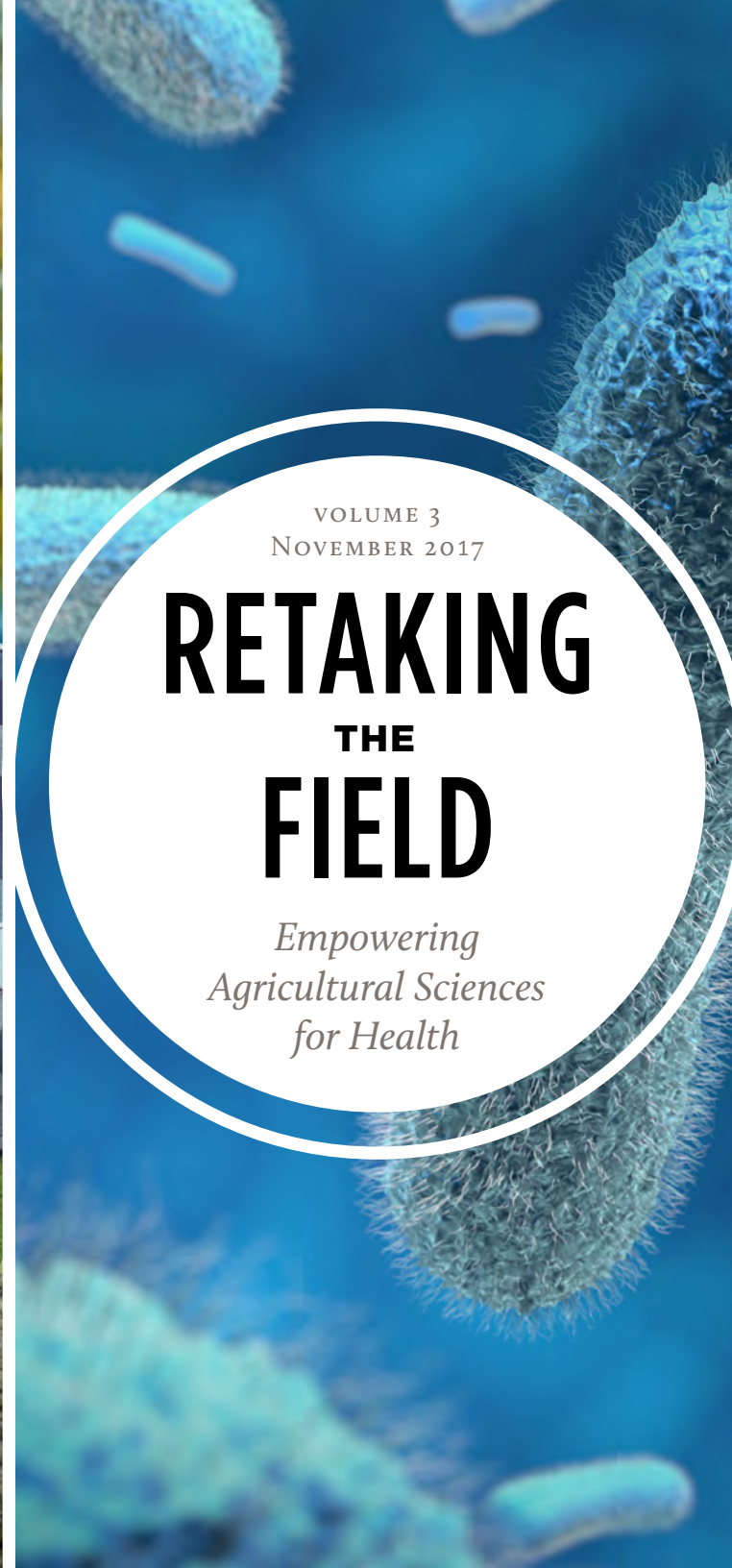




SoAR
FOUNDATION



VOLUME 3
NOVEMBER 2017

RETAKING THE FIELD

*Empowering
Agricultural Sciences
for Health*



“LET FOOD BE THY MEDICINE.”

~ HIPPOCRATES



RESEARCHERS DISCOVER SOLUTIONS TO PROTECT PUBLIC HEALTH AND HELP FARMERS PRODUCE NOURISHING FOOD FOR OUR FAMILIES

WHAT'S FOR DINNER, MOM? WHAT FOODS WILL HELP MY KIDS GROW STRONG AND MY FAMILY STAY HEALTHY?

From our breakfasts through late night snacks, American farmers grow the bounty that nourishes our bodies and minds each day. When we plan our families' meals, we expect to have access to a cornucopia of affordable foods from around the globe. Though we may volunteer or donate to the local food pantry to help hungry families, many of us have abundant food at every neighborhood market, gas station, restaurant, and grocery store.

As we fill our carts and plates, we depend on agricultural researchers who are enhancing the well-being of our families, friends, and communities. In *Retaking the Field*, we peek into the university labs across the country. We learn about food science and “what is left on the cutting room floor” when federal funding is not sufficient. Teams of scientists from a wide range of disciplines are working every day to conquer the challenges facing farmers and the food industry – from pests and diseases, to severe weather, to safely getting products to the market. They are also discovering how to unlock our bodies' ability to absorb crucial nutrients that safeguard our health. The researchers share a determination to improve our lives through advancing agricultural science.



AGRICULTURAL SCIENCE IS UNDERFUNDED

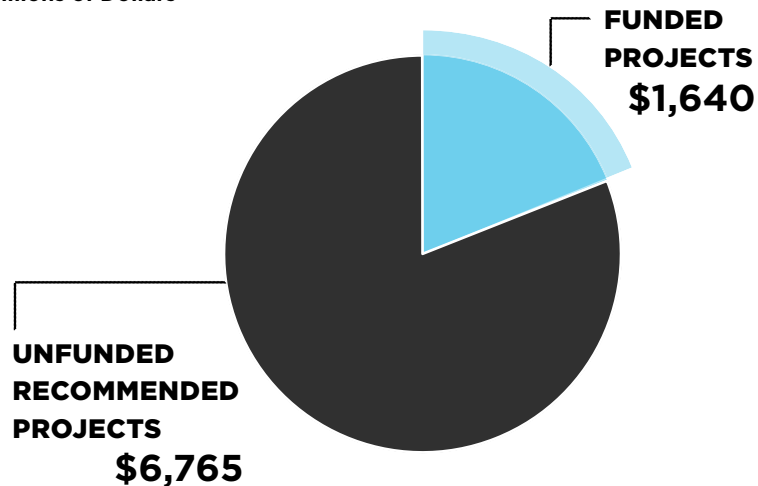
The Agriculture and Food Research Initiative (AFRI) is the nation's leading competitive grants program for agricultural sciences. The National Institute of Food and Agriculture (NIFA) awards AFRI research, education, and extension grants to combat childhood obesity, improve rural economies, increase food production, create new sources of energy, mitigate the impacts of climate variability, address water availability issues, ensure food safety and security, and train the next generation of agricultural workforce.

