorganisms in the system, and it has proven to be somewhat effective.

"In the next decade or two you're going to see much more sophisticated approaches involving the diet that are

being implemented to really control either assembly of this microbiota or function once it has assembled," Benson said.

Changing the microbiota assemblages will benefit human health by preventing abnormal assemblages that can lead to specific diseases.

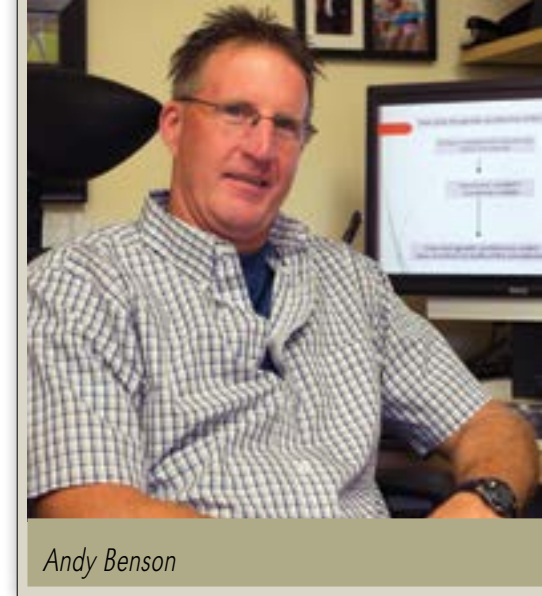
After establishing how the system works, Benson and the rest of the Gut Function Initiative team will study ways to change the assembly of microorganisms to introduce a specific compound in the diet that would influence just one single species of organisms. When important components of the ecosystem of the gut are influenced, it will cause the entire ecosystem to completely reconfigure, Benson said.

The group currently understands what organisms are present in the GI tract. With this information, they know what some of these organisms like to eat. Therefore, the group can distinguish the needs of specific organisms and use that knowledge to increase or decrease the quantity of a certain groups of organisms.

NEAR AND LONG-TERM GOALS

The Gut Function Initiative team's near-term goals are to define the GI system and understand how it functions and how it is put together and operates. Benson expects these goals to be accomplished in the next two decades. The long-term goal is to manipulate the GI system so no abnormalities occur when microorganisms assemble. Another goal is to develop new foods with specific traits that could encourage or discourage a specific group of microorganisms in the GI tract.

The Gut Function Initiative team also is analyzing livestock research to reduce pathogens in the animals' gastrointestinal system, resulting in a safer food supply. Foodborne pathogens that cause large illness outbreaks settle within livestock GI systems. The pathogens do not negatively affect the animals. These pathogens can cause problems in humans, Benson said. The team is looking for ways they can use the genetics of animals to reduce the amount of pathogens carried in the animal's GI tract. By doing this it will reduce the occurrence of foodborne illness in humans, he added.



Andy Benson

UNDERSTANDING THE GI TRACT

to counteract diseases

by Mollie Wilken



"How can we produce new foods that would be beneficial to health and, in some specific cases, even be considered a therapeutic kind of food?"

—Andy Benson, Professor, UNL Department of Food Science and Technology, W.W. Marshall Distinguished Professor of Biotechnology



GRAIN QUALITY, FIBER BENEFIT HUMAN HEALTH

“functional foods” may prevent disease

by Alex Wach



“My goals are to put forth evidence that whole grains and dietary fibers are really important to consume.”

—Devin Rose, Assistant Professor, UNL Department of Food Science and Technology

IT IS HARD TO CONVINCE PEOPLE that what they eat really does affect their health, especially when the science is so complex. But according to Devin Rose, assistant professor of food science and technology at the University of Nebraska–Lincoln, eating the right amount of dietary fiber means that people may

be less likely to develop Type 2 diabetes, colon cancer or cardiovascular disease.

“We are discovering new things every day,” Rose said.

Rose said his research focuses on developing grains that maintain the functionality that the food industry and its



Devin Rose

consumers need, while delivering products that consumers like and are good for them. Rose also studies the effect of grains on the gastrointestinal tract, or “gut,” where food is digested and absorbed.

“These carbohydrates can be digestible, like starch, or indigestible, like the dietary fibers. Our projects mostly involve how to make starch less digestible by our digestive enzymes and how to make dietary fibers more fermentable by our gut bacteria,” Rose said.

Making starch less digestible means that it will have less of an impact on blood glucose for diseases such as Type 2 diabetes. It could also mean products with fewer calories.

Making dietary fibers more fermentable “would better support the growth of beneficial bacteria in the gut at the expense of those that might cause us harm,” Rose said.

Rose oversees two laboratories at UNL. One lab focuses on whole grains and health, and the other lab receives grains and evaluates them for chemical composition and end-use quality. End-use quality means how well the grain will perform in its end use application, such as a loaf of bread.

EATING RIGHT FOR LONG-TERM BENEFITS

Through his research, Rose stresses the importance of whole grains and dietary fiber in the diet. The recommendation for dietary fiber is around 30 grams per day, but most people only eat around 15, Rose said.

“It is hard to convince people that it is important to do this because they do not feel like they are sick. I think the long-term effects are that you get things like Type 2 diabetes, colon cancer, or other associated diet-related diseases,” Rose said. “It is always hard to convince anybody to do something now that is going to affect them in 20 years, but that is really what it is with dietary fiber.”

Rose said research is moving toward isolated dietary fibers and purified dietary fibers that gut bacteria are able to ferment quickly and easily. He hopes to convince people that it is not necessarily the fibers that are rapidly used by the bacteria that we really need to be consuming.

“It is important for us to continually consume these naturally occurring fibers in order to maintain the gut bacteria that we want, and to have them produce metabolites that are beneficial to us,” Rose said.

Rose said technology in the food science industry has evolved dramatically. Down the aisles of a grocery store, whole grains can be found in bread, breakfast cereals, crackers and snack foods.

“If you are thinking about 30 years ago, it was pretty strange to consume whole wheat bread, whereas today it is fairly common,” Rose said. “I think food companies are really grasping onto this with their ability to put whole grain on the label, and consumers like to see that.”

Although whole grains are included in more and more products, whole grains become rancid more quickly than typical refined grains, affecting a product’s shelf life. Rose said rancidity is a development of off flavors due to a breakdown of lipids, which causes chemical reactions that release flavor compounds that are different than normal.

“Rancidity is not a safety issue, but is actually more of a flavor and nutritional issue,” Rose said. “In the process of the lipids breaking down, they can react with some of the more unstable vitamins.”

Rose addresses those challenges in his research, studying ways to improve the shelf life of whole grains.

FOOD RESEARCH HAS NATIONAL, INTERNATIONAL IMPACT

Food science research also has a national and global impact. Rose publishes his research and attends conferences globally to explain the importance of a diet rich in dietary fibers and whole grains, especially as the population is expected to increase to more than 9 billion by 2050.

“The population relies so much on grains. If we can make a little bit of improvement, whether it is making a better tasting whole grain product, or a product that has more slowly digestible starch, then we will have a huge impact on human health. Improving a staple food, like wheat, has potential to improve health dramatically, if only because people consume so much of it,” Rose said.

Conducting his research at the University of Nebraska–Lincoln has allowed Rose the opportunity to work with plant scientists in addition to other food scientists. His goal is to uncover interactions focusing on how the dietary fibers in whole grain interact with gut bacteria and how they impact health. In turn, he can make recommendations and work with plant breeders and food engineers to develop grain-based foods that will capitalize on the beneficial aspects of these interactions.

WHY STUDY THE HUMAN GUT?

we have 100 trillion good reasons

by Kristi Block



“There’s a lot of evidence that the microbes that reside in the gastrointestinal tract, called the gastrointestinal microbiota, have a link to health, and to diseases such as inflammatory bowel disease, obesity and metabolic syndrome.”

—Amanda Ramer-Tait, Assistant Professor, UNL Department of Food Science and Technology

WHEN MOST OF US THINK ABOUT THE CELLS that make up the human body, we imagine muscle cells, red blood cells, and maybe neurons. However, researchers at the University of Nebraska–Lincoln are also seeing trillions of cells that are microbial. These microbes are known collectively as the human microbiota, and scientists now understand that they play an important role in human health.

“The human gastrointestinal tract is one of the densest ecosystems in the world,” said Amanda Ramer-Tait, assistant professor in the UNL Department of Food Science and Technology. “There are up to one trillion microbes in every milliliter of contents in the large intestine.”

The gut microbiota performs many functions, including extracting energy and nutrients from food. “It also protects us from pathogens and helps train our immune system,” she said. Scientists also have learned that the gut microbiota has a tremendous impact on human metabolism. Changes in the composition of the gut microbiota have been linked to chronic inflammatory diseases including Crohn’s disease and ulcerative colitis, and to chronic lifestyle diseases such as obesity and metabolic syndrome, which can raise the risk for heart disease, stroke and Type 2 diabetes. As an immunologist, Ramer-Tait researches the dynamic relationship between gut microbes, the immune system, and development of these complex diseases.

“The trillions of microbes in our gastrointestinal tract have tremendous genetic potential and a wide range of metabolic functions that can significantly impact human health,” Ramer-Tait said. “We should really consider our microbiota as another organ in our body with its own unique purpose.”

UNL GUT FUNCTION INITIATIVE

Ramer-Tait works in collaboration with other UNL researchers in the Gut Function Initiative, which is comprised of scientists whose collective goal is to understand how gut microbes affect human and animal health. Funding from the National Institutes of Health, the U.S. Department of Agriculture, foundations, industry, commodity boards and UNL’s Institute of Agriculture and Natural Resources (IANR) supports the work of the faculty, staff and students of the Gut Function Initiative. “We use tools from biology, computer science and food science to answer fundamental questions: How does the immune system respond to gut microbes? How do food ingredients influence the gut microbiota?” Ramer-Tait said. “Ultimately, we want to know how can diet be used to improve health and reduce disease in animals and humans.”

The UNL researchers have learned that while there is a core human gut microbiota, there also are microbes that are unique to individuals. This observation has led to the concept of personalized nutrition. “If you understand someone’s microbiota as well as his or her genetic background,

then you may be able to take those pieces of information and design a dietary intervention that is uniquely suited to help keep an individual healthy,” Ramer-Tait said.

THE SCIENCE OF DIET CHANGES AND HEALTH

“The human diet consists of foods rich in complex carbohydrates such as fiber that we cannot digest on our own — we depend on gut microbes to do the work for us,” she said. Current research suggests a diet rich in these complex carbohydrates, known as prebiotic fibers, can increase the numbers of beneficial bacteria in the gut.

“The point of prebiotics is to increase the numbers of the ‘good guys’ already present in our gut,” Ramer-Tait said. Whole grains from corn and wheat, as well as fruits and vegetables, are especially good sources of these prebiotic fibers, she said. Because these fibers are not readily absorbed in the small intestine, they travel to the colon where most of the gut microbes are located. The microbial partners then successfully break down these fibers, use them as a fuel source, and produce molecules that provide health benefits to the human body.

Fiber has long been considered a key component of a healthy diet, but Ramer-Tait and other Gut Function Initiative investigators are discovering new benefits of eating

prebiotic fibers. “One example of a prebiotic fiber is resistant starch, found naturally in wheat, corn and other foods. Our current research shows that resistant starches improve metabolic health by strengthening immunity,” Ramer-Tait explained. Her laboratory is focusing on exploring exactly how these prebiotic fibers interact with gut microbes and the immune system to keep humans healthy.

The emphasis of the Gut Function Initiative is truly a “food for health” concept, Ramer-Tait said.

“If we are able to understand how diet can modulate the gastrointestinal microbiota, how it can impact our immune system, and what benefits it can have on our health, then we can eventually design dietary strategies to improve the lives of Nebraskans and individuals around the world,” she added.

FUNDING

Ramer-Tait’s research is funded by the University of Nebraska–Lincoln, the UNL IANR Agricultural Research Division (ARD), the UNL Office of Research and Economic Development, the Nebraska Corn Board, and the Crohn’s and Colitis Foundation of America.



Amanda Ramer-Tait

“The ultimate goal for my research is to ensure the food supply is safe. Besides that, we would like to use risk assessment to facilitate a sustainable agricultural food production. This means that in addition to food safety, we would like to ensure the health of the food production system and also to respect the people in the community who are involved in the production system — to encourage innovation, to optimize production and to reduce waste.”

—Bing Wang, Assistant Professor, UNL Department of Food Science and Technology



Bing Wang

A SAFE FOOD SUPPLY doesn't just happen — it involves people who are experts in the sciences, like microbiology, toxicology, chemistry, nutrition, food science, animal science, engineering, veterinary medicine and other disciplines — working together in all areas of the food supply chain.

One of those scientists is Bing Wang, who began her work at the University of Nebraska–Lincoln in January 2014 as an assistant professor of food safety risk assessment in the UNL Department of Food Science and Technology.

Wang earned a bachelor's degree in veterinary medicine and a master's degree in veterinary pharmacology and toxicology in China and a doctorate in veterinary microbiology at Iowa State University. Her role at UNL is assessing public health risks associated with the food supply, using a quantitative risk assessment approach, which can provide independent, science-based evidence to inform food safety management options for regulatory agencies, food industry and consumers.

“I think the ultimate goal is to use risk assessment to advance food safety management systems to supply safe food,” Wang said. The hazardous agents that food safety risk assessment usually deals with can include microbiological organisms, veterinary drug residues, food allergens, herbicides and pesticides. It also can involve assessment of a variety of foods, such as cereal grains and fresh produce, as well as beef, pork and poultry.

Risk assessment is an “applied” science, Wang said; it is science that can be used in practical ways. Risk assessment can be a tool used by the government to make a policy decision, or by a food industry to decide where there can be improvements in the system.

THE ULTIMATE GOAL: make food safe

by Mary Garbacz



“Take the beef supply chain for example, in the farm-to-fork continuum,” she said. “There are ‘critical control points’ at which improvements can be made after assessing risks.” A critical control point can be in a crop field, a feedlot, a processing facility, a restaurant — or a storage or preparation area in a home kitchen. Food safety can be affected at any point, and Wang uses a systems approach to determine where and how to intervene with strategies to mitigate risks.

ACTIVELY DEVELOPING TECHNOLOGY

Risk assessment is an evolving technology; assessing public health risks began in the 1950s with chemical carcinogens, then with microbial risk assessment in the 1990s. It has evolved into inclusion of more disciplines, as well as the quantitative assessments Wang uses.

“Very often, the big issue with risk assessment is the lack of data,” she said. Advanced computers and mathematics now allow Wang to interpret the data more precisely and accurately that will move forward the field of risk assessment.

“We use mathematical modeling as a way to describe the transmission of foodborne pathogens, or the change in behavior of foodborne pathogens in the food chain,” she said. If you were to build a model of this from the “farm-to-fork” continuum and enter inputs of various kinds, those input values can be affected by different intervention strategies and will change the final estimate of the human health risks, Wang said. The main products of risk assessment are identifying the points at which there will be the greatest impact on human health and evaluating the individual or combination of interventions in reducing potential public health risks due to food consumption.

CONSUMER RESPONSIBILITY FOR FOOD SAFETY

Risk assessment is comparing all the different interventions and stages, Wang said. Every person at every step in the food supply chain can contribute to reduce foodborne pathogen contamination, she said. The area that often has a great impact is the consumer side, she added.

Consumers do not need to understand the mathematical modeling, but can learn from the information that comes from risk assessment. For example, if the risk assessment indicates the storage temperature is important to reduce pathogen contamination that could lead to foodborne illness, a consumer would know to refrigerate foods promptly and at the correct temperature. If the risk assess-

ment indicates that cross-contamination is problem, the consumer would know that a cutting board and utensils used to cut raw foods should be kept separate from cooked foods and washed thoroughly after use. “This indicates hygiene practices for consumers,” Wang said.

In addition to hygiene in the home kitchen, there are recommended cooking temperatures for all meat, fish, poultry and egg products. The U.S. Food and Drug Administration (FDA) recommends cooking ground beef and pork to an internal temperature of 160° F; fresh beef and pork to 145° F; and chicken and turkey to 165° F. The complete FDA Safe Cooking Temperatures chart is available at: <http://www.fda.gov/downloads/Food/FoodborneIllnessContaminants/UCM260394.pdf>

“Every person at every step in the food supply chain can contribute to reduce foodborne pathogen contamination.”

— Bing Wang

EXTENSION/OUTREACH

Wang not only conducts risk assessment research; she also provides risk assessment information to consumers and to the food industry. The future holds workshops and online certificate programs that will extend food safety research internationally. The UNL Department of Food Science and Technology faculty and staff can provide the information in several languages, she said, including Chinese and Spanish.

FUNDING

Wang's work is funded by the U.S. Department of Agriculture and food commodity associations, such as the National Pork Board and the National Cattlemen's Beef Association.

PLANT science

"We can say with absolute certainty that the products on the market today through biotechnology are as safe or safer than any of the commodities ever delivered, because none have been put through such rigorous safety assessment."

*Thomas Clemente
Professor, Agronomy and Horticulture
University of Nebraska-Lincoln*



THE ROLE OF GENETIC ENGINEERING in feeding the world

by Kristi Block



“Genetic modification is any way that you change a gene’s composition. That means plant breeding. It also means I might irradiate a plant — we do that often with gamma radiation to create mutations, then look at the mutations and choose something good, like your ruby red grapefruit.”

—Sally Mackenzie, Ralph and Alice Raikes Professor
of Plant Science, UNL Department of Agronomy and
Horticulture, School of Biological Sciences

GENETIC ENGINEERING OF CROPS, proven safe and effective in 15 years of use, must be a factor in feeding the world’s growing population, said University of Nebraska–Lincoln plant scientist Sally Mackenzie.

“Over the next 30 years we’re going to be almost 9 billion on this planet, and we’ve never been 9 billion before...,” said Mackenzie, the Ralph and Alice Raikes Professor in UNL’s Department of Agronomy and Horticulture. “And to be really honest, the plant science community has no idea how we are going to cope. We don’t have enough food, and we don’t even have enough arable land and, more importantly, we don’t even have the technologies in place that if we did have those things we’d know how to cope.”

INTERNATIONALLY WORKING TOGETHER

In 2013, the international plant science community developed five unified goals to be accomplished in 10

years, which were published as “Unleashing a Decade of Innovation in Plant Science: A Vision for 2015-2025.” The goals focus on training future generations of plant scientists in addition to identifying and understanding plant traits to create solutions that could address future problems in crop and food production. With proper targeting of federal research funding, Mackenzie said these goals are achievable.