US Department of Agriculture's NIFA AFRI funds all of the projects highlighted in *Retaking the Field*. Teams of researchers are discovering novel solutions to tackle complex problems and ensure a safe, abundant, and nourishing food supply. These scientists' work would not be possible without NIFA/AFRI funding.

AFRI CAN ONLY FUND LESS THAN 1/4 OF RECOMMENDED RESEARCH¹

FY 2009-2015

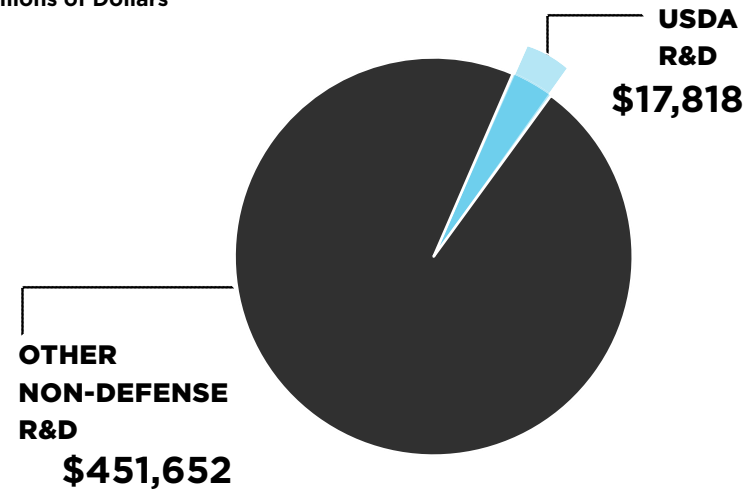
Millions of Dollars



USDA RECEIVES LESS THAN 4% OF THE FEDERAL NON-DEFENSE R&D BUDGET²

FY 2009-2015

Millions of Dollars



¹ Source: NIFA AFRI Annual Program Synopses

² Source: AAAS Total R&D by Agency, 1976-2017

ZOONOTIC DISEASES

THESE DISEASES ARE CAUSED BY INFECTIONS THAT ARE SHARED BETWEEN ANIMALS AND PEOPLE. ESTIMATES ARE THAT MORE THAN 6 OUT OF 10 INFECTIOUS DISEASES IN PEOPLE ARE SPREAD FROM ANIMALS. TENS OF THOUSANDS OF AMERICANS GET SICK EACH YEAR.

SOURCE: CENTERS FOR DISEASE CONTROL AND PREVENTION



NUTRITION

ABOUT HALF OF ALL AMERICAN ADULTS—117 MILLION INDIVIDUALS—HAVE ONE OR MORE PREVENTABLE CHRONIC DISEASES (E.G. CARDIOVASCULAR DISEASE, HIGH BLOOD PRESSURE, DIABETES, CANCERS) RELATED TO POOR QUALITY EATING PATTERNS AND PHYSICAL INACTIVITY.

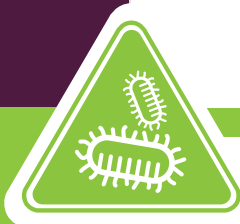
SOURCE: U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES, OFFICE OF DISEASE PREVENTION AND HEALTH PROMOTION



FOOD SAFETY

THE U.S. FOOD SUPPLY IS AMONG THE SAFEST IN THE WORLD. HOWEVER, 1 IN 6 AMERICANS - APPROXIMATELY 48 MILLION PEOPLE - GET FOODBORNE ILLNESS, WHICH RESULTS IN 128,000 HOSPITALIZATIONS AND 3,000 DEATHS ANNUALLY.

SOURCE: U.S. FOOD AND DRUG ADMINISTRATION



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ZOONOTICS

Zoonotic diseases can be transferred from animals to humans either by direct contact or by the consumption of food or water that has been in contact with the animals. About 75% of emerging contagious diseases in humans have animal origins.¹ Globally, zoonotic diseases have resulted in \$20 billion in direct economic losses and more than \$200 billion in indirect losses from 2000 to 2010.² In the last two decades, zoonotic diseases in the United States have remained a significant cause of morbidity and mortality in humans.

Farmers and ranchers use antibiotics to treat animal diseases. A vicious cycle occurs when bacteria deploy novel mechanisms of resistance to recently introduced classes of antibiotics – a process known as antimicrobial resistance (AMR) – that can render antibiotics ineffective for animals and humans alike. When even newer antibiotic classes are created, the cycle continues. In collaboration with partners from other universities, teams are working to answer these questions:

- Iowa State University: Can *E. coli* from chickens cause diseases outside the digestive system in humans, and is it possible to create a single vaccine to protect chickens from multiple strains of *E. coli* and *Salmonella*?

- Colorado State University: How can we reduce antibiotic resistance by analyzing the genetic makeup of entire bacterial communities from every corner of the farm and food processing environments?
- Texas A&M: How can resistance problems be tackled by exploring, defining, and developing principles and practical stewardship guidelines for prudent antibiotic use in animal agriculture?

AFRI-funded researchers studying zoonotic diseases are safeguarding animals and people from zoonotic bacterial infections and preserving the effectiveness of antibiotics into the future.

USDA supports research on antimicrobial resistance to reduce potentially negative impacts from antibiotic use, and identify alternative strategies for mitigating AMR in the food chain.

¹ <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1088493/>

² http://siteresources.worldbank.org/INTARD/Resources/PPP_Web.pdf



BANISHING BAD BACTERIA: CONTROLLING *E. COLI* TO PROTECT POULTRY AND PEOPLE

IOWA STATE UNIVERSITY

PROBLEM

ExPEC, a harmful *E. coli* bacteria found in poultry production systems, may lead to foodborne illnesses in humans.

SOLUTION

Confirm that ExPEC infections can be transferred from chickens and their food products to humans and then develop a single vaccine for chickens to prevent ExPEC and *Salmonella* infections.

RESEARCHERS

Dr. Melha Mellata, Iowa State University
Dr. Roy Curtiss III, University of Florida
Dr. James Johnson, University of Minnesota
Dr. John Fairbrother, University of Montreal
Postdocs & Students

FUNDING

USDA NIFA AFRI
Iowa Agriculture Experiment Station
USDA Hatch

Dr. Mellata and her team's project focuses on improving food safety by reducing harmful bacteria in poultry products. Its major goals are: 1) advance our understanding of the zoonotic risk of ExPEC (extraintestinal pathogenic *E. coli*) infections from chickens; and 2) develop and evaluate a vaccine for chickens to protect them and humans against ExPEC and *Salmonella* infections.

ExPEC is the leading cause of blood poisoning (sepsis) in humans. It can also cause diseases such as urinary tract infections and neonatal meningitis, which occurs when a mother passes an *E. coli* infection to her baby during birth.

The team's research revealed that when ExPEC are transferred from a chicken to a mouse, the mouse develops the same diseases that the bacteria cause in humans. This indicates that some ExPEC found in humans may be derived from uncooked, undercooked, or cross-contaminated chicken-food products.

The project also developed and evaluated vaccines that would eliminate the presence of diverse strains of *Salmonella* and ExPEC in chickens, and prevent diseases caused by *E. coli* strains in chickens and humans. While helping poultry farmers preserve their flocks, these vaccines would also protect people from zoonotic disease, and save billions of dollars in human health care costs.

“At a young age, I started testing different cooking recipes in my parents’ kitchen. I soon realized that the quality of the final product depends on the quality of the ingredients. This developed my laboratory skills and my appreciation for wholesome foods. I’m excited that our research improves both human and animal health.” – MELHA MELLATA



What is left on the cutting room floor?

With future funding, the team could continue to improve public and animal health while increasing animal productivity and reducing the costs of livestock production. This would be to use high-throughput screening to find out why the *E. coli* isolates that are dismissed by current screening methods are nevertheless virulent in animal models.

The degree of danger such *E. coli* pose to humans needs to be defined. Improved strategies to detect them in healthy animals and food are also required. In addition, the team could continue improving their vaccine to provide broad protection against multiple pathogens and to make the vaccines more accessible and affordable to poultry farmers.

SEQUENCING SOLUTIONS:

REVOLUTIONIZING UNDERSTANDING OF ANTIMICROBIAL RESISTANCE WITH GENOME ANALYSIS



PROBLEM

Traditional culture-based methods allow researchers to study only one bacterial isolate at a time in order to characterize antimicrobial resistance (AMR).

SOLUTION

State-of-the-art “metagenomic” sequencing techniques can help us understand the bigger picture of factors influencing AMR in entire microbial communities.

RESEARCHERS

Dr. Paul Morley, Colorado State University
Dr. Keith Belk, Colorado State University
Dr. Zaid Abdo, Colorado State University
Dr. Milt Thomas, Colorado State University
Dr. David Van Metre, Colorado State University
Dr. Dale Woerner, Colorado State University
Dr. Christina Boucher, University of Florida
Dr. Jaime Ruiz, University of Florida
Dr. Noelle Noyes, Colorado State University
Students

FUNDING

USDA NIFA AFRI

Antimicrobial resistant-microbes (AMRs) pose a serious threat to public health. AMRs are found in people, animals, food, and the environment. They spread from animals to people, and from person to person.

To solve this problem, Dr. Morley and his team are studying the genetic makeup of all of the organisms throughout the environments involved in animal (e.g. beef and dairy cattle) food production, not just one isolated bacteria at a time. Dr. Morley commented that you can't tell the health of a forest by only looking at a single blade of grass. Rather, the health of a forest is determined by investigating the mixture of plant species. For this reason, they are examining genomic sequences of entire microbial communities (metagenomes) in samples of feed, wastewater, manure, soil, and meat. By analyzing these complex ecosystems, they can better understand how antimicrobial resistance genes develop and evolve.

The team is making progress with this enormous task by using high-throughput sequencing and “big data” computer programs. They are building cloud computing resources called “AMR++” and “AMRStratus”, designed with the intention of making genomic software tools more accessible to non-computer scientists. This will help scientists track how bacteria spread resistance genes, discover where resistance genes originate, and access vital information about AMR genomes.

This project includes education and training components. The team develops curricula to promote widespread literacy of applied genomics. By increasing the understanding of genetic analysis

“People in agriculture are committed to promoting public health. I have had outstanding teachers and mentors during my training. I now have the great reward to train promising and dedicated young scientists.”

– PAUL MORLEY

techniques, the team is training the next generation of agricultural scientists.

This “next generation sequencing” technology uncovers cutting-edge opportunities to develop innovative tools, advances safe production methods, and creates a paradigm shift for the life sciences.



PHOTO: JOHN EISELE, COLORADO STATE UNIVERSITY



PHOTO: JOE A. MENDOZA, COLORADO STATE UNIVERSITY

FIGHTING FOR THE FUTURE:

MITIGATING ANTIMICROBIAL RESISTANCE THROUGH BETTER STEWARDSHIP



TEXAS A&M
UNIVERSITY

PROBLEM

Antibiotic resistance threatens to reverse decades of advances in human and animal health.

SOLUTION

Build a voluntary framework through broad stakeholder engagement to identify, evaluate, and implement effective interventions for preventing antibiotic resistance.

RESEARCHERS

Dr. H. Morgan Scott, Texas A&M University
Dr. Mayukh Dass, Texas Tech University
Dr. Yrjö Gröhn, Cornell University
Dr. Ellen Jordan, Texas A&M AgriLife
Dr. Guy Loneragan, Texas Tech University
Dr. Wm. Alex McIntosh, Texas A&M University
Dr. Gerald Midgley, University of Hull, UK
Dr. Jason Sawyer, Texas A&M AgriLife
Dr. Robert Hagevoort, New Mexico State University,
Clovis
Students

FUNDING

USDA NIFA AFRI

Antibiotics have been prescribed for people and animals at rates that have encouraged bacteria to expand resistance. If this trend continues, life-saving antibiotics may be ineffective in the future.

Dr. Scott and his team are combating this threat by developing and sharing a voluntary framework for antimicrobial stewardship for animals. Their efforts focus on beef and dairy cattle production systems. The framework includes core values and ethics, basic scientific principles, best management practices, tools, and protocols to improve voluntary compliance, optimize animal health, and minimize risks to people.