Mackenzie’s plant science research will be important to fulfill the report’s goals. Following the genome sequencing projects in humans, plants and animals, scientists have learned that organisms are not simply a collection of their genes, but how those genes are expressed. This revelation has led to the field of epigenetics, which involves the discovery of DNA modifications that affect gene expression during an organism’s development and in response to its environment.

In agricultural genetics, Mackenzie’s group studies ways to influence the epigenetic behavior of crop plants to learn how plants adapt to their environment. This research is especially important as agricultural systems adjust to cope with climate change.

USING TRANSGENIC TECHNOLOGY

“A human and a chimp actually share about 98 percent similarity in their genes and yet look very different. The difference isn’t in their genes, per se. The difference is in the way organisms express those genes. Same with plants — we call that expression control system epigenetics.”

She describes this process as “fooling” the plant using transgenic technology. Transgenic technology is “when we take foreign DNA [DNA not originally from that plant], clone it in a laboratory and introduce it using relatively natural technologies into the cell of a plant and have it expressed there,” said Mackenzie. Transgenes help fool the plant into thinking it’s in a situation it might encounter in the field, such as being stressed from lack of water. The transgene is designed to allow for the down regulation of a gene that is normally expressed in the plant. The transgene allows for the original gene to be artificially shut off.

Then, Mackenzie can remove the transgene through normal segregation. It “involves just watching a trait segregate those that have it and those that don’t. You know a mother and father with blue eyes — some kids have it, some kids don’t. You’re just looking at natural segregation,” Mackenzie explained.

“Realistically, something’s got to change, and that is public opinion. The public needs to understand that on the one hand, ‘I’d like to eat organic and not GM,’ but on the other hand, you’re looking at 9 billion (population) and you’re looking at climate change. Do the math. You know something has to change here.”

— Sally Mackenzie

After natural segregation, she picks out the plants that still have the stress trait present in them, but no longer have the transgene in the DNA. Commercial application of this technology will involve developing improved crops that have no foreign DNA in the food product. Her research allows for her to change “the way a plant expresses its genes without actually changing the gene itself.”

Although transgenic technology is used to start the process of epigenetic change, by the time the selection process is completed, the plants are improved but no longer possess the transgene. This approach is approved as a non-transgenic technology, which might make it more accepted in areas where genetically engineered foods are met with consumer skepticism.

COMMERCIAL APPLICATION DEPENDS ON CONSUMERS

Mackenzie hopes to see the technologies scientists are developing find commercial application.

“That’s the goal, because that really means the scientific process has succeeded in having a direct impact on



Sally Mackenzie

agriculture. It's great to make a discovery, but not if it sits on a shelf." This research could lead to increased crop yields, enhanced heat tolerance, and enhanced drought tolerance. Consumers could also benefit from additional emerging genetic engineering and transgenic technologies, Mackenzie said.

In 15 years of use, Mackenzie said, genetically engineered foods have caused no health problems. "So at some point you've got to recognize that the risk assessment has been done, and with a productive technology out there for 15 years — eaten by 90 percent of your consumers with not a single adverse health effect — maybe we need to think about being more accepting of this technology and making it a little more affordable."

Some of the problems that could be alleviated by genetic engineering include peanut and wheat allergies. Food scientists could genetically modify the proteins that cause allergies, but "the peanut and wheat industries feel that there would not be consumer acceptance," Mackenzie said. "Is that really sensible?"

Consumer misconceptions about genetic engineering are frustrating, Mackenzie said. Consumer acceptance of genetic engineering will be important if plant scientists are to achieve their collective goals of helping to feed the world's growing population.

Consumer perceptions also play a role in government decisions about research funding. "In terms of technology, there really are no insurmountable challenges. The real challenges are in public acceptance. If people don't accept the technology, they won't want their governments to fund the technology, which means research won't be done, which means that our food supply will be extremely vulnerable to climate changes," Mackenzie said.

In the United States, there are three primary genetically engineered traits on the market. "One is an insect tolerance, one is an herbicide tolerance, and one is a drought tolerance, and when it comes to the kinds of technologies we will need in the future, those are not adequate," Mackenzie said.

The United States used to be the world's leader in agricultural research, but other countries have begun to invest more, Mackenzie said. "China is making major investment in transgenic technology. The U.S. will have to prepare itself to be second, third or fourth in line. The most advanced technologies won't belong to us. They will belong to another country, and whether or not they share them (transgenic technologies) with us will be something we'll see for the future," Mackenzie said.

THE UNIVERSITY'S ROLE

Here at the university, "our job is to stay on the cutting edge. We have to be able to foresee both challenges and opportunities before any of our growers know them, and we have to be prepared to warn them and advise them and to support them with the technologies they will need. The agricultural community needs to understand what technologies are on the horizon and what challenges they might face in adopting those technologies, and they need to be given the capability to stay commercially and economically competitive as a business entity for this state. We sustain our economy through agriculture," said Mackenzie.

Modern genetic technologies, properly deployed, can help agronomists and farmers make huge strides in feeding the world's growing population.

FUNDING

Mackenzie's research is funded by the Department of Energy's Energy Biosciences Panel and the Bill and Melinda Gates Foundation.

INFO
bytes

Of the roughly 1,763 pounds of grain consumed per person each year in the United States, about 220 pounds is eaten directly as bread, pasta, and breakfast cereals.

The bulk of the grain is consumed indirectly in the form of livestock and poultry products.



ADVANCES IN SMALL GRAIN BREEDING are helping to feed the world

by Mollie Wilken



“Over 2.7 million people are fed their annual consumption of wheat by the project that I work with in the USDA/University of Nebraska–Lincoln wheat improvement project.”

—Stephen Baenziger, Professor and Nebraska Wheat Growers Presidential Chair, UNL Department of Agronomy and Horticulture

FEEDING PEOPLE drives the passion behind P. Stephen Baenziger’s research to develop a better wheat cultivar. Baenziger, plant breeding and genetics professor at the University of Nebraska–Lincoln, constantly works to improve cultivars to advance plant breeding and increase food production.

In 2010, Nebraska produced almost 4 billion pounds of wheat worth more than half a billion dollars, according to Baenziger, the Nebraska Wheat Growers Presidential Chair. He estimated that genetic improvements accounted for at least 20 percent of that yield. That means plant breeders have added \$100 million to producers’ farm gate income — the net value of the product when it leaves the farm.

In 2010, 67 percent of all the wheat grown in Nebraska was produced from cultivars developed through the joint funding of United States Department of Agriculture and UNL, Baenziger said. Of the \$100 million in increased Nebraska wheat yield each year, genetic improvements developed at UNL account for two-thirds of this revenue, or approximately \$70 million at the farm gate, he added.

Another way of looking at it is through the number of mouths fed. Based on the annual consumption of wheat in Nebraska, that 4 billion pounds of wheat feeds 20 million people, Baenziger said. About 20 percent of that is due to genetic improvements through plant breeding, meaning Nebraska wheat producers can feed an additional about 4 million people each year because of genetic improvements in their wheat, he added.

“I can’t take credit for all of that, but if you take two-thirds of that (4 million people), it’s over 2.7 million people who get fed their annual consumption of wheat by the USDA and UNL collaborative wheat improvement project I work within,” Baenziger said. “So if you wonder why I got into plant breeding, it’s to feed that 2.7 million people.”

If plantings of these cultivars outside of Nebraska were included, the impact would be even greater.

He has developed and released 46 small grain cultivars during his career at UNL, 35 of which were wheat. A cultivar is a plant variety that has been produced through selective breeding. Baenziger works primarily with hard red and white winter wheat, and to a lesser extent barley and winter triticale.

BASICS OF PLANT BREEDING

Baenziger described four phases to traditional plant breeding: select the target trait, introduce variation, select and breed for preferred traits, and evaluate new cultivars.

The first step is to select the target trait. For example, in hard red and white winter wheat, winter survival is an essential trait.

“It’s okay for a line to die in my research plots. It’s totally unacceptable if it dies in a farmer’s field. That means I haven’t done my job,” Baenziger said.

Three other core traits that Baenziger always selects for are resistance to stem rust, good agronomic performance, and good breadmaking ability.

In addition to the four traits that create a foundation for wheat cultivars, there are “nice traits” — ones that offer specific benefits to growers. Baenziger said for Nebraska wheat production these include some level of resistance to leaf rust, stripe rust, wheat soil borne mosaic virus, wheat streak virus, and Hessian fly as well as drought tolerance and heat tolerance. However, if a cultivar does not have these traits, but has good yield, winter hardiness, resistance to stem rust, and makes an excellent loaf of bread, it would still be released, Baenziger said.

“We have to decide what makes economic sense for our growers and what makes them the most profitable that they can be and then there’s a value chain. If it’s good for the grower, it has to be good for the elevator, has to be good for the miller, has to be good for the baker and then eventually has to be very good for the consumer,” Baenziger said.

After defining the target traits, the variation must be introduced by putting together genes and allowing them to separate out, making a cross. Baenziger said this can also be accomplished through mutation, but 99 percent of cultivars are produced by making crosses. Those plants that best exhibit the target traits are then identified. To put it in perspective, Baenziger throws away 99.9 percent of his crosses every year. The remaining 0.1 percent become parent plants, and out of that only 1 percent become cultivars. Baenziger’s research is different from genetically modified crop research because cross breeding

does not use transformation or transgenes to modify the plant. No wheat currently grown commercially is transgenic (commonly referred to as genetically engineered or as a genetically modified organism, GMO). However, in the future genetic engineering will be a valuable tool for adding variation in wheat breeding, Baenziger said.

“If you want to think about plant breeding, it’s no different than your parents. When they have children they cross and then you see the variation among the children, your brothers and sisters. We do the same thing in wheat,” Baenziger said. “We make a cross. We allow all of those genes to then segregate. That’s done by inbreeding; wheat is a naturally self-pollinated crop,” he added.

The third step in developing a new cultivar is inbreeding and selection. Inbreeding ensures it is a pure line and will perform consistently for the grower, Baenziger said.

The last phase is evaluation, where the merit of the cultivar is tested under various growing and climatic con-

ditions. In this phase, the cultivar is planted at numerous test sites across the state to discover where it is adapted and can be grown and where it should not be grown.

Baenziger’s research is funded by the Nebraska Wheat Board, private endowments, industry partnerships and federal grants.

THE FUTURE FOR CULTIVAR RESEARCH

According to Baenziger, It takes 12 years to release a new cultivar, a relatively slow process in comparison to the rapidly growing population and food demand. It takes this long to release a cultivar because of the large number of crosses needed to develop a successful cultivar. By the year 2050, Baenziger has three chances to completely turn over the wheat germplasm to create new cultivars. The germplasm or germ lines are the genetic resources that all breeders use to create new materials.

These germplasm lines can be shared freely with other institutions and be planted throughout the northern Great Plains. UNL works with ConAgra, ADM and Cargill to have a milling site so the research can influence national products. Baenziger also collaborates with the International

Maize and Wheat Improvement Center (CIMMYT from the Spanish name) to exchange information to create the best product for the growers.

“They (CIMMYT) have no testing site in their program, which has the winter hardiness requirement that we have in Nebraska. So we get some of their lead material, we test it for them, we send back the progeny of those crosses,” Baenziger said. “We provide them with the most winter hardy material to select from that they have in their system,” he added.

The future is unpredictable and the breeding program could be affected by many things in the next 35 years, including shifts in federal and state farm programs, climate change, and new milling and baking processes, Baenziger said. Baenziger is working to develop a research platform that will allow the Nebraska wheat industry to go in any direction the future takes.

“Our goal would be to be big enough and flexible enough, knowing that we can’t predict the future other than we know that it will be different than today, so that we can respond,” Baenziger said.

One way Baenziger plans to make this happen is by using state of the art statistics, mechanization, genetic engineering and genetic marker technologies. One example is wheat tortillas, Baenziger said. Wheat tortillas have different characteristics than bread wheat and require a different type of flour characteristics Baenziger said programs can always be improved and breeders can always change breeding procedures to become more efficient. For example, every experiment now uses sophisticated analysis programs to ensure the best data are being collected and analyzed properly.

With the development and inclusion of these new technologies, “The goal’s the same, but how we get there is different,” Baenziger said.



AGROECOLOGY

it's not just about the price of corn

by Dan Moser



"Agroecology is a new academic discipline that is holistic and looks at whole systems; it looks at more than just production and just economics, but also the environmental impacts of agriculture and the social implications of various systems that we choose."

—Chuck Francis, Professor, UNL Department of Agronomy and Horticulture

LONG-TERM AGRICULTURAL sustainability of the sort needed to feed a growing world population must be broad-based and expansive, with elements of high tech and organic practices as well as a good dose of sociology, agronomist Charles Francis believes.

Francis, an advocate for alternative and sustainable agriculture, doesn't dismiss the importance of genetic modification and other technological progress in agriculture, but he believes agriculture's embrace of that technology has been to the exclusion of other potential solutions and that the greatest successes may come with a melding of approaches.

Francis said he believes the organic and conventional agriculture communities have much to learn from each other.

"In the long term, I think we have no choice but to use systems that are either organic as we know them today, or some kind of organic systems that may include some transgenic, GMO varieties that help us to reduce pesticides," he said. "It may include much more complex, diverse rotations in cropping systems that are all part of organics."

A DEEPER LEVEL OF DIVERSIFICATION

For example, diversifying livestock and crop production on farms, now widely practiced, may need further refining, he said.

"You don't plant huge fields of corn, or soybeans or wheat. You plan a mixture of crops in the fields ... You plant strips of different crops. You plant them so they will mature at different times of the year," Francis said.

"That's not very popular when you have really large equipment, large systems," he acknowledged. "You look at the simple efficiencies of scale, on producing monoculture enterprises, this doesn't quite fit. So that's a shift in thinking that I think we're going to have to consider in the long term."

That approach could mitigate damage from what climate scientists believe is an emerging period of more major weather events, Francis said.

AGROECOLOGY TAKES HOLISTIC APPROACH

Francis uses the word "agroecology" to describe this approach as it marries agriculture and ecology.

"Agroecology is a new academic discipline that is holistic and looks at whole systems," Francis said. "It looks at more than just production and economics, but also the environmental impacts of agriculture and the social implications of various systems that we choose."

"We look at it beyond how much corn is produced and what the price is. We look at how much corn is going to be produced 20 years from now, given the resource scarcities," he added. "We look at (what) the economics may be."

Agroecologists also consider social dynamics of agriculture — farm families, ownership succession, the differences between consolidated farms and smaller farms in their impact on rural communities.

"We think all of these are just as important as producing corn, perhaps more important in the long term," Francis said.

Key to feeding the world through the looming population increase is careful stewardship of resources, Francis said. For example, "we are very fortunate that the soil is an incredibly resilient body that can absorb all kinds of bad use and bad treatment and still kick out crops for us, but that doesn't go on forever."

MORE THAN GMO

Francis said modern agriculture has embraced genetic modification of crops "in a very big way," perhaps overlook-

ing conventional breeding solutions that could be as effective or more effective.

"We don't know what progress we might have made through non-GMO breeding approaches. It may not have been as great, it may have been greater. We just don't know," Francis said. "Transgenic technologies are totally elegant, from a genetics standpoint; they are very clever. Whether they are economically sound in the long term and who they really benefit in the long term, whether it's the farmers or the companies that sell them, I'm not totally sure."

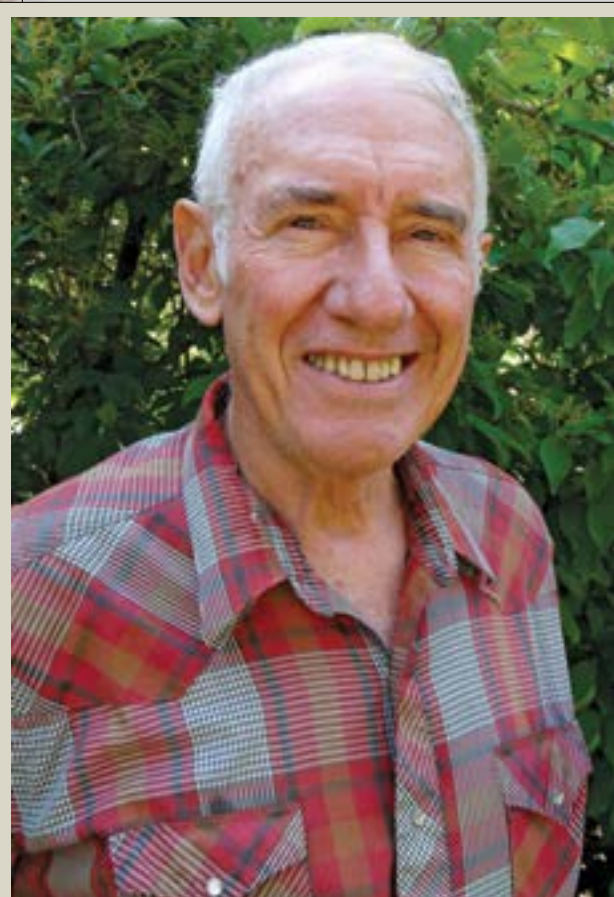
Francis said, "We need these disciplines, the basic research and the study that goes into them, but we also need to ask questions about 'so what? Why is genetics important? Why do we need to learn more about soil fertility — especially, how does this all fit together in a farming system that a farmer can look at, fine-tune and adapt to their particular situation, to their resources, to their goals, to the outcomes that they want to achieve.'"

A SCIENCE-LITERATE POPULATION IS ESSENTIAL

Land-grant universities such as UNL have an important role, through the students they teach and the research they conduct, in helping consumers become more literate about the science in their lives, Francis said.

"We as scientists present an awful lot of confusing information to the point that people don't know what to believe, to the point of not wanting to believe science, and that's a tragedy," Francis said. "On the other hand, we can't say we that we all have to agree because then science would be dead. There would be no science if we couldn't test each other's results and 'push the envelope' and try new things."

"I think we need a higher level of science literacy in the general population so people can, in fact, figure out how to figure out things," he added. "That's one of our goals in higher education — critical thinking skills. People can pick up knowledge theories, lots of things off the web. What they can't pick up off the web is perspective, how to sort things out, what kinds of criteria are important, how to answer that very question: 'What is sustainable?'"



Chuck Francis

SOIL – WHERE IT ALL BEGINS

producing more food sustainably starts with soil science technology

by Mary Garbacz



“Sustainability refers to producing food in a sustainable manner; it is balancing. Sustaining means there will be no scarcity of food, no damage to the environment. Inputs and outputs.”

—Humberto Blanco, Assistant Professor, UNL Department of Agronomy and Horticulture

SOIL IS THE BASIS not only for crops, but for humanity.

Soil grows crops, provides feed for animals and feedstock for energy. Soil cleans the water and the air; it filters runoff. Soil provides the ecosystem services that clean the environment. Soil is a living ecosystem, with billions of organisms in every tablespoon.

University of Nebraska–Lincoln Assistant Professor of Agronomy and Horticulture, Humberto Blanco, grew up on a farm in the highlands of Bolivia. The soils are different there, 12,000 feet above sea level. But Blanco’s father knew the soil. He would scoop up a handful of soil, feel it and smell it and pronounce it ready to receive the seeds that would produce the crops.

“We didn’t use any special tests or techniques to analyze the soil,” Blanco said. His father’s basic “feel and smell” test detected the organic matter in the soil, as well as the soil structure. It also led to Blanco’s lifelong intrigue with the physical, chemical and biological properties of the soil that sustains life.

Today, Blanco is an applied soil physicist. He studies basic soil processes and properties in short-term and long-term experiments, to better understand how different management practices affect soils, which are the basis for crops that feed the world.

Soil provides ecosystems services that regulate water flow, gas flux and air quality. Soil transforms residues above and below the surface into nutrients — it even stores those nutrients. Soil structure provides support for plants and their roots.

In the past, researchers studied soils based on just a few properties or discipline-based views. But as scientists learned more about soils, they expanded their studies, bringing in the perspectives and knowledge of researchers in different disciplines including agricultural engineering, soil hydrology, soil genesis, soil chemistry, soil microbiology, soil physics, plant science and others.

“We need to work together if we want to manage soils from a holistic point of view,” he said. “We want to improve soil ecosystem services. It goes back to not only producing more food, but to improving the environment.”

PROVIDING FOOD THROUGH TECHNOLOGY

Technology in the study of soils can be management practices, such as conservation tillage; it can be the use of cover crops to reduce soil erosion or add organic matter to the soil; it can be the way crop residues are managed. Technology in soil science includes careful management so that nothing negatively affects the soil or damages the environment, Blanco said, so that sustained agricultural production is assured.



Humberto Blanco



“The challenge is that we have to produce more food, more feed for animals, more fiber, more fuel — with less land, less energy and probably, with less fertilizer,” Blanco said. “So achieving sustainability will require that we improve current management practices.”

“As researchers, we talk about soil response to management based on the soil physical, chemical and biological processes and properties then say ‘this management practice improves soils; we should adopt it.’ It may not be that simple. What about economics?” Blanco said.

Adoption of new techniques may take time and may have to be proven to be profitable.

“It has evolved,” Blanco said. Since the Dust Bowl of the 1930s, conservation tillage practices have been gradually adopted that can help reduce wind erosion. “Now, no-till and reduced-till are more common than at that time. Conservation tillage is better than conventional tillage,” he said. Leaving crop residue on the soil surface protects the soil from erosion and adds organic matter to the soil and sustains crop production, among other benefits. For example, about 25 percent of the cultivated area is under no-till in the United States, and no-till is even more popular in other countries, such as Brazil, Paraguay and Argentina, Blanco said.

THE UNDERGROUND WORLD OF COVER CROPS

Cover crops are plants that are grown specifically to cover the soil, protecting the soil against water and wind erosion. Cover crops, Blanco said, act like blankets on the soil, but also improve the quality of soil, water and air.



Cover crops provide organic matter content, recycle nutrients and, with their roots as a mechanism, improve the soil structure so water will move into the soil quickly and have greater water-holding capacity. That water-holding capacity keeps the water in the soil for use by the crops. Management practices that increase soil organic matter will increase the ability of the soil to hold water. Addition of cover crops to conventional systems especially increases the amount of below-ground biomass (root biomass); this is key for improving soil structure and biology.

“As a result, cover crops feed the soil that feeds us,” he said.

Blanco said cover crops can add nutrients to the soil and reduce the use of inorganic fertilizers. Cover crops could become a more economical choice than addition of inorganic fertilizers if costs continue to increase. “There has to be a balance there,” he said. With increased production come concerns about soil and water quality, including erosion caused by wind and water, as well as nitrogen leaching.

Each cover crop provides different benefits to the soil. The decision of which cover crop to plant depends on the goal, Blanco said: coverage for the soil surface; addition of nitrogen to the soil; or reducing soil compaction.

Winter rye and mixed species are being studied as cover crops, with on-farm experiments underway. In those experiments, Blanco and his colleagues are monitoring not only yields of the subsequent crops, but also water use, organic matter content and soil erosion. Non-legumes such as winter rye, Blanco said, produce more biomass than legumes and provide better cover for the soil surface.

Legumes, he said, such as soybeans, will not provide the same coverage of the soil surface as winter rye, but legumes improve soil fertility, adding nitrogen to the soil.

Brassica, Blanco said, is a category of root vegetables with long tap roots, including turnips and radishes. The tap roots penetrate into the soil and fix compaction problems that may have resulted from the use of heavy equipment. These roots can grow deep into the soil, increasing infiltration of water and recycling nutrients.

COVER CROPS AS LIVESTOCK FEED

Another use of cover crops, Blanco said, is that livestock could graze the hay or the crop residue, depending on the cover crop, “which can be broadly appealing,” he added.

Nebraska is number one nationally in livestock production, Blanco said, so providing feed for animals is a top priority.

In dry years, such as the drought year of 2012, animal forage and feed were in short supply. In the absence of traditional feeds, farmers baled residue — corn stover and even wheat straw — to feed their animals. Cover crops can provide some feed resources, Blanco said.

But because grazing or haying cover crops reduces the surface cover, it may reduce the soil benefits of cover crops.

More research needs to be done on using cover crops for haying, Blanco said. “We need to make our decisions on solid research data,” he said. He currently is assessing how soil responds to grazing of cover crops.

NEW USES FOR CROP RESIDUES

Crop residues contain about 50 percent carbon, he said, and organic carbon in the soil is key to other soil properties, such as soil structure. Soil structure affects water flow, water infiltration, water runoff and the porosity of the soil, Blanco said. If the soil structure is not well-developed, it probably will not allow the support that plant roots need.

Although the main use for crop residues is to protect the soil or maintain soil properties, the residues now have found new uses, Blanco said. Cellulose is the main structure of plants and has been used in the production of cellulosic biofuels. Distillers grains, a co-product of corn ethanol production, are mixed with corn residues and used for animal feed.

“In some cases, we do have large amounts of residue so removing a fraction of residue produced may be feasible, but the amount of residue that is available for removal depends on soil type, management and cropping system,” Blanco said. Irrigated farmland that grows an abundance of crop residues may be able to spare some of that abundance for fuel production. Rainfed, or dryland farmland may need that residue to protect and sustain the soil.

Blanco said it is important to consider that cover crops can play a role in lessening possible negative impacts of residue removal on the soils. Planting cover crops after the residue is baled can be an option, he added.

Recent on-farm experiments UNL is conducting are studying crop residue grazing and baling in fields with and without cover crops in relation to the implication on soil

compaction, erosion, nutrient cycling and crop yields, he said.

LONG-TERM RESEARCH

Research takes time, which is why much research takes place in educational institutions.

As a faculty member at Kansas State University, Blanco took part in a nitrogen fertilization experiment that had been ongoing for 50 years. Fifty years and longer can provide valuable research information that shows how certain practices affect the soil in the long-term, Blanco said. The research goal was to see how inorganic fertilizers affected soil properties. Blanco also conducted similar work in Nebraska using long-term experiments.

The purpose of applying fertilizer is to increase crop yield, he said, which at the same time increases crop residue amount. “We know nitrogen will not directly improve soils, but it may positively influence soil by increasing crop residue,” Blanco said. But the applications must be the right amounts to reduce losses and any possible negative effects on soil and environment. Research has shown that if producers apply about 80 pounds of nitrogen per acre, there will not be any negative effects, he added.

NEBRASKA — THE PLACE FOR RESEARCH

Nebraska is a great place to conduct research, Blanco said. Western Nebraska receives less precipitation than does the eastern part of the state, so Blanco and his colleagues are starting soil experiments along the precipitation gradient across the state. The result is new knowledge that can be shared not only with Nebraska producers, but with others in the U.S. and other countries that have similar soils and similar precipitation.

Blanco also is pursuing funding opportunities to take research to a regional scale, looking at how soil responds to different management practices such as cover crops, crop residue management and others, under diverse climatic conditions across a precipitation and evapotranspiration gradient in the Central Great Plains. “It (evapotranspiration) changes from north to south, like precipitation changes from east to west,” he said. “That’s an opportunity to study interactions among agro-ecosystems, climate and soils.”

PLANT SCIENCE TECHNOLOGY WORKS

toward nutrition, sustainability

by Alex Wach



“Biotechnology should be seen as just a tool for crop improvement, along with plant breeding and making hybrid crops. We are trying to breed crops that have a higher yield and are resistant to pathogens, insects and drought.”

—Edgar Cahoon, Professor, UNL Department of Biochemistry and Director, Center for Plant Science Innovation

OILSEED CROPS, such as soybean, play vital roles in human and livestock nutrition, bio-based fuels and industrial chemicals, and University of Nebraska–Lincoln scientists are working to improve their performance and create new oil compositions.

UNL’s Center for Plant Science Innovation (PSI) is immersed in research into plant biochemistry and

molecular biology, said its director, Edgar Cahoon, also a professor in the Department of Biochemistry.

“Plant biotechnology should be seen as a tool for crop improvement, along with plant breeding and making hybrid crops,” Cahoon said.

Cahoon’s research team works to improve crops through plant biotechnology. Much of the scientists’ work is in plant lipid metabolism.

Lipids are organic compounds including fatty acids, oils, waxes, sterols and triglycerides that are greasy, insoluble in water and soluble in organic solvents. Lipids are a major structural component of living cells.

“Lipids are components of membranes, and membranes are important for the adaptability of plants to different stresses including low temperatures and drought,” Cahoon said.

Lipids are present in seed oils, so Cahoon works to improve the oil composition of seeds of different crops such as soybeans. He also works with a crop called camelina to try to improve its oil composition for uses such as biodiesel, and also for some nutritional uses. Cahoon’s research also includes aquaculture.

“We’re doing work to alter the composition of soybean oil for aquaculture applications,” Cahoon said. “For example, fish are fed fish meal with fish oil, and that’s not a sustainable process. To make one salmon through farmed

fish systems, you have to feed three lower-value fish. We’re trying to produce a fish feed within soybean that’s sustainable, where you don’t have to harvest the ocean for low value fish for fish meal and fish oil to feed the farmed fish.”

In addition to the aquaculture soybean research, Cahoon’s cellular research has led to improvements in other crops. Discoveries made by Cahoon’s research team in the plant *Arabidopsis* (a small flowering plant related to cabbage and mustard) are generally applicable to many crops. Much research also has been performed on the metabolism of vitamin E, which is an antioxidant that helps stabilize vegetable oils.

MOVING GENES TO CREATE NEW PRODUCTS

“Certain genes have been discovered from one plant species, and if we take that gene and put it into other crops, we can make higher levels of vitamin E, along with different types and different forms of vitamin E that have higher antioxidant capacity,” Cahoon said. “So the discoveries that we make are not like plant breeder discoveries, where one crop is focused on and we make genetic manipulations in that one crop. We can take genes that we discover from one source and move them into different crop species to try to make new oil compositions.”

The Center for Plant Science Innovation brings together researchers from several UNL departments, which allows for important collaboration across disciplines. For example, a researcher may have a specialty in oils and membranes, but the information could be useful for engineering plants for fungal and bacterial pathogen resistance. “Cross-disciplinary and collaborative research makes us better as a whole and allows us to achieve more than is possible as individual researchers,” Cahoon said. One of the discoveries made in the Center for Plant Science Innovation was a new type of herbicide resistance, called dicamba resistance. Dicamba is a type of herbicide that Cahoon’s colleague, Donald Weeks, figured out how to detoxify by finding bacterial genes that could break down this herbicide to a form that is not toxic to plants. Weeks and colleague Tom Clemente discovered a way to engineer these genes into the soybean plant to make them resistant to dicamba herbicide. Monsanto has licensed this technology and is now in the process of combining it with Roundup® resistance.

INTERNATIONAL IMPACT

Cahoon’s research also has an international impact in the areas of health and human vision. Lipid-soluble compounds such as carotenoids and beta-carotene are needed in

a diet to improve vision. In some parts of the world, such as sub-Saharan Africa and Southeast Asia, many people suffer from deficiencies in vitamin A due to insufficient beta carotene in their diets.

Cahoon is conducting research funded through the Bill and Melinda Gates Foundation to engineer a crop called cassava, a staple crop in sub-Saharan Africa, that will have higher levels of beta-carotene.

“In different nations, there are very high levels of clinical deficiencies of provitamin A, and there are a lot of young children who suffer from blindness or night blindness because of not getting enough beta-carotene in their diets,” Cahoon said.

“The beta-carotene is provitamin A. In other words, your body takes the beta-carotene and converts it into retinol for vision. You have to get this from your diet, and so helping these populations, where vitamin A deficiency in children is prevalent, is important and our research will contribute to addressing this problem,” Cahoon said.

OBJECTIVE UNIVERSITY RESEARCH

Cahoon said that although some research should be performed by private companies, universities such as UNL can focus on basic research. He said that companies sometimes focus more on what their next product will be and how it will be profitable in the marketplace, so their research has a shorter-term focus.

“We can think longer term, and so we can focus on making basic discoveries that can then translate into improved crops,” Cahoon said. “Within a company, you are thinking about how to do it very quickly, and you don’t really necessarily go in and try to figure out the basic mechanism of how plants work.”

“What companies do is often based on the research that comes from the public sector, from universities like UNL.”

Cahoon said his research is funded from a wide range of sources. Along with the Bill and Melinda Gates Foundation, the U.S. Department of Energy provides funds for the UNL Center for Plant Science Innovation to perform research on biofuels. The U.S. Department of Agriculture, the National Science Foundation and the Nebraska Soybean Board also provide funding.



Edgar Cahoon

GENETIC DIVERSITY a positive for all

by Kristi Block



Tom Clemente

“Some of the technology being developed is enhancing water use efficiency.”

—Thomas Clemente, Eugene W. Price Professor of Biotechnology and Manager, Plant Transformation Facility, Center for Plant Science Innovation, UNL Department of Agronomy and Horticulture

PLANTS ARE CONTINUALLY EVOLVING, naturally developing traits in response to the environment. Similarly, through genetic engineering, Thomas Clemente, a plant scientist at the University of Nebraska–Lincoln, adds traits to plants to increase their genetic diversity and their ability to withstand changing environmental stresses.

“Genetic resistance is essentially evolution. When you have a pathogen or host, there is always a co-evolution. The plant evolves. The pathogen evolves more ways to infect that plant. The plant comes back to combat that stress. So it’s a war that is ongoing year after year,” said Clemente, Eugene W. Price Professor of Biotechnology. Plant breeding and genetic engineering allow Clemente to accelerate plant resistance to pathogens by increasing the diversity of traits to combat potential threats.

“The most important thing plant transformation technology does is broaden the genetic base of any plant species — the variety and genetic variation is now unlimited,” Clemente said. This technology provides the opportunity for plant breeders “to have access to a whole array of traits that historically they did not have access to,” Clemente added.

Clemente, who also is director of the Plant Transformation Core Research Facility (PTCRF), uses genetic engineering to broaden the genetic diversity of plants and provide more options for plant breeders who are work-

ing on solutions to specific plant problems, such as drought tolerance. The PTCRF is one of seven core research facilities in the university’s Center for Biotechnology. Seven scientists work in the Plant Transformation lab, transforming plants by adding or removing genes in a genome sequence. By changing the expression of a single gene and discovering the effect in the development of a plant by turning on or making more of a particular gene, genetic variability in a particular plant can be increased. The PTCRF works with all major commodity plant species grown in Nebraska — maize (corn), soybeans, wheat, sorghum and common beans, such as kidney beans and navy beans.

“The technologies we are evaluating and developing in collaboration with a lot of other resources directly impact plant production by enhancing yields or protecting yields under a stress environment,” Clemente said.

PRODUCER BENEFITS

Producers will see a direct effect when crops with herbicide resistance, insecticide resistance, fungal resistance and drought tolerance are introduced on the commercial market in 10 to 20 years, Clemente said.

Two focus areas for Clemente and researchers in his lab are getting the most production from each drop of water and maximizing mineral use efficiency. Nitrogen, the primary mineral applied in Nebraska crop production, has an environmental and an energy cost.

“If you can have a producer get more ‘bang’ for every drop or every gram of nitrogen fertilizer they put on their soil, that is a return on investment — not only for the farmer but to the environment,” Clemente said.

“One of the biggest projects is developing a soybean feedstock for aquaculture — farm-raised fish,” Clemente said. Clemente’s lab hopes to use the soybean feedstock as fish food, displacing fish meal and fish oil in current aquaculture production practices. Such a soybean-based aquafeed would be a more sustainable option for the aquaculture industry and the environment, he said, and would expand traditional uses for soybean.

CONSUMER BENEFITS

Clemente also is using plant transformation technology to develop more nutritious plants for human consumption. One example studied by his lab is a high-oleic acid soybean. Soybean varieties with high oleic acid oil have been developed by both DuPont Pioneer® and Monsanto® and are expected to be released in the next couple of years. Soybean varieties carrying this trait will be marketed under the trade names, Plenish® from DuPont Pioneer and Vistive® Gold Soybeans from Monsanto. This “monounsaturated” oil is a heart-healthy, less costly alternative to olive oil. Before it reaches consumers, it will need to go through an intense regulatory review and approval process.

“We can say with absolute certainty that the products on the market today through biotechnology are as safe or safer than any of the commodities ever delivered [through traditional breeding], because none have been put through such rigorous safety assessment,” Clemente said. “We can say we have done every test possible, and we are confident that we have mitigated the risk to the best of our potential,” Clemente said.

REGULATORY PROCESS

To move a product from research and development to the marketplace, a company will invest \$50 million to \$100 million. This means companies will only develop those products with the potential to bring in enough capital to cover costs for research and development (including failures) and regulatory approval, Clemente said.

It takes 10 to 20 years for a potential product to move from gene discovery to research and development, and then through regulatory approval to become a commercial product, Clemente said.

In the United States four government agencies must grant approval for a biotech product to become commercially available. Each of these agencies — the United States Department of Agriculture (USDA), the Food and Drug Administration (FDA), the Animal Plant Health Inspec-

tion Service (APHIS) and the Environmental Protection Agency (EPA) — require different kinds of testing and data. Outside of the United States, the data and regulatory requirements vary from country to country, which is why a product takes 10 to 20 years to reach consumers.