This consultative process engages industry partners and other key stakeholders early in the process. Based on field research with cattle, they emphasize voluntary stewardship and adoptable actions to mitigate resistance that surpass product label requirements.

This science-based framework must be able to adapt to change, particularly as new and emerging resistance genes develop. Animal trials are underway. Ultimately, Dr. Scott and his team are aiming to provide empirical data about the science of antimicrobial resistance to guide the best practices for antibiotic use. They are working to preserve populations of bacteria that can continue to be treated by antibiotics.

Dr. Scott emphasizes that this research is based on a moral imperative. For the sake of future generations, society needs to develop a plan to ensure that we have the ability to continue to treat bacterial infections. The agricultural industry can do its part by voluntarily implementing a code of best practices based on sound science.

“Bacteria can outsmart us at every turn. We must maximize voluntary stewardship so that we are able to effectively treat bacterial infections in the coming years and decades. We have moral and ethical obligations to future generations.”

– MORGAN SCOTT



ZOONOTICS

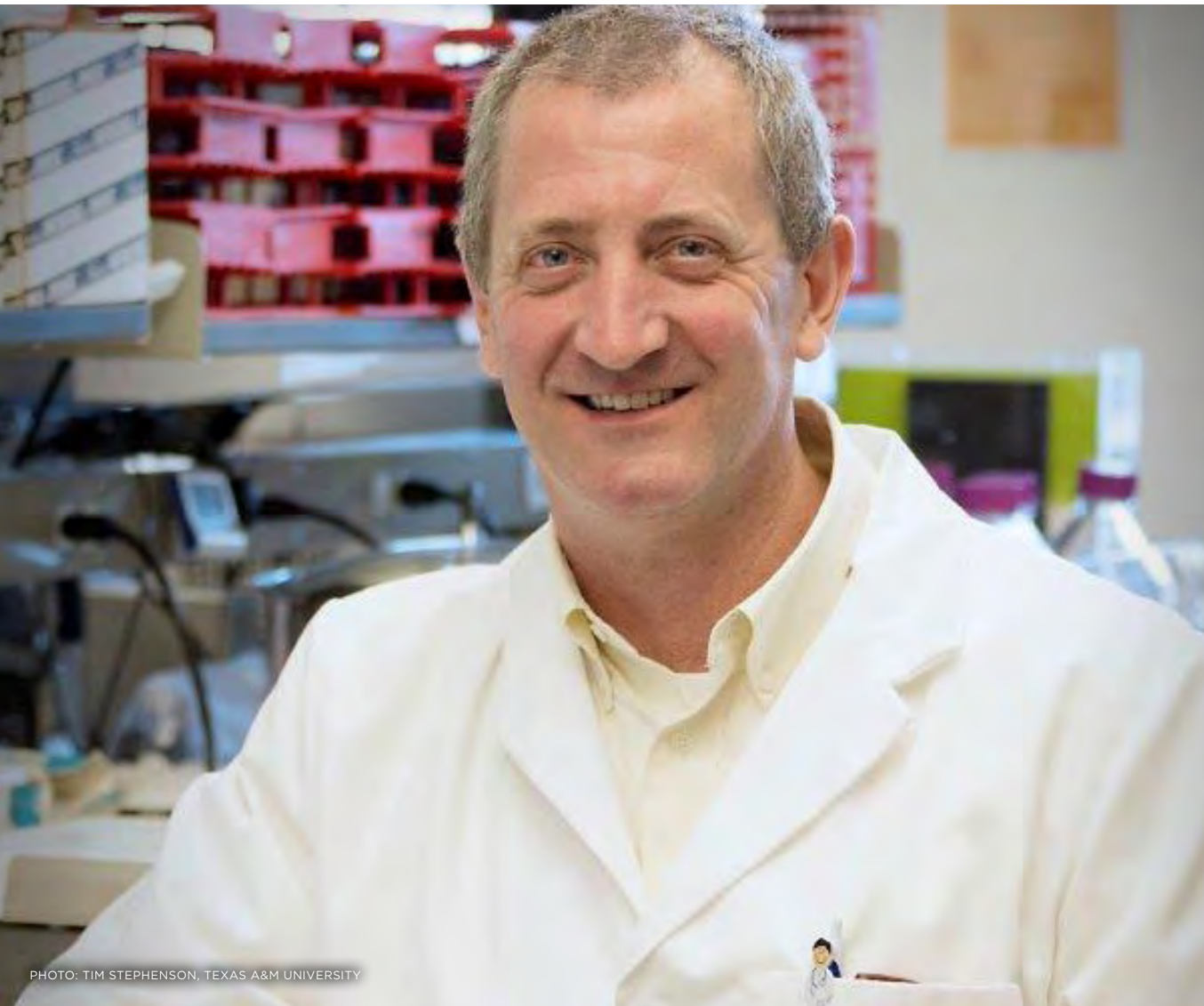


PHOTO: TIM STEPHENSON, TEXAS A&M UNIVERSITY

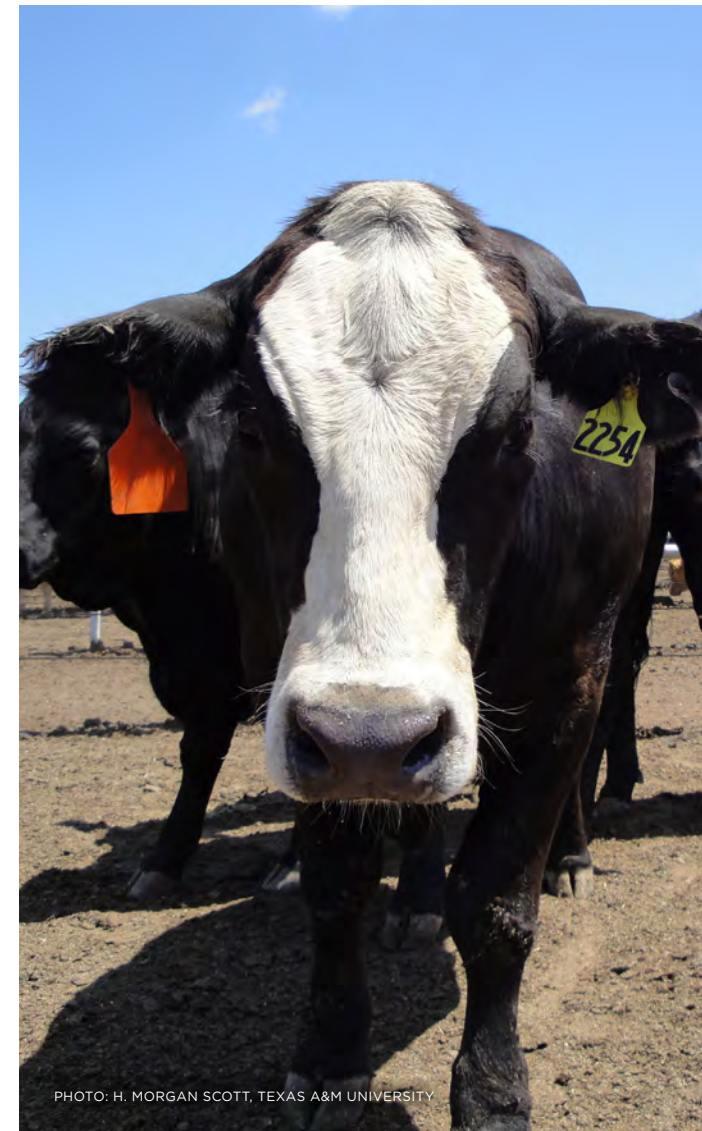


PHOTO: H. MORGAN SCOTT, TEXAS A&M UNIVERSITY



NUTRITION

Non-communicable diseases (e.g. cardiovascular diseases, cancers, chronic respiratory diseases, and diabetes) cause 63% of all annual deaths globally.¹ Nutritional factors can influence the onset and progression of these diseases. Nutrition-related diseases are estimated to cost Americans billions of dollars in medical costs each year: high cholesterol, \$34.5 billion; obesity, \$147 billion; diabetes, \$176 billion; heart disease, \$193.4 billion.²

To learn how nutrition can help prevent and perhaps cure diseases, researchers study the entire, diverse community of microorganisms (microbiota) living in the human gut, especially the genetic material of these organisms, known collectively as a microbiome.

One of the challenges is that each person's microbiome is unique, and doesn't necessarily absorb the benefits of all types of food. Researchers are exploring how microbiomes impact individuals' responses to different foods, how to fortify foods with essential nutrients, and the links between food and human health.