The regulatory process is one factor in why it is so expensive to develop a new product, Clemente said. A company probably has “the technology to address many novel traits through biotech, but is it worth the profit? That’s the issue. Until we come to a regulatory process, not only within the United States, but abroad, that’s more rational and based on science, the cost is going to limit the technologies that see the light of day,” said Clemente.

“If we’re really going to keep these innovations going — doing more sustainably, more food production with less land — this is the answer: we have to go for investment in public sector research,” Clemente said.

THE UNIVERSITY’S ROLE

The university’s role in plant transformation occurs in the earliest stages, during innovation, research and development, and then moves to a private company for testing, further development and commercialization. By using genetic engineering to transform plant DNA, “Everybody benefits in one way or another, including students,” Clemente said. The main goal at a land-grant university like UNL is educating the student, he added.

The people who will benefit most directly from this research are the undergraduate and graduate students who receive training in the biosciences, Clemente said. Getting people interested in science, providing laboratory experience, and inspiring innovation is what the university is supposed to do, he said.

“My legacy is the student who leaves my lab and later looks back and says, ‘I learned something from that guy.’ You hope those students will go forward and make a little bit of a contribution and those contributions will add up,” Clemente said. Everyone helps provide another piece to the puzzle.

FUNDING

Clemente’s research is funded by the United Soybean Board, North Central Soybean Research Program, Nebraska Soybean Board, Nebraska Wheat Board, the U.S. Department of Energy, the U.S. Department of Agriculture, the National Science Foundation and the private sector.

DEVELOPING CLIMATE-RESILIENT CROPS

securing global food supply

by Mollie Wilken



“As we move into the future, the climatic patterns are going to shift and when they shift, they result in an event such as a drought, or flooding, or heat stress. Not only do we have to overcome this hurdle of higher productivity, but we have to increase production overall to feed the higher global population. It’s a double-edged problem we are trying to address.”

—Harkamal Walia, Assistant Professor, UNL Department of Agronomy and Horticulture

THE MAJOR CHALLENGE by the year 2050 is securing the global food supply for the growing population. Assistant Professor and Plant Molecular Physiologist at the University of Nebraska–Lincoln, Harkamal Walia, is passionate about developing more stress tolerant crops that could ultimately enable greater global food security.

Walia said it’s estimated that farmers lose about 50 percent of their yield to heat stress, drought stress and flooding, called abiotic stresses. Biotic stresses include: pressure from disease, viruses and pathogens. All of these can damage the crop and decrease yields, resulting in decreased food production. Walia’s research with wheat, rice and corn aims to counteract some of these yield losses.

As a child growing up in a farming community in India, Walia saw firsthand how environmental stresses can affect farmers’ livelihoods.

“I learned quite early that when you have good years and bad years it impacts what you get and what you don’t get,” Walia said. “Most of the times the bad year was one that we didn’t have enough rainfall or there were temperature spikes that resulted in yield losses,” he added.

“This research is significant because the major challenge is ‘How do we secure the food supply for a population that’s going to go above 9 billion people by 2050?’ One of the ways you could contribute to achieving this food-for-9-billion-people goal is by improving the genetic potential of crops that we consume every day such as wheat, rice and maize (corn), depending on where you are in the world,” Walia explained.

COUNTERACTING STRESSES

Wheat is the third most important crop in Nebraska and the second most important crop for food security globally. Walia’s research seeks to improve the crop’s drought tolerance by focusing on the roots. The goal is to examine the genetics and physiology of the roots to enhance water uptake.

“We are trying to understand what makes better roots or what makes more adaptive roots for drought tolerance,”

Walia said. “Bigger roots in many situations can be better, so we are trying to see what makes bigger roots.”

Water is an absolute necessity for plants to grow. When water is more available deeper in the soil, a wheat plant with more adaptive roots will be able to reach that water and sustain growth during a short duration of drought.

Rice is the most important crop in the world for food security, Walia said. It grows in extremely wet, even flooded conditions. Walia’s research on rice is focused on both drought and salt tolerance. Similar to wheat, to increase drought tolerance in rice Walia is focusing on the roots.

Irrigation inevitably results in accumulation of salts in soils. As water evaporates or is absorbed by soil, salt is left behind on the topsoil. Research on hundreds of rice varieties from more than 80 countries is being conducted to understand the genetic basis of salt tolerance.

“We are trying to dissect the mechanisms that may be involved in making rice more salt tolerant,” Walia said.

As for corn, the Nebraska Corn Board is funding research to understand the crop’s drought response.

“We are trying to find specific genetic variations that can improve the drought tolerance of corn,” Walia said.

Walia’s research team works with other UNL corn breeding researchers and agronomists to discover specific information about drought tolerance to share with Nebraska farmers.

With all three crops, Walia’s research seeks to improve productivity even when there is limited water available, high salt levels or extreme heat.

“More tolerant crops can survive better and produce more, and contribute towards the global challenge of food security for our planet,” he said.



Harkamal Walia

LOOKING AHEAD

Changing climate patterns will be a major challenge for future production, Walia said. When there is a shift in climatic patterns, events such as drought, flooding and heat stress occur more frequently and with greater intensity. Not only do crops need to be productive even in unfavorable climates, but overall production must increase to feed the increased global population.

Another key to alleviating crop stress is to transfer genetic information from one crop species to another. Because some crops are more tolerant than others, the objective will be to enhance the less tolerant crop species’ ability to sustain yields.

Walia said his work is two-pronged: conducting research on crops that are critical for Nebraska and the world, and training scientists who will carry on with the research efforts in decades to come.

“We haven’t scratched the surface in terms of harnessing the genetic potential that exists in nature for making crops more resilient to climate change,” he said.

“The second opportunity that excites me a lot is being in Nebraska and being in an environment where agriculture really matters.”

BREEDING FOR SUCCESS

soybeans respond to changing threats

by Emily Taylor



“There’s a lot of work going on at UNL that has had really significant impacts in the U.S. and internationally in soybean improvement.”

—George Graef, Professor, UNL Department of Agronomy and Horticulture

PLANT SCIENTISTS at the University of Nebraska–Lincoln are developing new soybean varieties that respond to changing threats from pests and climate while still delivering high yields.

George Graef, UNL soybean breeding and genetics specialist, uses traditional plant breeding techniques to improve yield and counter threats that decrease yield. That means developing cultivars that offer resistance to drought, disease and insects and perform well under a variety of conditions, including high pH soils.

IMPACTS MAY BE DECADES AWAY

In plant breeding, scientists focus on long-term impact and goals.

The development of a new cultivar begins with identifying the objective, such as increased yield or improved responsiveness to water. Producing a soybean variety that yields well with less water is a key goal of Graef’s research.

“Then we have to find sources for those traits and the genes that control those traits,” said Graef, a professor in the Department of Agronomy and Horticulture in the Institute of Agriculture and Natural Resources. “Once we identify the soybean lines to use as parents, we then make the cross. That is one season in the breeding process.”

The crossing process starts in a winter nursery in Puerto Rico or the field nursery on East Campus, eventually moving through winter nurseries in Puerto Rico and South America, then to test plots and fields in Nebraska, where large numbers of plants can be evaluated.

During Nebraska’s fall and winter, two additional generations are grown in the Puerto Rico nursery. In Chile, where plant growth is similar to that in Nebraska, scientists can evaluate traits such as yield and directly relate them to Nebraska.

“By using all those multiple seasons in a year, we can complete the process in five to seven years, including regional testing in the U.S. and seed increase for potential new cultivars,” Graef said.

From the initial cross, two or three generations of soybeans are self-pollinated. Plants are allowed to set seed on their own, and the crosses are done by hand. The soybean plants go through those selfing (self-pollinating) generations to make them more homozygous — that is, to allow the genes that are segregating in the cross to become fixed

in different plants in the population. Then scientists harvest single plants to create new lines of soybeans, Graef said.

“We go through what we call progeny rows so that there’s a single row from each plant (variation),” Graef said. “We have thousands of those a year and then from those we make selections to go into our yield testing at multiple locations. That is the first yield evaluation step that occurs for us in Nebraska, at four or more different locations. That’s when we can get a good idea of their performance for yield, lodging, height, maturity and any kind of traits that are important for Nebraska.”

Based on all of that data, scientists select the better soybean lines and advance them through another two or three years of testing in Nebraska and at other locations. During that process they analyze the data to determine if any of the new soybean lines are better than what’s already available and good enough to be released, Graef said.

UNIVERSAL IMPACT

Although Graef’s main research focus is on soybean improvements that would be beneficial in Nebraska, many of the improvements could also affect global production. Nebraska’s soils and climate differ significantly from one end of the state to the other, providing a number of variables that would be similar to other regions around the globe.

Variations include soil type, climate, geography, water availability, use of irrigation, and soil pH levels. Higher soil pH can result in iron-deficiency chlorosis in soybeans, a problem in some Nebraska soybean fields. At UNL researchers have identified a genotype response that allows soybean cultivars to grow well under high pH conditions, Graef said.

Graef’s research is funded by the Nebraska Soybean Board, United Soybean Board, United States Department of Agriculture grants and an endowment from Bayer CropScience. The endowment also funds undergraduate scholarships for students working on soybean research and international internships on the industry side of research and development.



George Graef



BUILDING MORE EFFICIENT IRRIGATION SYSTEMS

farm by farm

by Dan Moser



“We must implement technology into our practices, because using technology in irrigation or fertilizer management or in other soil or crop practices eliminates human error within the field. It can help us determine exact timing and amount of any product or irrigation water.”

—Suat Irmak, Harold W. Eberhard Distinguished Professor, UNL of Department of Biological Systems Engineering

IT IS NO EXAGGERATION to say that Suat Irmak has been working to make agriculture more efficient most of his life — from his childhood on the family farm in Turkey to his role as a leading scientist.

“I started picking cotton by hand and setting siphon tubes for gravity irrigation when I was 8 and a half years old with my father and grandfather,” Irmak said. “Over the years I saw my parents doing different things, playing around with different technologies or practices” to raise a crop in an extremely arid environment where it does not rain from April through October.

That experience led Irmak to his career as an irrigation engineering scientist focused on helping farmers produce more food while using less water.

Irmak said about one-third of the world’s population already lives in countries experiencing water stress. With a population expected to top 9 billion by mid-century, that stress will worsen, especially since irrigated agriculture accounts for more than 70 percent of total freshwater withdrawal globally.

IRRIGATION KEY THROUGHOUT HUMAN HISTORY

Irrigation has been playing an important role in the history of human civilization since about 10,000 B.C. from which the remains of the first manmade water delivery systems, built by the Sumerians of Mesopotamia, still can be found. By 5,000 B.C., Egyptians had refined agricultural technology significantly, including canal irrigation with water diverted from the Nile; then the Ro-

mans perfected engineering principles of irrigation delivery systems.

Today more than 800 million acres are under irrigation worldwide, Irmak said. China and India are the world’s leaders. Nebraska is the United States’ leader in acres of farmland under irrigation with about 8.9 million acres. Irrigation can increase yields by up to 400 percent, depending on the crop type, climatic conditions, and other factors. Globally, about 40 percent of the total food and fiber is produced on only 15-20 percent of the total arable land area that is irrigated. Irrigation not only helps meet crop water requirements, but also enables nutrient and micronutrient movement through the soil to where they’re needed by the crop.

Through the Nebraska Agricultural Water Management Network (NAWMN; <http://water.unl.edu/cropswater/nawm-dn>), founded and led by Irmak with a team of educators, USDA-NRCS partners, and others in 2004, major strides have been made in making irrigation and crop production more efficient in the state.

A WATER-MANAGEMENT NETWORK BEGINS — AND GROWS

The network’s primary objective is technology implementation in agriculture to enhance productivity while reducing chemical leaching to water resources through effective irrigation management; and to enable effective communication and information exchange (about issues and developing solutions related to water resources and crop production) among university personnel, farmers,

crop consultants, private industry partners, state and federal agencies, and others.

The network began with 15 farmers interested in learning from UNL scientists how to use new technology to make more efficient use of irrigation water. Ten years later, there are more than 1,100 farmers in the network, representing about 1.7 million acres of production; where once there was one natural resources district (Upper Big Blue Natural Resources District) involved, now there are 18; where once there were four UNL Extension educators involved, now there are over 20. It has become the largest agricultural water management network in the nation, Irmak said.

The network’s impact is significant: On average, corn and soybean producers are reducing irrigation water withdrawal by 2.2 inches per growing season. Farmers accomplish this by using several types of technologies, including soil-moisture monitoring equipment that alerts producers when their crops need water and sophisticated equipment that measures crop-water use. Sensors can be purchased for about \$35 a sensor; hand-held meters and data loggers are similarly affordable. NRDs have helped share costs in most cases.

Looking ahead, Irmak predicts further technological advancement. Irmak is working to incorporate wireless soil moisture and remote crop water use measurement technologies in farmers’ fields.

TAKING THE TECHNOLOGY GLOBAL

These technologies and results are transferable to other

countries, even those with different climates, soil types and farming practices, Irmak said.

“The network is being replicated in China, India, Bulgaria and Turkey and now I’m in the process of applying to USDA for \$5 million to enhance the network with additional next generation technologies and also to extend the network to other states (California, Kansas, Arkansas, and Mississippi) in the United States,” Irmak said.

In addition to web and other electronic media, dissemination/sharing this knowledge through good old-fashioned Extension work — one-on-one on individual farms is still one of the most effective ways, Irmak said.

“The challenge is finding people in those countries and in other states to be able to do extensive demonstration projects and extensive education, one-on-one, on the farm,” Irmak said. “We have traveled 20,000 plus miles a year in the initial 7-8 years with my extension team members.”

American farmers are known for being “extremely pioneering in their stewardship” and respectful of unbiased, science-based information, Irmak said. “So, they’re eager to adopt new technologies once they see the benefits of quality research-based information through robust demonstration programs.”

“However, we should not be satisfied with what we have achieved and we must constantly research better ways of doing things and develop strategies and better practices for future generation farming practices where advanced technologies will increasingly play a critical role,” Irmak said. “Thus, we must be ahead of the game and always think about future potential issues that agriculture might face and develop excellent research programs to develop tools and practices to deal with these future potential issues while meeting current needs of our citizens related to agricultural production and water resources.”

“Unfortunately, that’s not the case globally,” he added. “For example, even though there are great, cost-effective technologies available, they’re not being implemented in many countries.”

Irmak’s work is funded by a variety of state and federal sources, including the U.S. Department of Agriculture, Natural Resources Conservation Service, National Science Foundation, NASA, Environmental Protection Agency, private industry and NRDs.



Suat Irmak

PRECISION AGRICULTURE: merging technology and knowledge to increase production efficiency

by Mollie Wilken



“There are many sources of data for farmers to use in their operations. The biggest challenge we have today is understanding which sets of data are important and how to use those to improve production operations.”

—Joe Luck, Assistant Professor and Precision Agricultural Engineer, UNL Department of Biological Systems Engineering

PRECISION AGRICULTURE addresses economic and environmental challenges. Locally, producers face economic challenges of creating a profit as well as trying to be sensitive to the environment, according to Joe Luck, extension precision agriculture engineer at the University of Nebraska–Lincoln. Precision agriculture technologies allow Luck to monitor management systems to compare the inputs and outputs in crop production. Globally, the challenge is producing enough food to feed the world, he said. Precision agriculture in this case revolves around efficiency, or maximizing outputs versus inputs.

Long term, Luck is focused on feeding more people with fewer acres. “If we can do a better job of managing our resources, that’s where precision agriculture comes in: more efficiently using the resources that we have to produce the food that we need,” he said. There is a lot of opportunity for resource tracking and understanding how to use the data that is collected to produce that food, he added.

The application of technology in agricultural practices is changing. Luck, who also is a UNL assistant professor of

biological systems engineering, is working to help producers maximize production through the use of technology.

“We get input from agencies and other entities that tell us what they think are important areas,” Luck said. “I like to show our stakeholders and our producers that we’re interested in solving the issues that they are having,” he added. Luck’s research has been funded by a combination of public and private groups such as local commodity groups, industry groups and the United States Department of Agriculture (USDA).

Precision agriculture requires the expertise of engineers, data specialists, faculty who work with sensors and control systems, agronomists, plant physiologists, and agriculture economists. Part of Luck’s appointment is with UNL Extension, so he takes the combined information to the people who use it — agricultural producers.

TOOLS THAT MAKE UP PRECISION AGRICULTURE

Many management tools are used in precision agriculture. In a hardware sense, there are sensors, control systems, application systems, field equipment and many more, Luck said. On the software side, the information is collected and analyzed and then used to improve the production system.

“We are trying to use the most current knowledge and technology in terms of machinery, control systems and electronic devices to manage our systems. It takes bringing those things together to try and improve our production systems,” Luck said.

Luck focuses on providing user-friendly systems to producers so they can efficiently manage their production operations. Luck is developing instruments that producers can use to collect information in their own operations in water use efficiency, irrigation systems and crop input use efficiency.

IMPROVING TECHNOLOGIES

Luck said past research has shown opportunity in technology as it relates to reducing pesticide applications, for example. “Technologies don’t do everything for us,” Luck said. “They can reduce errors when we apply chemicals in the field, but the systems aren’t perfect and we’re trying to communicate that to people to show there are things that operators can do to even improve how those systems perform,” he added.

“One concern I have is related to application accuracy. We rely on these systems a lot to apply what we prescribe

out in the field, and there could still be improvement in how those systems function,” Luck said.

The goals of Luck’s research relate back to collecting accurate data and that takes input from other professionals, he said. One goal is to use information from these professionals to accurately manage inputs, find ways to measure those inputs, and use that information to plan for the next year’s crop. “We have to be able to measure that information accurately and so, ‘How do we improve on the technologies that we have right now out in the field to do that?’” Luck said.

COMMUNICATING TO PRODUCERS

Luck’s work in both research and extension includes conducting workshops and meetings to share information with producers to help them improve their operations. “We try to use a variety of sources because we know not everybody’s going to learn or get that information in the same way,” Luck said. He uses the web, publications, video and audio to communicate to the people who can benefit by having the information. In addition, a mobile app could be on the horizon for producers to have better access to management tools, Luck said.

Through workshops, producers are able to learn from each other through discussion and Luck is able to teach them how to manage their data. “We learn things that they want to know in the future. We can teach them one aspect of precision agriculture systems and then they start asking questions about the next phase in that process,” Luck said. “We can take that information, come back, generate more information for them, and put it out there for them to learn,” he added.

LOOKING AHEAD

Sensor technology in plants in regards to nitrogen application, for example, is one area in which Luck believes there will be future development. “We are trying to sense the greenness, in effect, which can give us an idea of nitrogen availability,” Luck said. “We have to be able to interpret that information somehow and use that to tell us what we are seeing or what that sensor is seeing,” he added.

Luck also expects development in the areas of plant disease and pest sensing. Unmanned aerial vehicles (UAVs) in agriculture also will be something of great interest to researchers. If a crop scout has to walk through an entire field to see weed pressure, insect diseases or other defects, a UAV can go out and collect that information more quickly and benefit farmers, Luck said.



Joe Luck (right) with graduate research assistant Sam Marx (left).

MAXIMIZING IRRIGATION

through irrigation technology and GIS

by Alex Wach



“Technology involves four things: an ability to look at variability in the field; to apply water uniquely in certain areas of the field; to develop decision support systems; and implementation of a feedback system so you can monitor how well you are achieving your goals.”

—Derrel Martin, Irrigation and Water Resource Engineer, UNL Department of Biological Systems Engineering

UNIVERSITY OF NEBRASKA–LINCOLN research in irrigation water use efficiency is helping crop producers — in Nebraska and around the world — grow more food with less water.

One of the researchers focusing on this work is Derrel Martin, a UNL water resources and irrigation engineer, who is studying how to enhance the value of the water that irrigators use in crop production. His findings are used by growers as well as by state agencies developing water management policies to protect the quality and quantity of Nebraska’s water supply.

Martin first saw the need for developing water and irrigation management systems growing up on a farm and ranch in southwest Nebraska, where irrigation often made the difference between a high yielding and a low yielding crop.

Today, Martin’s research focuses on irrigated cropping systems in Nebraska, particularly corn and soybeans, as well as sugarbeets, pinto beans, wheat and other commodities. His findings are the basis for information and recommendations he shares with growers through educational programs and online tools on center pivot management.

Martin, a professor of irrigation and water resource engineering in the UNL Department of Biological Systems Engineering, said he lets producer practices and information needs help define the direction of his research.

DEVELOPING NEW TOOLS AND INCORPORATING GIS

Martin has worked with the Nebraska Department of Natural Resources to develop computer programs to help growers use their irrigation water more efficiently. His programs look at the water balance in a watershed to track how much water is coming in, how much water is being used, and the long-term sustainability of water practices.

Martin also works with geographic information systems (GIS), a computer technology that manages, collects, and interprets geographical data that can help assess irrigation efficiencies under various field types.

“We can look at the variability within a field, and begin to overlay different characteristics that you would see in the field,” Martin said. “You could look at slope, soil type, and past water practices among other things, so we can build an information stack that describes a field in a lot more detail.”

Martin and other UNL water resource researchers don’t stop at the field level, but are developing tools to assess and manage the water balance across a watershed. In turn, this will help users “achieve the goal that society sets for that watershed,” he said.

“It’s not our place to decide how much water should flow in a stream or necessarily what the quality of that water should be,” Martin said. “But once those criteria are established, then I think it’s contingent on us to develop those systems that allow efficient irrigation within the constraints that we have in that watershed.”

WATER USE AND WATER WITHDRAWAL IN IRRIGATION

“Water use” is a general term that can mean different things for different uses. This has led to some confusion as to how it is defined for irrigation. Water that is extracted from groundwater or from surface water such as a stream is termed a water withdrawal. Irrigation accounts for over 90 percent of the water withdrawals from those two sources in Nebraska. The term “water use” also may be used to describe water that leaves the watershed through evaporation or plant transpiration, Martin said.

“What we are trying to do is to look at how we can reduce the amount of water that we extract from the stream or from groundwater and how to predict and manage the consumptive use,” Martin said. “It’s really the consumptive use that drives sustainability of water resources.”

To improve irrigation management, Martin said many factors need to be addressed:

- ➔ How efficiently is water being applied?
- ➔ Is the water where it needs to be at the right time?
- ➔ Is the right amount being applied?
- ➔ Is irrigation meeting plant water needs?

“It’s not our place to decide how much water should flow in a stream or necessarily what the quality of that water should be. But once those criteria are established, then I think it’s contingent on us to develop those systems that allow efficient irrigation within the constraints that we have in that watershed.”

— Derrel Martin

“We need to make sure we’re achieving our goal. In some cases it may be to maximize the yield that we could produce while in other cases, growers may be limited on how much water they can use,” Martin said.

About one-sixth of Nebraska’s land area or about 9 million acres is irrigated cropland, Martin said. About 85 percent of that is center pivot-irrigated. Center pivots have been widely adopted because of their efficiency in water application, labor savings and reliability, he said.

IMPROVED FOOD AND NUTRITION

In Nebraska irrigation helps ensure a zone of environmental conditions that support crop production. Internationally, irrigation may be associated with many other issues than crop production.

“If you were to go to some developing countries, the water that’s delivered might be in a canal, and that canal is used for many different purposes,” Martin said. “It is intended for irrigation but people may bathe or take water out of it, so there are a host of environmental and public health issues that surround that aspect of it.”

“Here in Nebraska or really in the Great Plains region, it’s mostly about maintaining crops in a healthy range to produce a quantity of food that is desirable,” Martin said.

NEBRASKA’S VARIABILITY HELPS RESEARCH

Annual precipitation levels vary significantly across Nebraska, providing a statewide laboratory to study irrigation questions under a variety of growing conditions from sub-humid to semi-irrigated that reflect those found around the world. In Nebraska average annual rainfall decreases about one inch for every 25 miles across the state.

“A lot of those semi-irrigated regions in the world are where we have some of our most critical water supply and food demands,” Martin said.

Martin said it is important that land-grant institutions such as UNL conduct research on irrigation technology because the university has the resources to take a broad interdisciplinary approach to researching and solving complex problems.

“There aren’t many places that have that breadth of technology compared to the University of Nebraska. We have a very good relationship with all elements of the irrigation industry, from seed corn to center pivot manufacturers,” Martin said. “It is important to us to reach out to growers and producers in the state of Nebraska and the Great Plains.”

Martin’s research is funded by federal grants, the Nebraska Department of Natural Resources, the Nebraska Environmental Trust and center pivot manufacturers.



Derrel Martin



- ➔ About one-sixth of Nebraska’s land area or about 9 million acres is irrigated cropland. About 85 percent of that is center pivot-irrigated.
- ➔ Nebraska’s farms and ranches use 45.5 million acres — 93 percent of the state’s total land area.

UNMANNED AERIAL VEHICLES

can help farmers evaluate crops

by Alex Wach



“Unmanned aerial vehicle technology is allowing us to significantly increase yields, or maybe more importantly, to achieve those yields in an environmentally efficient way.”

—Richard Ferguson, Professor, UNL Department of Agronomy and Horticulture



IN THE NEXT THREE TO FIVE YEARS, unmanned aerial vehicles (UAVs) will be a common sight over Nebraska fields, performing tasks such as scouting for pests and assessing crop nutrient use in a timely and efficient manner.

UAVs have been part of a University of Nebraska—Lincoln soil scientist’s research for the past 16 years. Richard Ferguson started his UAV research with a model plane in 1998 and has graduated to studying a variety of aerial platforms since then. He defines a UAV as any aerial platform that does not have a person in it, such as a motorized platform, balloon, blimp, or another platform that can carry sensors.

“Over the next few years, the largest use of unmanned aerial vehicles will be agriculture related,” said Ferguson, professor of soil science in the Department of Agronomy and Horticulture in the Institute of Agriculture and Natural Resources. “I think as soon as regulations are set for

commercial use, you will see a rapid expansion of these kinds of systems in agriculture and farmers will be using them broadly in Nebraska within the next three to five years.”

Ferguson said that the public has become most familiar with UAVs through military uses. While there are some privacy concerns related to commercial use, generally those aren’t an issue in agriculture.

“There is imagery being collected all the time with airplanes and satellites, and this is just a little lower elevation type of imagery than what we can get with a satellite or an airplane,” Ferguson said.

Currently, UAVs cannot be used commercially, but that is likely to change in the near future, Ferguson said. Universities and governmental agencies can use UAVs for research if they have a certificate of authorization from the Federal Aviation Administration.

“An unmanned aerial vehicle image can be taken at a much lower altitude so you have higher resolution in your image and potentially at a much lower cost.”

—Richard Ferguson

BIRD’S EYE SCOUTING

Ferguson’s UAV research has focused on sensing crop stress related to water and nutrients, particularly nitrogen.

“How we manage fertilizers to supply nutrients to crops is important because we have learned that we can sense stress in plants with sensors often before we can see it with our eye,” Ferguson said. “So by measuring that stress and being able to manage that early before it becomes an economic risk, we can manage our inputs in such a way that they are very carefully managed and can still be economically beneficial to the grower.”

Ferguson evaluates patterns in the field and other indications of stress that might not be visible to the farmer, including damage from nutrient deficiencies, weeds, insects, disease, and too little or too much water. These stressors can be tracked through UAVs with different sensors that can detect interactions of both water and nitrogen stress in crops.

“The goal of this kind of research is to better understand how farmers can manage water and fertilizer in order to optimize yield, profit, and production,” Ferguson said. “It is also important to minimize loss of nitrogen to the environment in such a way that can impact water quality negatively and be an economic loss to the farmer.”

Many advances are being made in UAV technology for agriculture, particularly with sensors and the application of those sensors to agriculture, Ferguson said. One of his primary interests is how producers can use this information to better manage a crop.

“There is a continual evolution in the types of sensors being used, and the types of stress being measured or managed,” Ferguson said. “The UAV platform itself is very rapidly changing as things become more miniaturized in the sensors, and the power systems become more capable.”

For example, farmers are using sensors to manage irrigation water using a technology that was not broadly available 5 or 10 years ago.

“The technology that is in a farmer’s tractor or combine is pretty amazing now in terms of use of GPS and auto-steer technologies,” Ferguson said. “Increasingly, farmers are becoming comfortable with technology and using it, understanding how it applies to their enterprise. Aerial sensing is just another extension of that type of technology.”

UAV BENEFITS IN FARMING

Ferguson described many advantages to using UAVs in agriculture. In the past, farmers have used aerial images of crops and fields from satellites or airplanes.

“The advantage to a UAV is that you can spontaneously go to a field and see what is going on,” Ferguson said, without having to schedule an airplane or access satellite data.

He prefers a UAV over a satellite because a satellite revisits a site every five to seven days. If it happens to be cloudy when the satellite passes, the producer would not have an image to use. A UAV image can be taken at a much lower altitude and provide a higher image resolution, and potentially at a much lower cost.

“The cost of a UAV platform is pretty inexpensive compared to scheduling an airplane flight or buying satellite imagery. One flight of an airplane might pay for a UAV in some cases,” he said.

The future of UAVs in agriculture looks bright, Ferguson said. He recently was in Spain for a conference, and UAVs were being used on vineyards to sense stress from inputs such as pesticides and fertilizers during the growing season.

“This type of technology is allowing us to gradually, or in some cases, significantly increase yields along with achieving those yields in an environmentally efficient way,” Ferguson said. “If our inputs of fertilizer, water, and pesti-

cides are minimized and our yield potential is maximized in a profitable way, we are optimizing profit and minimizing agriculture’s impact on the environment.”

Conducting this research at a public university such as UNL “allows us to consider economics, the environmental impacts, the crop physiology, and all those things together as we develop systems that are more efficient for crop growers.”

Ferguson’s UAV research is funded by private industry, natural resource districts, and state and federal agencies.



Richard Ferguson

ECONOMICS

“The Rural Futures Institute is drawing together a remarkably wide and deep set of resources with the idea of building both community capacity and the confidence of rural people to pursue a preferred future. If we can help to build strong, vital rural communities built upon strong, local leadership, then we believe we will have made a major contribution to the State of Nebraska, to the strength of the United States of America and to strong countries around the world.”

*Chuck Schroeder
Executive Director
University of Nebraska Rural Futures Institute*



WITHOUT PLANNING FOR IT, it seems as if Chuck Schroeder has been preparing for a lifetime for his job as founding executive director of the University of Nebraska's Rural Futures Institute (RFI).

Schroeder grew up in a small town in Southwest Nebraska and went on to stints with the Nebraska Department of Agriculture, the University of Nebraska Foundation, the National Cattlemen's Beef Association and the National Cowboy and Western Heritage Museum before returning to Nebraska in 2013 to take the RFI post. Along the way, he has nurtured an appreciation for rural America and a passion for helping it succeed against challenging odds.

The RFI was founded in 2012 as a University of Nebraska-wide partnership. It aims to succeed where other rural-improvement efforts in Nebraska and the United States have fallen short — by bringing together expertise from all four NU campuses to partner with community leaders, local governments and businesses, non-profit organizations and more.

"Throughout my life, I've observed rural communities and it's always been apparent to me that the challenges and opportunities they face are complex, they are unique and often specific to the communities themselves," Schroeder said. "Consequently, many of the efforts that have been made by a single institution or a single organization

to address rural issues have been too narrow and not as effective as they might be."

RFI's broader, more inclusive effort, "it seems to me, is the very best opportunity I've seen in my lifetime to really make a difference in these communities that are so important to our country," Schroeder said.

'RURAL' AND 'FUTURE,' DEFINED

How to define "rural"? In Nebraska's case, Schroeder said, it's essentially all of the state outside the Lincoln and Omaha areas. Even Grand Island, now classified by Census standards as "urban," is so surrounded by rural culture and interests, it meets the rural definition.

It's just as important to have as expansive a definition of "futures," he added. One community's desired path does not need to be the same as another's. That's one of the keys to RFI's mission — allowing communities themselves to "pursue their preferred futures," rather than look to experts from elsewhere claiming to have all the answers.

"We are not in the business of bringing a prescription from on high to every rural community and trying to make all of them either look alike, behave alike, or even have similar dreams," Schroeder said. "We begin by going to the communities themselves and asking community stakeholders what their vision is for the future? What are the oppor-

tunities they believe they could pursue based on the unique strengths of their community?"

"When we know that, we can start drawing from this really remarkable universe of resources that are connected and starting to collaborate within the Rural Futures Institute to address those very specific issues that confront each community," Schroeder said.

WORK UNDERWAY IN TEACHING, RESEARCH, ENGAGEMENT

The RFI awarded an initial round of grants in 2013, and a second round of awards are slated to begin on July 1, 2014. The awards are targeted at a variety of specific projects, some in teaching and engagement, others in research and engagement. Schroeder is particularly pleased with some projects that involve university students. They are getting "real on-the-ground, dust-on-their-boots experience" in building relationships with community leaders, coming to understand the communities' challenges and helping address them.

Among other things, research grants are funding attempts to measure entrepreneurial support in individual communities with an eye toward increasing economic activity, without which it is nearly impossible to address other challenges.

LOOK BEYOND '4 OLDEST, FATTEST GUYS IN TOWN'

Schroeder challenges the so-called experts who tout formulas and rules for rural-community success that might include population numbers, economic diversity and distance from the interstate.

"My experience has been that those rules are hardly reliable predictors," he said. "I have seen communities of various sizes, various locations, various economic mixes that blow those rules out of the water, and the truth is that it always comes down to the people who live in that community deciding whether or not they're going to have a viable community or not."

Communities that succeed don't just have "the four oldest, fattest guys in town making all the decisions," he added. School teachers, farmers, local business people, students come forward and get involved.

Schroeder points to communities in Nebraska that survived desperate economic times in the 1980s and revitalized themselves: Eustis, Broken Bow, Imperial and others.

Broken Bow's example is particularly instructive. It suffered devastating losses in the '80s, but a group of young business owners "sat down and said, 'We think our community can be better. We think it can be stronger. We're not OK with the way it's deteriorating,'" Schroeder said.

They didn't have a "pot of money to throw at it," but they started by talking differently about their community, he added. Instead of bemoaning their losses, they focused on the community's strengths and built from there. That thinking was infectious.

"They re-established the notion that there are wonderful elements to this community today, and tomorrow could be better than today and by golly, we have the power to make it so," Schroeder said. "Clearly, this is a community that refused to follow the rules, refused to follow the trend lines and assume that the past is prologue, and they said no, we have genuine hope for our future and we're going to build it."

NEBRASKA CAN LEAD ON RURAL DEVELOPMENT

So, how can we measure RFI's success in, say, 2050? Schroeder said he expects other communities to follow Broken Bow's path — in their own way, of course — and for Nebraska to be seen as a national and international leader in rural development.

"I think Nebraska will be nationally recognized as a hotbed for strong, vital rural communities that are really poised for small business development, small business growth. (They will be) great places for entrepreneurs to come and take advantage of local resources to make things happen, and by the way, demonstrating capacity to deal with issues ranging from housing and law enforcement, to immigration to quality of life issues, demonstrating that we can wrestle with issues of that nature and empower our own community leaders to deal with them and move forward," he said.



Chuck Schroeder

INSTITUTE AIMS for better future for rural Nebraska

by Dan Moser



"We as an institution believe that rural matters, that strong and vital rural communities are important to our economy, our society, our culture — and we're going to make the investment necessary to help those communities that are in our purview to be as strong and vital as they can."

—Chuck Schroeder, Executive Director, University of Nebraska Rural Futures Institute

AG ECONOMICS EXTENSION

helps producers improve techniques, profits

by Mary Garbacz



“We are the stewards of our land, trying to do the best we can to maintain sustainability within agriculture. It’s being an open book in showing (people) that we’re not trying to hide anything.”

—Kate Brooks, Assistant Professor, UNL Department of Agricultural Economics

AGRICULTURAL ECONOMISTS study everything related to agriculture, from large-scale, global economies to individual companies and consumers.

Kate Brooks’ area of expertise is livestock markets in Nebraska, the U.S. and around the world. Brooks travels throughout Nebraska as a University of Nebraska–Lincoln Extension agricultural economist, providing information to the state’s livestock companies and producers so they can make the best possible decisions in every situation. Those decisions make a difference not only to a single producer or company, but to the entire economy of Nebraska. Increased revenue brings about more jobs, which help to stabilize the state’s economy, insulate it from recession and encourage future growth.

Even though she specializes in the economics of livestock production, it is essential to consider the entire production system, Brooks said. “It’s looking at the whole system within livestock production and crop production and how these all interact with one another,” she explained. In beef production, it’s not only the cow-calf producer, but following that calf all the way to the end consumer — including how the feed was grown, how the calf was fed and raised and the effects of various decisions on profits.

Just because a neighbor makes a specific decision or implements a particular management technique or tool doesn’t mean it is right for someone else, Brooks said. Her advice and information about managing risk and understanding

the ag markets are tailored to the individual company or producer.

“There are a lot of different things that can go into the word ‘technology’ or advancements within science,” Brooks said. Managing producers’ risk can include technologies such as new management techniques, new kinds of equipment, alternative feedstuffs, or even just monitoring the markets with the latest mobile phone applications.