Research teams are answering these questions:

- University Of Nebraska – Lincoln: How can a combination of probiotics and prebiotics effectively treat digestive-related conditions, such as leaky gut syndrome, that afflict obese adults?

- North Carolina A&T State University: How can flavonoids in fruits and vegetables remove diabetes-causing compounds from the body?
- University of Wisconsin-Madison: Which gut bacteria improve the digestion of flavonoids to help heart health?
- Pennsylvania State University: How can broccoli and other cruciferous vegetables help maintain a harmonious balance of gut flora, enhance host barrier function, and reduce gastrointestinal inflammation and related health problems?
- Purdue University: How can staple foods be fortified with an essential vitamin (Vitamin B-1, also called thiamin) to reduce deficiencies for people with celiac disease and others?

AFRI-funded researchers are revolutionizing our understanding of the complex and vital role that nutrition plays in preventing diseases and enhancing wellness.

USDA NIFA AFRI supports research that addresses the science of human health and food to lower the risk of heart disease, diabetes, stroke, cancers and improve the overall health of Americans.

¹ http://www.who.int/features/factfiles/noncommunicable_diseases/en/
² <https://www.gobankingrates.com/saving-money/11-expensive-diseases/>



INFLUENCING INFLAMMATION: BOOSTING GUT HEALTH TO HELP OBESE ADULTS



PROBLEM

An unhealthy balance of gut bacteria can lead to inflammation and other intestinal disorders.

SOLUTION

Through a combination of probiotics and prebiotics, scientists are discovering ways to enable beneficial bacteria to thrive in the gut.

RESEARCHERS

Dr. Robert Hutkins, University Of
Nebraska - Lincoln

Dr. Jens Walter, University of Alberta

Dr. Heather Rasmussen, Rush University Medical
Center

Dr. Ali Keshavarzian, Rush University Medical
Center

Dr. Janina Krumbeck, University of Nebraska

FUNDING

USDA NIFA AFRI

Nebraska Research Initiative

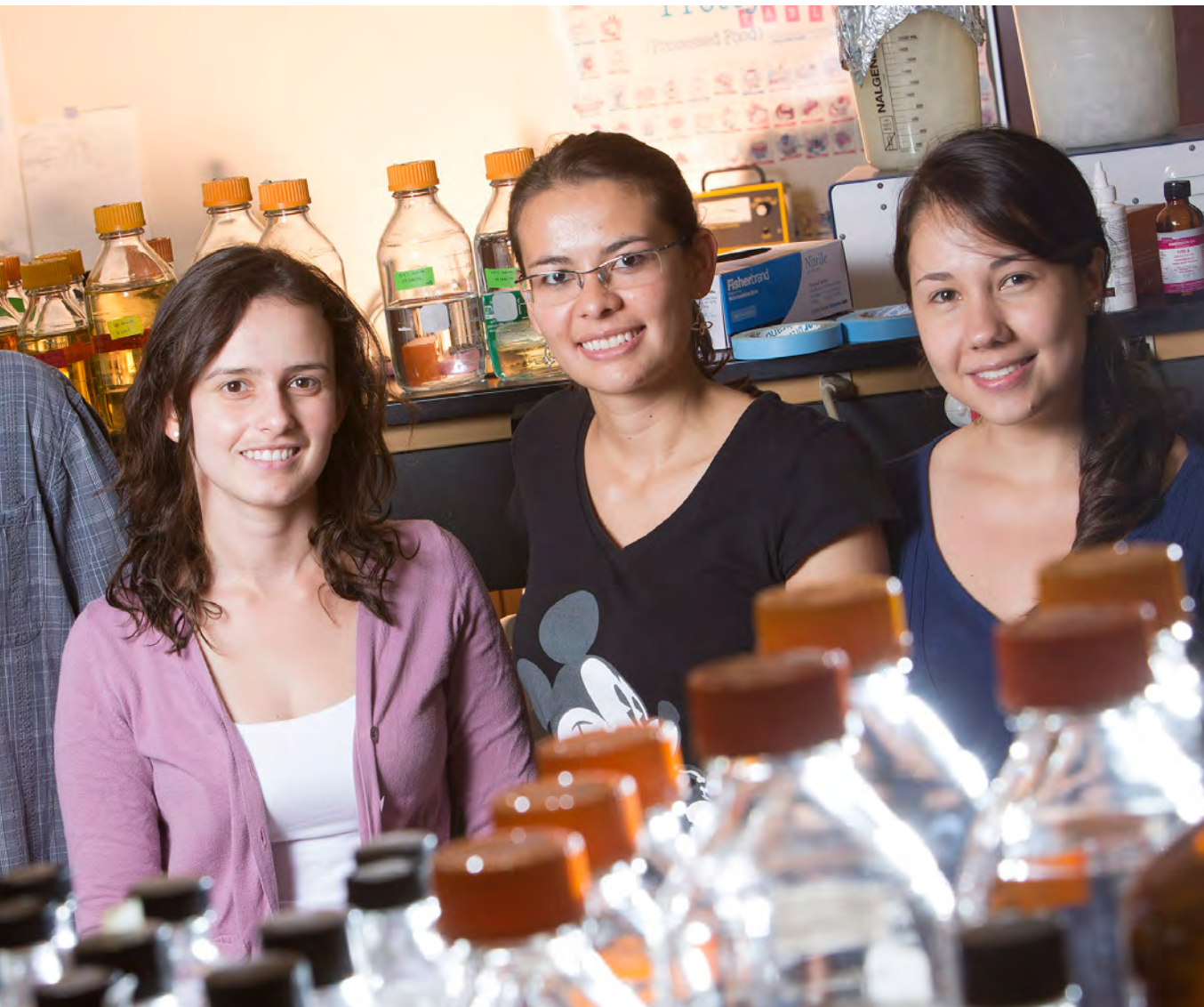
Inflammation is a major cause of health problems. When gut bacteria (microbiome) are out of balance, our protective intestinal barrier is disrupted, leading to an inflamed intestinal tract and the release of toxins into the body. This condition, called leaky gut syndrome, is more prominent in obese people, whose gut microbiomes may often be affected by high fat diets.