Brooks sees her responsibilities as helping producers and business owners to understand supply and demand, policies and the livestock markets — and how to make those markets work in producers’ and companies’ best interests.

CATTLE NUMBERS, BEEF PRICES

Nebraska faced a serious drought in 2012, which forced some Nebraska producers to cut back their cow herds. Now that the drought has eased, producers are rebuilding their herds, but it takes time, money and information to make the decisions that can produce abundant, high-quality food products and still allow producers to make a profit.

“We’re seeing record-high cattle prices as well as declining input prices,” Brooks said, “so we see market signals for expansion.”



Those prices will allow producers to gradually expand their cattle herds, which will result in more stable prices. Increases in cow-calf profitability potential signal producers to expand, she said. This increased profit potential causes the beef cow numbers to increase, which increases the animals available for Nebraska feedlots. The expansion of the cow herd, however, is a slow process due to biological constraints, she added.

“We have a competitive advantage in Nebraska, with the resources that we have available for inputs, and the cost advantages we have for ethanol production,” Brooks said. Corn ethanol production yields a co-product — distillers grains — that becomes a high-protein feedstuff for cattle. Another resource is the Ogallala Aquifer, which underlies most of Nebraska and provides water to animals and crops, even during dry years. Livestock producers in other states send calves to Nebraska feedlots, especially when conditions are too dry in their own states to produce enough feed for the animals. There has been a general shift in cattle on feed numbers to the Northern Great Plains regions, she said.

EXPORTS TO OTHER STATES, OTHER COUNTRIES

Nebraska ranks No. 1 in the U.S. in commercial red meat production and third in corn production, according to the Nebraska Department of Agriculture, which means the state has a surplus of those products. The state ranks second in the U.S. in exports of protein products, Brooks said — not only to the international market, but also to other U.S. states. Those protein products include not only the high-end beef, but also what Brooks calls “value meats” — the products that are not as popular in America but are valued in other cultures. Examples of value meats are tongues, livers and other organ meats.

“We want to use the entire animal,” she said, which makes the total cost lower than if only the high-end cuts were sold. “We’ve seen a strong demand in the export market for not only beef, but all protein products,” she added. Finding a market for every part of the animal, whether it is beef, pork or chicken, results in the best possible profitability.

Nebraska’s top four markets for international exports are Canada, Mexico, Japan and Hong Kong, Brooks said. The state exports beef, pork and chicken, but also cheese, dried milk and other products, she added.

TRADE BARRIERS

International marketing must take into account any cultural, religious, policy or trade barriers that a country

might impose. Those barriers can change frequently, depending on the issue and the country, so Brooks stays current so she can provide accurate information to Nebraska individuals and companies.

An example of a trade barrier occurred in late 2003 when one Canadian-born dairy cow in the state of Washington became the first animal in the U.S. to test positive for Bovine Spongiform Encephalopathy, better known as BSE. Although the animal never entered the food supply, international markets for U.S. beef products were affected. Today, more than 10 years later, the markets for U.S. beef are just approaching pre-2003 levels, Brooks said.

“We’ve been slowly, over the last several years, getting those export markets back open,” Brooks said. Japan had been accepting imports of U.S. beef if the animals were under 30 months of age at time of slaughter, but recently opened its market further so it now accepts imports of beef animals more than 30 months of age. China still has not opened its borders to imports of U.S. beef, she said.

Some countries have bans on genetically engineered products or on feed additives. Methods that are used in the U.S. to produce meat products may not be what other countries prefer, Brooks said.

But sometimes, the trade barriers or bans are politically motivated; sometimes countries are trying to protect their own country’s production of meat products.

“We do have 20 countries that we have free trade agreements with,” Brooks said. “We’re trying to decrease trade barriers and open up some of those borders with other countries.”

CONSUMER INTEREST IN AGRICULTURE

Brooks said it used to be that people were closely connected to farms and farming, having either grown up on a farm or regularly visited a relative’s farm. However, fewer people now have that connection, but have a renewed interest in understanding where their food comes from.

“Showing consumers that the product is safe and helping them understand where it comes from — and the entire process — works for a global market as well,” Brooks said. She believes in being open and clear in communicating how products are produced, as well as in how Earth’s resources are used.

“We are stewards of our land, trying to maintain that sustainability within agriculture. It’s being an ‘open book’ in showing them that we are not trying to hide anything,” Brooks said.



“We’re seeing record-high cattle prices as well as declining input prices — so we see market signals for expansion.”

—Kate Brooks



Kate Brooks

MARKET AND POLICY ANALYSIS

to improve understanding of economics of policies, innovations

by Alex Wach



“Our research shows the kind of technologies needed to combat hunger are drought-resistance GM technologies, or crops that have enhanced water use efficiencies. In most of those areas that are hunger stricken, the major problem is water.”

—Konstantinos Giannakas, Harold Eberhard Professor, UNL Department of Agricultural Economics



Konstantinos Giannakas

EFFECTIVELY ADDRESSING the world’s growing need for food will center not only on advances in scientific research, but also on consumer awareness and properly designed public policy.

At the University of Nebraska–Lincoln, the Center for Agricultural and Food Industrial Organization–Policy Research Group (CAFIO-PRG) has developed a new policy analysis framework that takes into account differences in consumer preferences and crop agronomic characteristics, competition among agribusiness firms, and links and interactions between agri-food supply channels.

“We’re very excited about this new framework as it enables us to determine the effects of different policies on different consumers and producers,” said Konstantinos Giannakas, CAFIO-PRG project director and Harold Eberhard professor in the Department of Agricultural Economics. “We no longer have to aggregate consumers or producers as a group, as we can segregate those groups and find the effects of different policies on different consumers and producers.”

The global mission of CAFIO is to bring together scholars from around the world who have an interest in the industrialization and organization of the agri-food system.

The new policy analysis framework provides a method for analyzing multiple markets with different structures and the competitive relationships between key firms.

“Having a better understanding of the effects of a policy can lead to improved policy design, increased effectiveness, and enhanced efficiency,” Giannakas said.

GMOS AND COUNTRY-OF-ORIGIN LABELING

National and international policies on genetically modified organisms (GMOs) are among the topics analyzed by CAFIO-PRG. A GMO is an organism whose genetic material has been altered using genetic engineering techniques.

The market and welfare impacts of GMO crops or products in a food system depend on the nature and the type of the genetically modified product, Giannakas said. The first generation of GMOs provided insect and virus resistance and herbicide tolerance for agricultural crops such as corn, soybean, and cotton. Last year, 18 million farmers in 27 countries planted these new crops. Consumers have been less enthusiastic about this new technology mainly due to health, environmental, and ethical concerns about GMOs, Giannakas said.

“The consumer aversion to GMOs varies between different countries. We expect this aversion to be reduced with the introduction and extensive commercialization of second generation GMOs,” Giannakas said. Second generation GMOs will focus on improving product quality and providing consumer benefits.

Another important policy impacting the agri-food system is country-of-origin labeling. The underlying hypothesis, Giannakas said, is that consumers care about the source of their food and where it is being produced.

“Our research has shown that three key factors — the value consumers place on the country of origin information, the size of the labeling costs, and the market power of the retailers — determine who will be the winners of this policy,” Giannakas said. “We have found that the policy affects different groups differently.”

FOOD SECURITY AND NANOTECHNOLOGY

Giannakas also researches food security, looking at how innovations and policies can be used in the fight against hunger and malnutrition around the world. His research focuses on how technologies, innovations, and policies affect yields, cost of production, product quality, and consumer access to food.

Over the last 15 years genetic modification has been a major transforming force in the agri-food system. Much of Giannakas’ research has looked at the market and welfare impacts of introducing genetically modified products into the agri-food system. He also has been researching the impacts of nanotechnology, now that this technology is being used to increase food safety and quality of products. Nanotechnology refers to interventions made at the nanometer scale; a nanometer equals one-billionth of a meter.

“We hope our research can help design better policies, more effective policies, more efficient policies that create fewer unintended consequences,” Giannakas said.

SPREADING THE WORD

Giannakas’ research extends beyond Nebraska. He has made presentations to USDA and the European Commission, and has released CAFIO policy papers (titled “Pagers”) that have been distributed to national and international policymakers.

“With CAFIO Policy Pagers, we discuss key policy issues, like labeling of GMOs, coexistence of GMOs with their conventional and organic counterparts, nanotechnology, and purity standards in food labeling,” Giannakas said. “In one page, each Policy Pager communicates the essence of the issue, why people should care about it, and the findings of our research. We have received excellent feedback from both academia and policy-making circles.”

TARGETED POLICY RESEARCH

In a world that will need to feed 9 billion people by 2050, understanding the potential effects of agricultural and food policies can lead to more targeted and effective policies. “Not all consumers are the same, especially when we discuss 9 billion people by 2050. We need to focus on certain segments of the population that will have greater needs than others, and have to make sure the policy instruments are designed to fit the idiosyncrasies of these groups,” Giannakas said.

Another example of his targeted policy research focuses on providing incentives for a company in the western world (like Monsanto in the United States) to develop a crop that will be needed in a developing nation.

“There need to be sufficient incentives for innovating firms, and then, once the technology is developed, there should be sufficient incentives and access for the people in need to be able to adopt this technology,” Giannakas said.

It’s important that such policy research be conducted at land grant institutions like UNL because often private institutions may not have sufficient incentives.

“The benefits the private sectors perceive do not always include all the social benefits that could result from this research. Universities like UNL often have the right human capital in place and synergies that are necessary to tackle big problems that will impact people, and will have benefits outside of the short boundaries of any firm that would be undertaking this research,” Giannakas said.

“It is a great privilege to work at a land-grant university in a state that has such a tremendous support for higher education,” Giannakas said.

CONSUMER TRUST A KEY COMPONENT in genetic engineering trends

by Kristi Block



“I grew up in Europe, then lived in Canada and now in the U.S., so I am more likely to look more critically into what kinds of factors affect consumer attitudes. It is not just having the information or not having the information, as many believe.”

—Amalia Yiannaka, Associate Professor, UNL Department of Agricultural Economics

CONSUMER RESISTANCE OR consumer acceptance decides whether products, policies, and technologies succeed in the marketplace. To better understand consumer influence, University of Nebraska–Lincoln Associate Professor Amalia Yiannaka studies the market and welfare effects of agri-food innovations. Her research helps predict the market acceptance and profitability of these innovations by studying why consumers accept or resist a new product, policy or technology.

Yiannaka has found that consumer acceptance of new technologies depends on the level of real or perceived benefit to the user.

GENETIC ENGINEERING’S GENERATIONAL EVOLUTION

Having lived in Europe, Canada and the United States, Yiannaka looks critically at the factors that influence consumer attitudes.

It’s not just whether consumers have the information or don’t have the information, as many believe,” said Yiannaka, associate professor in the UNL Department of Agricultural Economics. Some consumers oppose genetically engineered plants and food products because they don’t see any direct benefits to themselves.

“There are studies that show when it comes to GMOs [genetically modified organisms], providing more balanced information to consumers makes them more

suspicious and more skeptical,” she said. “It’s almost that they find this information is suspiciously persuasive. So the answer is not just giving consumers more information or reducing prices of this [genetically engineered] product. It’s really in having the consumers see a benefit.”

The first genetically engineered products were plants with insect-resistant traits that only directly benefited crop producers by reducing costs and increasing yields. Recent efforts have focused on developing products that benefit consumers by improving food safety, nutrition, and palatability, Yiannaka said.

NANOTECHNOLOGY INCREASING FOOD SAFETY AND TASTE

Nanotechnology — engineering at the molecular level — allows developers to “change the processability of the product by going to the nano-scale [molecular] level to enhance some of the food properties like taste, for instance,” Yiannaka said. Examples of foods currently produced using nanotechnology include fortified juices, chocolate, ice cream and cream cheese.

In New Zealand, nanotechnology has been used to develop a smart package. The package has a label on top with a nano-sensor that changes color, signifying the ripeness of the fruit in the package, Yiannaka said. Another smart package being developed will change color if the food becomes contaminated or spoiled, Yiannaka added.

“So as a consumer, you would see from the package whether the product is safe. It’s not just when you go and buy the product in the supermarket, it’s when you store it at your house that you may run the risk of the product being contaminated with bacteria,” Yiannaka said.

Crop producers could also benefit from nanotechnology innovations. Nano-sensors could monitor plant disease and help with pest control. Other nanotechnology innovations could be used to monitor chemicals in the soil.

NANOTECHNOLOGY INDICATORS

(2000-2008)

- ➔ 35 percent increase in research and development funding for nanotechnology
- ➔ 35 percent increase in patent applications involving nanotechnology
- ➔ 25 percent increase in the workforce employed in the nanotechnology industry

LABELING GENETICALLY ENGINEERED FOODS

Another area of Yiannaka’s research on consumer preferences is examining how genetic engineering and nanotechnology have contributed to a public debate about food labeling. In the United States, the premise has always been that genetically engineered foods are equivalent substitutes for conventionally grown foods. This premise is why genetically engineered products are not labeled as such in the United States, Yiannaka said.

The European Union has followed a more precautionary premise: in the EU the claim is that genetically engineered and non-genetically engineered products may have differences and are labeled accordingly so consumers can make an informed choice, Yiannaka said. After the bovine spongiform encephalopathy (BSE) outbreak, European regulatory bodies had initially assured consumers BSE was not transferrable to humans eating infected meat, she said. When BSE was linked to human illness, consumer trust was diminished.

The debate over labeling has led Yiannaka to research these questions: “Does the fact that something is labeled make you more likely to question how good the technology is?” and “Is it more likely to make you more confident that the food you consume is safe?”

Given that research shows consumers interpret balanced information based on their demographics, cultural beliefs and values, “if they are opposed to the technology, seeing it referenced on the label may increase their opposition. I am currently studying how one can frame information about new technologies so that diverse groups of consumers interpret it in a similar manner,” Yiannaka said.

GENETIC USE RESTRICTION TECHNOLOGY

Similarly, Yiannaka is looking at consumer acceptance of a new crop seed technology. Seeds produced with genetic use restriction technologies (GURTs) will produce a single year of crop. Any seed saved from that crop will be sterile, so will not reproduce. Currently, producers sign technology-use agreements stating that they — the producers — will not save and replant any proprietary seed bought from the seed company. GURTs would allow seed developers to retain earnings from the scientific development without the cost and difficulty of monitoring and enforcing technology use agreements, Yiannaka said. While companies are patenting GURTs, they haven’t introduced the technology commercially.

Yiannaka’s research indicates developers should not introduce GURTs if consumers are opposed to the technology; if consumers do not buy the product, producers won’t find it profitable to adopt the technology.

FUNDING

Yiannaka’s research is funded by the Agricultural Research Division (ARD) of UNL and the National Institute of Food and Agriculture (NIFA), part of the United States Department of Agriculture.



Amalia Yiannaka

ANIMAL and veterinary science

"I would argue that there is no way we can feed the world population in 2050 using science from 1950. We have to use all available tools to be able to feed a growing population and that means evolutions in science, but also evolutions in understanding science."

*Matt Spangler
Associate Professor of Animal Science
University of Nebraska-Lincoln*



SEEKING A NEW and improved rumen

by Dan Moser



IT'S A FAR CRY FROM BREEDING guppies for tail color to manipulating ruminant gut microbial communities for a more efficient animal to help feed the world, but that's the journey scientist Samodha Fernando has taken.

"That's how I got into science," Fernando said of his aquarium experimentation. In high school he got interested in microbes in animals — primarily the ones that cause diseases.

Fernando, a molecular microbiologist and assistant professor of animal science, leads University of Nebraska-Lincoln scientists' efforts to "reprogram the rumen" to increase livestock efficiency. Others involved in the research are Galen Erickson, James MacDonald and Terry Klopfenstein.

A rumen is the largest of four chambers in ruminant animals' digestive system. It is filled with billions of tiny

microorganisms that are able to break down grass and other coarse vegetation and complex carbohydrates that non-ruminants, including humans, cannot digest efficiently.

Dairy and beef cattle are ruminant animals.

GOOD GUYS VS. BAD GUYS

Fernando's research seeks to answer two basic questions: What different species of microbes are found in the rumen, and what are they up to? Among the billions of microbes found in the rumen, most are beneficial but some pathogenic microbes that can cause disease also are present.

The concept is that if scientists can encourage growth of beneficial microbes in the rumen by introducing them early in life, they can get established and help increase animal performance and prevent or decrease the colonization of pathogenic microbes through competitive exclusion.

Fernando's research seeks to answer two basic questions: What different species of microbes are found in rumen, and what are they up to?

—Samodha Fernando, Assistant Professor, UNL Department of Animal Science



The most abundant group of microbes in the rumen are bacteria, but protozoa, fungi, archaea and viruses are also present within the rumen. "You cannot understand how these work together if you just focus on one," Fernando said. "So we're looking at all of them to see how they interact."

Some perspective on just how daunting this is: One milliliter of rumen fluid has 100 billion bacterial cells; the rumen can hold up to 65 gallons of fluid (that's about 246,000 milliliters). This is just the bacteria.

MORE PEOPLE, MORE PROTEIN

As a growing population demands more food — including more, and meatier, proteins — scientists and producers must figure out how to make current resources stretch to meet those needs, Fernando noted. Since there's no way to increase, say, beef cattle production 38 percent by 2050 — the approximate expected increase in human population — they must get more out of existing, or even with decreased number of animals due to limitation of space and other resources.

Manipulating the rumen may be one way to do this. For example, if microbes that are more efficient in breaking down low quality feeds can be colonized in the rumen, feed costs can be reduced (feed comprises 60 percent of production costs), leading to huge economic benefits to the producers. This could increase production of milk and meat while lowering costs.

Beyond such basic questions, Fernando said, he and others are working to find management strategies producers can apply in their operations. One such study that introduces a direct fed microbial (DFM) has the potential to decrease shiga toxin producing *E. coli* shedding in cattle and to increase cattle performance about 10 percent. "The DFM were eating less but putting on more weight," Fernando said.

Fernando also researches cattle emission of methane. Producers are skeptical of claims that cattle are a major contributor to greenhouse gases, but Fernando said they are looking for ways to convert the energy loss during methane by diverting the hydrogen produced during fermentation to other processors using microbes that convert the hydrogen and methane produced during fermentation into other energetic compounds.



Samodha Fernando

Fernando, together with Dr. Paul Kononoff, is also looking into why feeding distillers grains to dairy cattle decreases milk fat — a concern for producers because the fat level in milk determines prices.

A GUT REACTION

Scientists elsewhere in the UNL Institute of Agriculture and Natural Resources are engaged in research on the human gut. Due to the large number of similarities between the human gut and the pig digestive systems, there are important lessons scientists can learn from using livestock species as a model for human gut microbiome research. Fernando said.

For example, he is developing a model to investigate how microbial genes interact with host genes in germ-free pigs inoculated with human gut microbiota, with an eye toward translating those findings into understanding the therapeutic potential of the gut microbiome to reduce obesity in humans.

Fernando's research is funded by the U.S. Department of Agriculture, Nebraska Beef Council, National Cattlemen's Association, Nebraska Corn Board, National Pork Board, and the Nebraska Center for Energy Sciences Research.

USING GENETICS TO INCREASE FEED EFFICIENCY and reduce production costs

by Mollie Wilken



“At the end of the day, what we want to do is develop tools that producers can use in a relatively easy fashion, to help improve profitability in their operation. Making genetic change is one of the tools we have to improve profitability, as well as adopting new management strategies. Think of it as nutritional strategies and using those tools together to improve the profitability of the enterprise.”

—Matt Spangler, Associate Professor, UNL Department of Animal Science

ANIMAL SCIENTIST MATT SPANGLER is working to develop genetic tools to increase feed efficiency in cattle and help cattle producers increase profitability. The research also could help consumers by resulting in better marbling and increased tenderness in the beef they buy.

“The beef industry should actually pat itself on the back because here’s a case where we’ve actually adopted something that’s fairly novel and we’ve done so fairly quickly,” said Spangler, an associate professor in UNL’s Department of Animal Science.

Historically, scientists have used genetic selection to improve qualities such as animal weight, carcass traits and fertility, Spangler said. Those are output traits; not as much research was done on input traits.

Among the input traits Spangler’s team now is studying is feed efficiency.

IMPACT ON FOOD PRODUCTION

The beef cattle industry is critical to Nebraska’s economy, Spangler said. Improvements in genetic selection of beef cattle, specifically feed efficiency, is important on a state,

national and global level. In the past few years, the project has gained international collaborators from places such as Canada and Ireland.

“We completely agree we should make this (project) bigger because we can do more if we all collaborate, and so there’s definitely a global push in the utilization of genomic technology, but also improving these novel traits,” Spangler said.

Spangler’s research contributes to food production in its ability to make rapid changes toward meeting consumer demands in terms of product quality and protein production. “We have to become more efficient in the way we do things and that means making the correct selection decisions,” Spangler said.

FOCUSING ON FEED EFFICIENCY

Feed efficiency is a ratio of how much feed an animal eats compared to ultimate protein production resulting from that feed intake, Spangler said. “Essentially, how much did they eat versus how much did they gain,” he added.

The industry has not had genetic selection tools for feed efficiency because the data is difficult to collect. Spangler’s team, however, now has feed intake records on more than 10,000 animals representing eight breeds of cattle. These breeds include Angus, Red Angus, Hereford, Simmental, Gelbvieh, Limousin, Charolais and Wagyu.

After the data is collected, scientists use as many as 800,000 DNA markers in the animals to begin to understand genetic differences between those that have greater feed efficiency and those with less.

“So with that in mind we can use that information in the industry to determine the genetic merit of an animal for feed intake without ever having to collect the actual feed intake records for it,” Spangler said.

Based on Spangler’s research, scientists now can determine 20 to 40 percent of the phenotypic differences in dry matter intake or residual feed intake using those DNA markers, he said. The industry then can use those tools in breeding programs for selection or change of feed intake traits.

In addition to feed efficiency, Spangler also collects information from the DNA markers on birth weight, weaning weight, yearling weight and carcass traits. In the past four years, large beef breed associations have expanded their traditional expected progeny differences (EPDs) of those traits using this genomic information, Spangler said.

WHY FEED EFFICIENCY?

Spangler said improving feed efficiency is important because feed costs represent a major portion of a beef operation’s expenses.

“Depending on whether calves are put into a feed yard as weaned calves or as yearling cattle, feed costs can account for between 65 and 80 percent of total costs, so it’s extremely important to improve,” he said.

If an animal reduces its intake by two pounds per day, and gain stayed constant, the U.S. feedlot sector could save close to \$1 billion annually. Research has shown that feed efficiency is heritable and rapid improvements can be made, Spangler said.

INFO
bytes

Cattle outnumber people in Nebraska, with nearly 6.3 million head of cattle on farms and feedlots and only 1.8 million residents.

Nebraska has the top three beef cow counties in the U.S. No. 1 is Cherry County.



INDUSTRY RESPONDS WITH TECHNOLOGY ADOPTION

Spangler wants to ensure that usable information is presented to the industry. In addition to the research, the project includes an outreach component to help the industry adopt its findings. Spangler works with breed organizations and key technology adopters in the United States. Seed stock producers have a track record of being early technology adopters, Spangler said. They are directly involved in the research project by allowing their animals to be used for discovery or evaluation of results. By incorporating their livestock Spangler hopes the producers will become familiar with the process and results.

“This project at large is a five-year project. We’re wrapping up year three so we have a bit of time yet, but it actually has been encouraging how much the industry has been engaged with it,” Spangler said.

Breed associations and their members are prepared to use this information, Spangler said. He has observed that when producers couple their traditional genetic selection

tools with this new information, animal genetics are improved because of the increase in accuracy.

“This means we can make genetic change at a faster pace now than what we could before,” Spangler said.

RESEARCH EVOLUTION

Spangler’s ultimate goal is to develop genetic tools, or Expected Progeny Differences (EPDs), which are numerical values that represent the genetic potential of an animal as a parent. Producers then will use that information when making selection and mating decisions so they can increase their profitability.

“At the end of the day, that’s what any beef enterprise should be concerned with — profitability in a sustainable manner — and so that’s what we want to help the industry do,” Spangler said.

To meet the world’s growing food needs, the industry needs to use all available tools, Spangler said.

“The goal is two things — evolving research, but ensuring that we can actually apply those research results,” Spangler said.

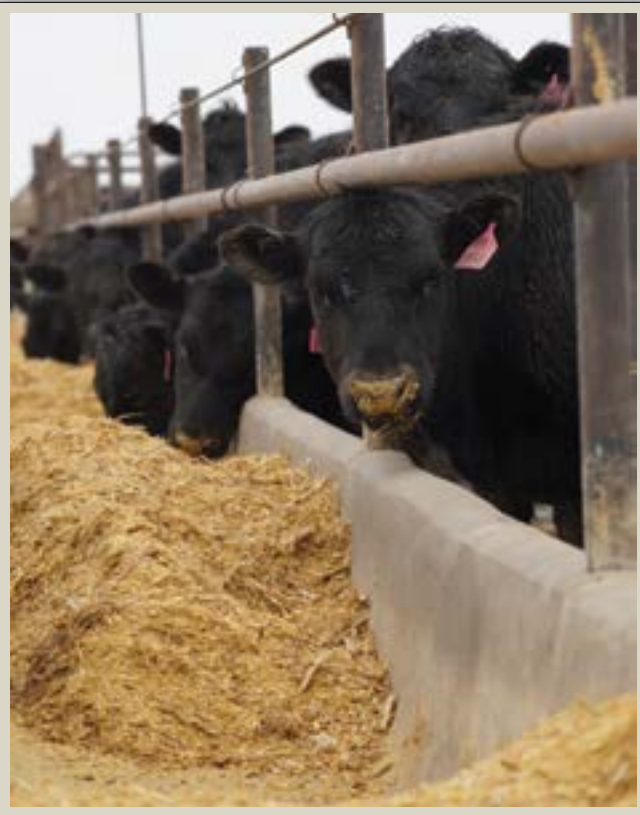
These latest findings are helping livestock producers further refine their decision-making to be more accurate and efficient while also making better use of natural resources, Spangler said.

It is important that cattle producers understand the tools that are provided and use them correctly, Spangler said. He also believes it is important that consumers understand industry practices are done with their interests in mind. By producing more food and using fewer resources, the beef industry is able to produce less-expensive food than it has in the past, Spangler said.

The feed efficiency project is funded by the U.S. Department of Agriculture and includes multiple universities, industry organizations and the U.S. Meat Animal Research Center at Clay Center.



Matt Spangler



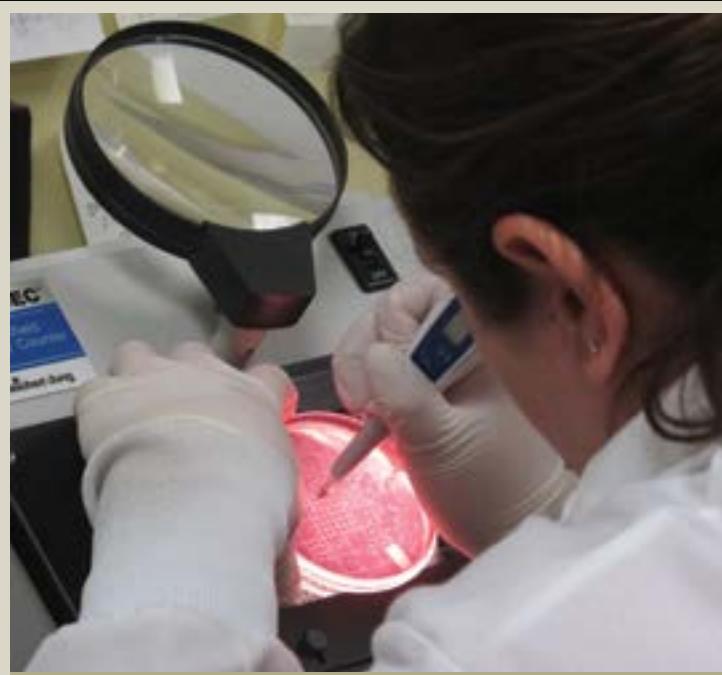
USDA–NIFA GRANT TARGETS reducing *E. coli* in beef

by Dan Moser



*“Our long-term goal is to reduce the public health risk of Shiga toxin-producing *E. coli* in beef. It is a multi-institutional project that involves 15 institutions and 48 scientists. It is very comprehensive.”*

—Rodney Moxley, DVM, Professor, UNL School of Veterinary Medicine and Biomedical Sciences



Research creates a safer food supply.

UNIVERSITY OF NEBRASKA–LINCOLN scientists are developing and refining new methods for detecting *E. coli*, including at extremely small levels in beef, as part of a national research project aimed at reducing the bacteria's threat to human health.

The \$25 million U.S. Department of Agriculture-funded project targets the main types of Shiga toxin-producing *Escherichia coli* (STECs) that pose a risk to food safety in the beef chain. More than 50 scientists at 15 institutions, including UNL, are participating in the research and education project.

Scientists are conducting pre-harvest, post-harvest and consumer research into these STECs, which comprise the often-researched and best-known O157:H7 and several other lesser known members of the *E. coli* family.

“To be realistic, we won't eliminate the organisms, but our goal is to lower the public risk of them,” said UNL's Dr. Rod Moxley, a veterinary pathologist. “These organisms are thought to be commonly carried by cattle, although we don't know their actual prevalence and concentration in them. That's part of what we're asked to determine.”

PROGRESS IN DETECTION

In the third year of the five-year project, progress is being made on several fronts, including the critical detection phase, Moxley said.

“Before we can say that interventions actually work, we have to be very confident in our detection methods to say how much of this organism is actually there in the first place,” he added.

“We have developed new molecular methods for detection in which we can detect specific genes from all of these organisms at one time in one type of assay,” he said. Further refinement is needed to allow us to definitively identify that a specific pathogenic of STEC type is present.

Moxley's team is also assessing differing types of media for growing and isolating the organisms to enhance their detection.

Moxley's team is also developing antibody-based reagents for use in detection. “We are in the midst of developing what are known as monoclonal antibodies that are very sensitive and specific for detecting these organisms,” Moxley said. These antibodies can detect the bacteria in retail beef at “very minute levels.”



*Rodney Moxley (center) has worked for decades on improving *E. coli* detection methods.*

RETAIL-BEEF TREATMENTS CAN INCREASE RISK

Scientists also are assessing the prevalence of these organisms in feedlot beef cattle, the pre-harvest phase. As for post-harvest, findings so far seem to indicate that the same type of cooking methods that will kill *E. coli* O157:H7 in beef will work on the other STECs too, Moxley said.

However, some treatments of retail beef can increase the risk of STECs. For example, blade-tenderization of steaks could double the infection risk; use of chemically injected tenderizers appears to increase the risk about four-fold.

In addition to improved diagnostic techniques, the STEC project will:

- Study the biological and epidemiological factors that drive STEC-caused illness
- Develop intervention techniques to reduce STEC risks from cattle, hides, carcasses and beef and devise ways to implement these interventions for all beef producers
- Develop a risk analysis model to evaluate the cost-effectiveness of mitigation strategies
- Communicate findings to stakeholders, food safety professional, regulators, educators and consumers so they can implement efforts to lower STEC exposure

UNL has experts working in four of these five areas; the only one it doesn't have a hand in is development of the risk-analysis model. On another front, scientists are studying antimicrobial sprays that could kill STECs on veal carcasses.

TEACHING HIGH SCHOOL TEACHERS

As for outreach and communication efforts, UNL has hosted high school teachers at workshops aiming to help them teach science more effectively. Already in place in

12 high schools in Nebraska and Kansas, new curricula are teaching students about food safety for college credit.

Also, one collaborator in the STEC project has developed nine educational modules to be made available over the web and through which people working in feedlots, ranches and processing plants can earn certification in STEC safety.

The project also includes an internship program that included 27 students in 2013 and 27 in 2014, working with scientists in all phases of the research.

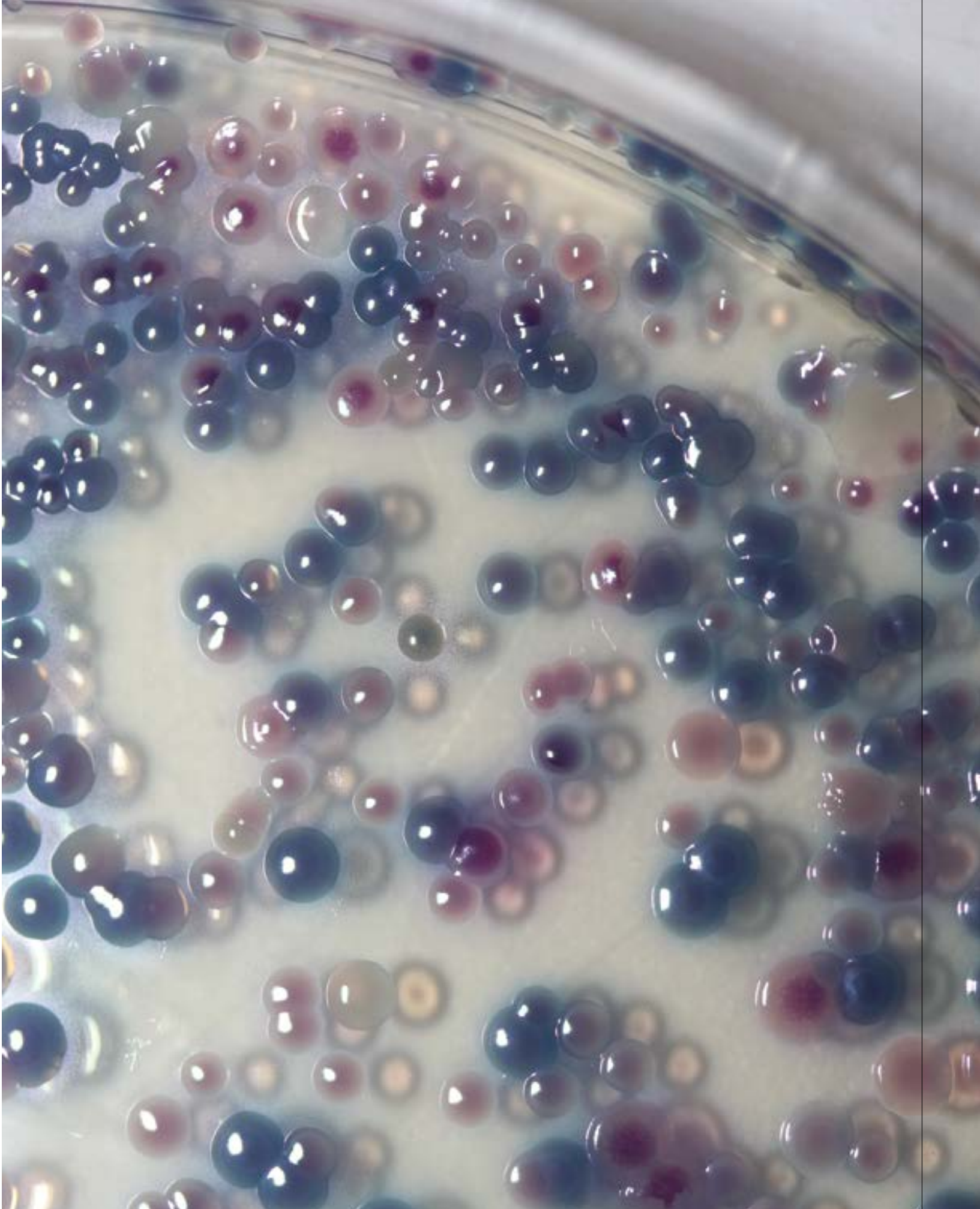
Moxley, who has been studying *E. coli* for about 30 years, said this research has significance both in Nebraska and around the world.

E. coli is extremely expensive for the beef industry. Recalls of potentially contaminated beef can be very costly; on top of that, subsequent public concern can reduce sales. Moxley said scientists also understand that it's likely the intervention techniques they devise might increase industry costs, but on the other hand, in the long run, might actually result in reduced costs. "Part of our research here at UNL is to assess what it's going to cost a beef packer or processor to implement these new interventions, and also to assess their benefits."

Although meat-borne STECs have so far been most prevalent in developed countries, where more meat products are consumed, it's expected that meat consumption will increase with a world population that is growing and, likely, will become more affluent, so the research now under way should help ensure a safer food supply globally.

"To be realistic, we won't eliminate the organisms, but our goal is to lower the public risk of them."

—Rod Moxley



ONE WORLD, ONE HEALTH

initiative aims to improve health of beneficial species of all types

by Dan Moser



“The One Health Initiative is an attempt to promote collaboration and creativity to deal with some of the health challenges that we face, both as a nation and a global community.”

—David Hardin, DVM, Professor, UNL School of Veterinary Medicine and Biomedical Sciences

THINK OF THE WORLD as one huge organism, with its various elements — human, plant and animal — interacting with each other, contributing to each others’ health, sometimes for better, sometimes for worse.

This is no hypothetical exercise; in countless instances, it is true, and the national One Health Initiative is an effort to get professionals in health sciences — for all species — to work together to improve the health of beneficial species and to combat detrimental ones.