Drs. Hutkins and Walter and their collaborators set out to improve gut health by using a novel formulation of probiotics (healthy bacteria) and prebiotics (food for healthy bacteria). The team had previously fed a specific prebiotic called galactooligosaccharide (GOS) to human subjects. They then isolated bacteria enriched by the GOS, including one strain named *Bifidobacterium* IVS-1. The researchers knew that *Bifidobacterium* is important for maintaining a healthy microbiome and for protecting the intestinal barrier. They therefore wanted to introduce this organism into obese adults, who tend to have increased intestinal permeability, a condition that leads to inflammation.

“Intestinal diseases like Crohn’s disease and ulcerative colitis are terrible diseases that negatively affect the quality of life for many Americans. We often hear from people desperate for answers. This motivates us to develop strategies to restore gut health.” – ROBERT HUTKINS



PHOTO: CRAIG CHANDLER, UNIVERSITY OF NEBRASKA-LINCOLN



They reasoned that if probiotics are introduced by themselves, the bacteria are at a competitive disadvantage because the gut is already populated by other organisms. To overcome this, the researchers formulated a synbiotic that combined the prebiotic food directly with the probiotic bacteria. By analogy, applying grass seed alone to a weedy lawn will not have much effect, but grass food plus seed could restore the lawn to a healthy state.

This novel approach has now been used in a human study to improve gut barrier function. Ultimately, this research may provide a basis for developing personalized nutrition strategies based on individuals' microbiomes.



PHOTO: CRAIG CHANDLER, UNIVERSITY OF NEBRASKA-LINCOLN

DEFENDING DIABETICS:

DEVELOPING FLAVONOID-ENRICHED FOODS TO PREVENT AND TREAT DIABETES



PROBLEM

Millions of people are suffering from life-threatening complications related to diabetes.

SOLUTION

Flavonoid-enriched foods and beverages hold great promise in safely and effectively improving the lives of diabetics.

RESEARCHERS

Dr. Shengmin Sang, North Carolina A&T State University

Dr. Yantao Zhao, North Carolina A&T State University

FUNDING

USDA NIFA AFRI

More than 30 million Americans have diabetes and more than 80 million American adults have prediabetes. In 2015, diabetes was the seventh-leading cause of death in the United States, claiming around 80,000 lives. The chronic intake of food products, beverages, and cigarette smoke that contain certain compounds—methylglyoxal (MGO) and glyoxal (GO)—has been shown to cause diabetes and related complications.

Dr. Shengmin Sang is working to determine if there are dietary strategies focused on flavonoid consumption that can prevent diabetes, as well as diseases such as Parkinson's and Alzheimer's. Flavonoids are the natural compounds that are widely distributed in almost every food including fruits, vegetables, beans, tea, and coffee. Recent studies have shown that dietary flavonoids can assist the gut microbiome in removing MGO and GO. Therefore, the consumption of flavonoid-enriched foods holds promise to improve the lives of those afflicted by diabetes.

Dr. Sang studies foods with the most active flavonoids—apple, tea and soy. His group studied the harmful effects of MGO alone, and in combination with a high-fat diet on the development of diabetes and related complications in mice, and the preventive effects of different flavonoids against the harmful effects induced by MGO. His work also demonstrated that certain flavonoids are more active than others, and that the microbiomes in the guts of individuals react differently to various types of flavonoids.

This knowledge is important to develop dietary strategies that will enhance diabetics' quality of life. Consuming bioactive foods to prevent or delay complications from diabetes is a safe, economical way to improve public health.

“I am a big fan of a healthy lifestyle and believe that Mother Nature has cures for chronic diseases. I hope our findings will inspire the public to eat healthy foods and use dietary strategies to prevent diseases.”

– SHENGMIN SANG



What is left on the cutting room floor?

With additional funding, Dr. Sang and other researchers could build upon this important work in multiple ways. As examples, researchers could study the efficacy of flavonoids, individually and in combinations, to determine which have the most curative powers. Scientists could analyze safety issues; impacts of combining flavonoids with various drugs; and the health outcome of enriching foods with flavonoids.

Teams could also work to establish the most effective dose range for flavonoid consumption and investigate why various peoples' microbiomes react differently to flavonoids. Ultimately, this additional research could help scientists fine-tune their flavonoid prescriptions to suit individuals' unique needs and improve public health.

HELPING HEARTS:

DISCOVERING THE IMPACTS OF FLAVONOIDS AND INTERPERSONAL GUT VARIATIONS TO IMPROVE CARDIOVASCULAR HEALTH



PROBLEM

Dietary interventions aimed at improving heart health are not always successful.

SOLUTION

Understanding how interpersonal differences in gut bacteria impact the ability of individuals to process nutrients will lead to more effective ways to improve heart health.

RESEARCHERS

Dr. Federico Rey, University of Wisconsin-Madison
Dr. Bradley Bolling, University of Wisconsin-Madison
Dr. Kazuyuki Kasahara, University of Wisconsin-Madison
Dr. Robert Kerby, University of Wisconsin-Madison
Students

FUNDING

USDA NIFA AFRI

The American Heart Association notes a recent study that showed millions of people worldwide could prevent early deaths and disability from heart disease by eating more fruits and vegetables.¹ Some health benefits associated with this diet are derived from pigments present in plants called flavonoids. However, our bodies do not absorb most flavonoids in their natural state. Flavonoids can be metabolized by our microbiome, the trillions of microbes that inhabit our gut.

Studies that analyze the health effects of flavonoids show either positive or no effects. However, there is limited research on how different gut microbes affect the ways that flavonoids are metabolized. The team theorized that specific gut microbes contribute to the beneficial effects of flavonoids by making them more absorbable. Thus, they are studying the relationship among interpersonal differences in how the gut microbia help digest flavonoids and their resulting health impacts.

“As I grew up, my parents instilled the concept that we can improve our health by making good decisions at the grocery store and the dinner table. I hope my work inspires people to make dietary choices that take into consideration their gut microbes. Eat lots of whole grains, veggies, and fruits!” – FEDERICO REY

¹ <https://news.heart.org/lack-of-fruits-vegetables-partly-to-blame-for-global-heart-disease-burden/>



PHOTO: BRYCE RICHTER, UNIVERSITY OF WISCONSIN-MADISON



To see the effects of flavonoids on cardiovascular diseases in humans, his lab bred germ-free mice that were genetically susceptible to heart disease. They introduced bacteria from a human microbiome into half of the mice and left the other half germ-free. After feeding all of the mice a flavonoid-rich diet, only those with the added microbiome benefited from the consumption of the flavonoids, highlighting the importance of gut bacteria in mediating the effects of flavonoids. The next step is to see exactly which bacteria in the microbiome help metabolize flavonoids and can help diminish cardiovascular disease.



TREASURING THIAMIN: OPTIMIZING VITAMIN B1 DELIVERY IN FOOD PRODUCTS



PROBLEM

Thiamin, a vitamin with important health impacts, degrades over time.

SOLUTION

Investigate which forms of the vitamin are most stable in order to optimize the delivery of thiamin in foods.

RESEARCHERS

Dr. Lisa Mauer, Purdue University
Dr. Lynne Taylor, Purdue University
Dr. Vivekanand Bhardwaj, Purdue University
Adrienne Voelker, Purdue University
Collin Felten, Purdue University
Seda Arioglu Tuncil, Purdue University
Jenna Miller, Purdue University
Erica Grush, Purdue University

FUNDING

USDA NIFA AFRI

In 1889, a physician studying beriberi (now called thiamin deficiency) discovered that the disease disappeared when people replaced white rice with whole-grain rice. It was later discovered that vitamin B1, also known as thiamin, is contained in the rice husks that are removed by the milling process.

People suffering from thiamin deficiencies often don't know the cause of their symptoms, which may include exhaustion, loss of appetite, and shortness of breath. U.S. laws require that the food industry fortify milled-wheat with thiamin. However, there are no comparable laws in some developing nations, where as much as a quarter of the population suffers from deficiencies. In the U.S., thiamin deficiencies cause problems in people with celiac disease, alcoholism, and low-calorie diets.

"I became intrigued with food science as a kid when learning about NASA's space food program from Tang to ice cream. My seventh grade science fair project was to develop 'freeze dried space food.'" – LISA MAUER

Dr. Mauer and Dr. Taylor's research is aimed at improving the delivery of thiamin in food products because thiamin degrades over time. Their goals are to identify all factors that impact the stability of thiamin in food products (including those containing whole and refined wheat, rice, and corn) from production to storage, and to determine if new salt forms of thiamin can be produced.





The food industry currently uses two forms of thiamin to supplement food: thiamin hydrochloride and thiamin mononitrate. The team found that the crystalline forms of these types of thiamin are more stable than the amorphous (non-crystalline) forms, but that the vitamins are amorphous in many food formulations.

These findings could improve the current methods of delivering thiamin and lead to ways of incorporating thiamin into foods that have not been previously fortified, such as gluten-free products.

VALUING VEGETABLES: INVESTIGATING BROCCOLI TO IMPROVE GUT HEALTH



PROBLEM

We have a limited understanding of how and why cruciferous vegetables improve digestive health.

SOLUTION

Determine if broccoli alters the microbiome by activating a specific receptor in the gastrointestinal lining to increase resistance to toxic insults.

RESEARCHERS

Dr. Gary Perdew, Pennsylvania State University
Dr. Andrew Patterson, Pennsylvania State University
Dr. Philip Smith, Pennsylvania State University
Dr. Iain Murray, Pennsylvania State University
Dr. Troy Hubbard, Pennsylvania State University
Students

FUNDING

USDA NIFA AFRI

Why is broccoli healthy for you? Dr. Perdew explains that all cruciferous vegetables (broccoli, brussels sprouts, kale, cabbage, cauliflower) contain an organic chemical compound called “indole glucosinolates.” When that compound is digested in the stomach, it breaks down into other compounds, including indolo[3,2b]carbazole (ICZ).