Dr. David Hardin coordinates this initiative at the University of Nebraska–Lincoln.



David Hardin

“We live in a world that has much complexity and all the components really integrate, and the better we understand that integration ... the healthier we are as a population,” Hardin said.

This is not a new concept. The ancient Greek physician Hippocrates wrote about the importance of people understanding how the air they breathe, the water they drink, the food they eat and the communities in which they live affect disease and illness.

“It’s important that we address these things as the population grows to a projected 9 billion people worldwide in 2050,” added Hardin, a doctor of veterinary science.

70 PERCENT OF EMERGING DISEASES TRANSMIT BETWEEN HUMANS, ANIMALS

It’s estimated that about 70 percent of emerging diseases, which are defined as diseases that appear in a population for the first time or are rapidly increasing in a geographic region, are zoonotic, which means they can cross species lines, in some instances from animals to humans; in others, vice versa. These diseases are caused by bacteria, viruses, parasites and fungi that are carried by animals and insects. Examples are anthrax, dengue, Ebola hemorrhagic fever, *Escherichia coli* infection, and Lyme disease, malaria, Plague, Rocky Mountain spotted fever, *salmonellosis*, and West Nile virus infection.

Hardin said the University of Nebraska, including the medical center in Omaha, has scientists researching many

of these diseases. One goal of the One Health Initiative is to ensure scientists from different disciplines work together when appropriate.

“Working together, we better understand those relationships and we understand how to deal with these diseases,” Hardin said. “So the One Health Initiative is an effort to get the people working in all those various disciplines to interact, to have a better understanding of how those interactions and relationships affect the air we breathe, the water we drink and the food that we eat.”

As scientists from different disciplines work together, they may make surprising connections. “You sure learn a lot from your colleagues. They may make a discovery in a plant, for example, that might trigger a thought in another scientist to wonder if that same thing occurs in animals.”

WE ARE WHAT WE EAT

Diseases spread by food consumption are a particular concern for scientists. UNL’s Gut Function Initiative, for example, includes food, crop and animal scientists because humans’ gastro-intestinal systems are populated by microbiota that come from a variety of sources, including the food they eat. Some of those microbiota have positive influences; others cause disease.

“It’s important that we understand how the food that we eat is affected by the environment that it’s grown in,” Hardin said. “Again, the better that we understand those interactions, the safer the quality of food that we can produce and consume.”

This is an ever-evolving science, Hardin said. Many of the organisms that affect food are in a constant state of genetic reinvention, and they evolve in reaction to humans.

“They are survivors, and so our ability to understand the mechanisms that allow them (to evolve) puts us in a much better position to develop strategies to prevent those that cause diseases,” he added.

NEBRASKA HAS SPECIAL RESPONSIBILITY

UNL has an important role in the One Health Initiative because the state is a leading producer of the world’s food — both crops and livestock.

“It’s very important that we understand as we modify our production systems and constantly work to improve those production systems ... how those production systems impact the environment they’re operating in,” Hardin said.

Outside the university, key partners in this effort include agricultural producers and a variety of public-health officials, both from state and federal government and doctors in communities. Social scientists, too, play a role, Hardin said, since people’s feelings about their environment and what they eat often are driven as much by emotion as proven fact.

UNL’s Veterinary Diagnostic Lab also is important. The lab diagnoses diseases in animals and often is the first discoverer of an emerging zoonotic disease threat in the state. West Nile Virus is an annual example. Tularemia is another; it’s carried by rabbits and people sometimes come into contact with it from their own pets. The Lone Star Tick is a relatively recent arrival in Nebraska; it carries certain diseases that can be transmitted to humans, so in the UNL Veterinary Diagnostic Center faculty conduct surveillance for it.

Misconceptions about diseases often are rampant, so another part of the One Health Initiative’s mission is educating the public.

UNINTENDED CONSEQUENCES

As scientists work to feed the world’s growing population, unintended consequences can be expected. A larger population means more and different interactions with environments — the land, plants and animals. New food production methods also can have unforeseen impacts.

“When we change our production systems, inadvertently sometimes we create an environment that allows an organism to flourish and then it places our food system at risk,” Hardin said. “Anytime we start changing our systems there’s a learning curve, and one of the downsides of that is you can create these other opportunities for basically what we would consider opportunistic microorganisms, some of which aren’t friendly to human health.”

Hardin said he expects this effort to draw some of the world’s leading scientists in the coming decades.

“For us as scientists, that’s kind of the exciting part of it. We’re not a stagnant world where at some point we would run out of discoveries because we’ve discovered everything,” Hardin said, “Well, that won’t happen because it’s an evolving world and there are new things being created to be discovered.”

Funding in Nebraska for the One Health Initiative comes from a variety of sources, including state and federal grants, as well as private industry.

PROCESSED MEAT TECHNOLOGIES

increase value, taste, safety

by Mary Garbacz



“The ultimate goal in meat processing is to improve the palatability and the shelf life of products. And when we utilize these parts and extend the shelf life, we actually can feed more people. We can reduce the amount of waste that occurs.”

—Gary Sullivan, Assistant Professor, UNL Department of Animal Science

IT’S TIME FOR LUNCH.

Millions of people every day reach for a hot dog or a sliced meat sandwich without thinking of the research that has made those products delicious and safe.

But Gary Sullivan has thought about it — he does the research to ensure those products are safely produced and processed — and appeal to hungry consumers.

Sullivan is an assistant professor of animal science, focused on meat science at the University of Nebraska—Lincoln, contributing to research that has a legacy of adding value, taste and shelf life to meat products through processing techniques and ingredients.

Sullivan said consumers generally recognize the value and price of steaks, roasts, chops and other high-end cuts of meat. But with a world population expected to reach more than 9 billion people before 2050, reducing food waste is a priority. Parts of the animals that aren’t used for steaks and roasts are processed into processed meat products that consumers enjoy and buy, again and again.

“We take the trim that isn’t used in steaks and roasts and we process it to improve the palatability, quality and the safety and health aspects,” Sullivan said. “The ultimate goal is to provide not only a safe product, but also one that consumers enjoy eating,” Sullivan said.

NEW TECHNOLOGY, BETTER PRODUCTS

And, with a population that is increasingly interested in the ingredients in their food, Sullivan said research is

finding alternative ingredients that work the same way in processing as traditional ingredients.

Cured meats

Cured meats, such as frankfurters and bacon, traditionally have been cured with sodium nitrite — that is what provides the curing action and the characteristics of traditionally cured meat. However, in recent years there has been greater interest in more natural or organic products, Sullivan said, so research has studied alternative ways to produce foods using natural ingredients. Even though the U.S. Department of Agriculture requires bacon and frankfurters to be cured as their statement of identity, research has developed another way to cure meats: celery juice powder.

Celery juice powder, Sullivan said, is simply dried celery juice, which is naturally high in nitrate. Adding celery juice powder and a starter culture allows for nitrite to be produced and provides the same curing action as sodium nitrite added directly. But “celery juice powder” is on the product label instead of “sodium nitrite.”

Enzymes for tenderness

Sullivan and his UNL colleague, Professor of Meat Science Chris Calkins, also have studied commercially available enzymes and how those enzymes tenderize meat. A U.S. Department of Agriculture category called GRAS, which stands for Generally Recognized as Safe, includes a list of food ingredients that have been fully evaluated and are safe to use in foods.



INFO bytes

Americans consume an estimated 20 billion hot dogs per year. That means Americans are consuming about 70 hot dogs per person.

Many of those hot dogs — roughly 20 million — are consumed in baseball stadiums.

The first American hot dog stand opened in 1871 at Coney Island in New York City.

“We had some plant-based enzymes which come from papaya, figs and pineapple,” Sullivan said, as well as some other enzymes — and they studied the effect of the enzymes on various cuts of meat. The resulting tenderizing qualities allow home consumers or restaurants to use lesser-value cuts of beef with good results. “It’s a way to improve the tenderness and palatability,” he said.

Animal feed, effect on meat

Sullivan and his colleagues have completed a study that looked at the diet of the animal related to the shelf life and quality characteristics of the processed meat, Sullivan said. Antioxidants such as rosemary and green tea were used to counter oxidation and decreased shelf life, he said. By adding natural flavorings like this, he said, the label reflects natural, recognizable products.

TRANSFORMATION

Sullivan teaches UNL meat science courses in addition to his research. Much of the teaching takes place in UNL’s Loeffel Meat Laboratory, a U.S. Department of Agriculture-inspected operation. “We spend time in the meat lab, manufacturing products,” he said. Sullivan

teaches students the technologies that are used in industry, but on a smaller scale.

Sullivan’s predecessor, UNL Professor Emeritus of Meat Science Roger Mandigo, developed some of the technologies that were later used to make the McRib for McDonald’s, Sullivan said. “That is an example of some of the technologies that have been developed at UNL.”

“When I look at a processed meat product, I always tell my students there are three things it includes: it has meat; it has non-meat ingredients; and it goes through mechanical and physical processing,” he said. “We’re really taking the product and transforming it to make sure we have a quality, safe product.”

The added ingredients in processed meat products aren’t just additives; they have specific functions. Some can prevent the growth of specific bacteria, such as *Listeria monocytogenes*. Additives such as simple vinegar, which contains acetic acid, can be added to prevent bacterial growth; so can cultured sugars that form lactates naturally.

In addition to additives, other processes and techniques are used to keep the products safe.

“We make sure we have clean equipment to start out with; we keep the product cold; and we use proper processing techniques to keep bacteria and pathogens from growing,” Sullivan said. Another benefit is an extended shelf life of the product, he said.

EXTENDING SHELF LIFE

“My job is to take all the little bits of meat that aren’t used elsewhere and make it worth as much, and last as long as we can,” Sullivan said. “The ultimate goal in meat processing is to improve the palatability and the shelf life of products. And when we utilize these parts and extend the shelf life, we actually can feed more people” he said. “We can reduce the amount of waste that occurs.”

Historically, meat processing was used to extend the shelf life of a product in the absence of freezers. An animal was slaughtered in the cold weather, then the meat froze during winter’s cold temperatures. Meat also was dried, fermented or salted, Sullivan said.

Technologies such as refrigeration brought the shelf life of meat a long way, he said. One of the next advances to extend shelf life was packaging technologies. Vacuum



and anaerobic packaging can extend the products’ shelf life by controlling the growth of pathogens or bacteria.

INTERNATIONAL RELEVANCE

This is a small world in many ways, Sullivan said, and research that is conducted in the U.S. doesn’t just affect people in the U.S. Sullivan had an internship in Ethiopia for two months before he began his college career and that experience opened his eyes, he said.

“When we think of the food industry overall, it has become more global. What takes place in South America affects prices around the world. A drought in the Midwest can affect grain prices around the world, and consequently, meat and other commodities,” he said.

Along with growing enough food for a world population that is expected to reach 9 billion before 2050, comes the discussion of reducing food waste, Sullivan said.

“What I do in food processing is the way to use the products and extend their shelf life. Some of the technologies we develop can make an impact on global food needs,” he said.



Gary Sullivan (middle).

“When I look at a processed meat product, I always tell my students there are three things it includes: it has meat; it has non-meat ingredients; and it goes through mechanical and physical processing. We’re really taking the product and transforming it to make sure we have a quality, safe product.”

—Gary Sullivan

BUILDING ON THE 'Nebraska advantage'

by Dan Moser



Based on an interview by Emily Taylor

"Technology is something that allows us to become more efficient."

—James MacDonald, Associate Professor,
UNL Department of Animal Science



A KEY TO NEBRASKA'S SUCCESS as a powerhouse agricultural producer is the integration among crop, livestock and biofuels production, and University of Nebraska–Lincoln scientists continue to search for ways to strengthen those interactions to increase efficiency.

Beef cattle play a central role in this system, sometimes dubbed the "Nebraska Advantage" or "Golden Triangle," and Jim MacDonald, associate animal science professor, is among the UNL scientists working to make beef production more efficient as part of that system.

SYSTEMS APPROACH IMPORTANT

A systems approach to managing cattle is important, MacDonald said, because changes in one aspect of production can have an impact on others.

For example, "we may focus on how does changing a management system or changing a feed ingredient change reproduction rate in a cow/calf herd," MacDonald said. "But does it also influence gain of the calves while grazing range, and how does it change feed efficiency of those calves when they are in the feedlot?"

"My passion is about putting all of those systems together and looking at 'How does a change in a particular segment affect the entire system,'" MacDonald added.

An example: Weaning calves and putting them out to graze corn residue is a long-standing conventional practice. "It doesn't sound very exciting, right?" MacDonald said.

But cornstalks remain one of the most important forage resources in Nebraska, especially given trends in corn production and traditional grassland forages. However, calves feeding on cornstalks need some supplemental protein to reach maximum gains. Some cattle may graze grass after grazing cornstalks. Scientists and producers must determine whether they should continue to provide supplemental energy in that situation and also factor in a careful balancing act between cattle gains before and after they go into the feedlot.

MAKING THE MOST OF DISTILLERS GRAINS

Distillers grains — much of the research on which has been done at UNL — are a significant feed resource that has helped Nebraska become the number one cattle feeding state. While a majority of distillers grains are used in

feedlots, they are also used heavily as a protein and energy supplement to growing calves prior to entering the feedlot. When distillers grains are fed in the feedlot, cattle carcasses end up with more polysaturated fat, which can decrease shelf life in retail stores.

"So, how much (distillers grains) should we provide to (cattle) in each of those segments" of production, MacDonald said. "See, if I look at just one segment I don't know what effect I'm having on the whole system. ... If I make a change in the amount of distillers grains that I feed while they are grazing cornstalks, what effect does that have on the gain that they can achieve on grass, how efficient they are in the feedlot and what is the final beef product? What is the quality of that final beef product when it gets to the consumer?"

A TEAM APPROACH TO RESEARCH

UNL's dedication of a team of scientists, expert across many disciplines, is key to evaluating the entire beef cattle system and how it fits into the even larger agricultural production system in Nebraska, MacDonald said.

"We think we can increase crop production and we can increase beef production to meet the increasing global demand for food here in Nebraska, but it is going to take some cooperation among beef producers and crop producers," he said.

Among the most significant developments in the future, MacDonald said, will be refinement of the use of cellulose to produce ethanol. Ruminant animals such as cattle will be central in that process because they can digest cellulose, while other animals, including humans, cannot.

Cellulosic ethanol, once commercialized, may compete for land and forage resources used by the beef industry. However, the technologies associated with growing, harvesting, and processing biomass may provide additional feed resources for Nebraska beef producers. It also could further strengthen the Nebraska Advantage.

"I think that cellulosic ethanol is going to be a big game changer for beef production," MacDonald said.

MacDonald's research is funded by the Nebraska Corn Board, the Nebraska Beef Council and other sources.

GLOBAL COMMITMENT for a sustainable future

by Emily Taylor

“Increasingly, things are changing with consumer tastes and preferences and people want to know where their food is grown, and they want to know how it’s grown. I think that’s a real opportunity for our industry because in America and in the U.S., we have great practices, great traceability and traceability systems, and the brand and reputation that we have for safe food and safe products is outstanding.”

—Joe Stone, President, Global Animal Nutrition Cargill®

BETWEEN NOW AND 2050, the world population is expected to increase to more than 9 billion people. That population will reflect a much larger middle class than the world has previously seen.

Joe Stone, president of global animal nutrition for Cargill® and a graduate of the University of Nebraska–Lincoln, said the global increase in the middle class means those individuals are projected to have more money to spend on higher-quality protein, including meat.

Even with the projected 9 billion people expected to be living on Earth, more complex issues are being considered outside of producing enough food, including trade barriers. Some countries have trade barriers on genetically engineered products and use of antibiotics in animals produced for food. Those trade barriers make it difficult for the U.S. to export to those countries.

The U.S. must stay current on the politics of trade barriers to be certain shipments will be allowed to enter the country.

“I think it really speaks to the exciting complexity and the ongoing puzzle that we try to put together in the world of agriculture,” Stone said.

TECHNOLOGY

Stone said the company’s animal nutrition business is focused on bringing innovation to help its customers thrive. Cargill invests heavily in research and in developing new technologies. Science-based approaches are used to make the decisions on what the company will and won’t market. Consumers are becoming more aware of what they are eating and how the ingredients are being raised. In July of 2013, the company adjusted what it will buy to meet the consumers’ concerns, he said.

“We have 13 research facilities around the world and spend tens of millions of dollars on research to develop biological models and other things that can be used by our customers to become more efficient, more effective and more sustainable,” Stone said.

“I think it is up to us to really make sure that we are investing in technology and in our people to ensure that we can help make our customers as prosperous as possible,” he said.

CONSUMERS’ RESPONSE

Due to consumers’ interest in their food, there is an opportunity for agriculture to showcase good practices, such as traceability, through which consumers can trace their food all the way back through the food chain. These practices in the United States have helped to build a reputation for safe food and products and it is a competitive edge for the U.S., Stone said.

Regardless of politics around the world, products produced in the United States are valued because of their safety, particularly Nebraska beef, he said.

FREE TRADE

“We are very vocal about free trade,” Stone said. “Free trade allows us to have our products, such as Nebraska beef, available all over the world. Free trade enables that to happen.”

Free trade allows products to be transported to areas that need them. “Personally, I think that free trade is a really important part of solving the world’s problem — and opportunity — of feeding those 9 billion people that will be on this Earth by 2050,” Stone said.

With global diet changes predicted for the future, it creates a challenge for the agriculture industry to meet the demands of the population in a sustainable manner. The goal is to accomplish that and leave the Earth in a better condition than before, Stone said.



Joe Stone

The growing population will put stress on the environment, especially with the demand for higher protein consumption. Several solutions are being studied at Cargill to improve the efficiency of animal production that will be better for the environment and use fewer resources, he said.

“I have never been more optimistic about the future of agriculture, its essential work that is done at the University of Nebraska–Lincoln as well as other parts of the U.S. and around the world to help feed the growing population,” Stone said. “I think the future is really bright, and I’m glad to see more people consider agriculture for their careers, because we have to have the best talent in the world if we are going to meet some of the challenges of feeding the population and doing so in a more sustainable way.”



This test plot at the University of Nebraska–Lincoln Southeast Research and Extension Center at Ithaca is one of many in UNL research and extension locations throughout Nebraska.

Strategic Discussions for Nebraska



P.O. Box 830918
Lincoln, Nebraska 68583-0918



Strategic Discussions for Nebraska

sdn.unl.edu

It is the policy of the University of Nebraska-Lincoln not to discriminate based upon age, race, ethnicity, color, national origin, gender, sex, pregnancy, disability, sexual orientation, genetic information, veteran's status, marital status, religion or political affiliation.