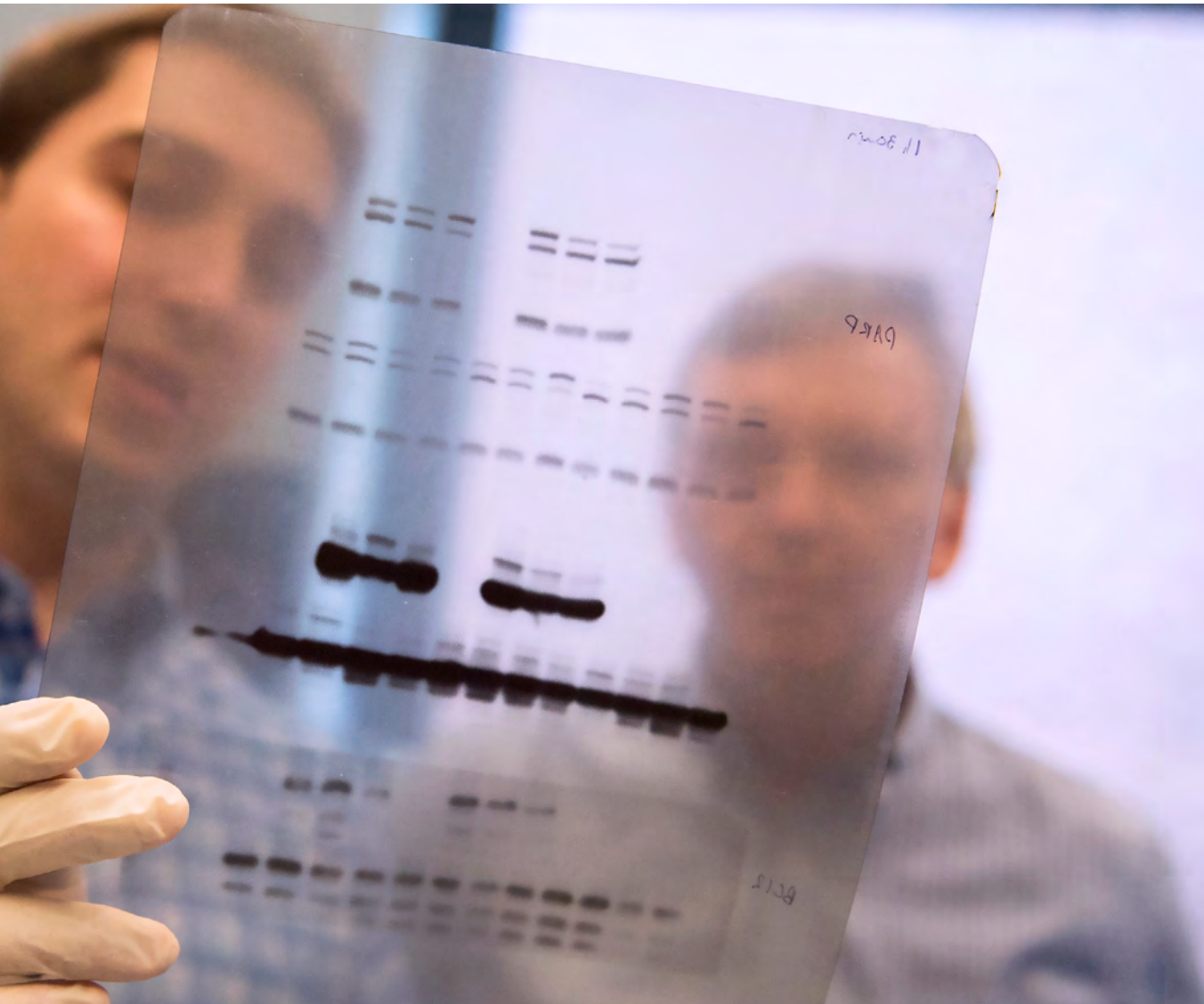
When ICZ binds to and activates the Aryl hydrocarbon receptor (AHR) in the intestinal lining, it aids in maintaining a healthy balance in the gut flora and enhances host barrier function. This may help prevent diseases (e.g. cancer, Crohn’s) caused by inflammation in the gastrointestinal lining.

“I have a long-term interest in how chemicals in foods impact our health. Broccoli consumption offers significant gastrointestinal protection. I hope this research inspires people to eat more cruciferous vegetables.” – GARY PERDEW

The study used mice as models for humans. Intestinal cells in specific mice lines have either a low or a high affinity AHR that can differentially bind ICZ. Broccoli was fed to both groups of mice. They found that when broccoli made up 15% of the diet, the mice that have a lower ability to bind ICZ to the AHR were not protected from a toxic chemical insult. In contrast, the mouse line with the higher ability was protected from the toxic insult.



PHOTO: PATRICK MANSELL, PENN STATE

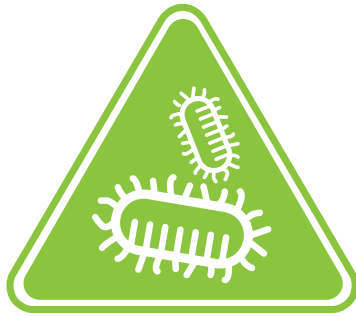


This research provides evidence that eating cruciferous vegetables can lead to a stronger gastrointestinal tract. It is also helping us to understand how much to eat to gain the benefit. The team's study extrapolated to humans suggests that a person would need to eat about 3 ½ cups/day of broccoli to effectively increase AHR activity. Eating raw or slightly cooked cruciferous vegetables is the best way to boost this beneficial impact.

If funding becomes available, the next step is to study how broccoli may protect the gut from additional possible insults such as drug exposure and aging to keep us healthier.



PHOTO: PATRICK MANSELL, PENN STATE



FOOD SAFETY

Foodborne illnesses place a significant burden on public health. The Center for Disease Control (CDC) estimates that 48 million (1 in 6) Americans suffer from food poisoning, and 3,000 individuals die each year. Pregnant women, newborns, older adults, and individuals with weakened immune systems and chronic illness have increased risks. There is a steep financial toll to foodborne illness as well. The USDA estimates that foodborne illnesses cost Americans \$15.6 billion annually.¹

According to CDC, researchers have identified more than 250 foodborne diseases. Most cases are caused by infections from a variety of bacteria (e.g. *Salmonella*), viruses (e.g. norovirus), and parasites. Harmful toxins and chemicals also contaminate foods.²

The Academy of Nutrition and Dietetics notes that reducing foodborne illness by 10 percent would keep about 5 million Americans from getting sick each year.³ To reduce the number of infections, researchers are working to understand how these contaminants interact with food, from the farm to processing plants to our tables.

Research teams are answering these questions:

- Cornell University & Rensselaer Polytechnic Institute: How can we use ground-breaking nanotechnology to develop surfaces that prevent bacteria from adhering to food during processing?
- University of California, Davis: How can we eliminate cross-contamination of fresh produce by developing innovative and sustainable antimicrobials and creating a “gold standard” for best-washing practices for the food industry?
- Michigan State University: What are the most cutting-edge and effective solutions to prevent *Salmonella* from surviving in low-moisture foods?

USDA NIFA AFRI supports research that protects people by reducing foodborne illnesses and deaths and improving the safety of our food supply.

¹ <https://www.cdc.gov/foodsafety/cdc-and-food-safety.html>

² <https://www.cdc.gov/foodsafety/foodborne-germs.html>

³ <http://www.eatright.org/resource/homefoodsafety/safety-tips/food-poisoning/food-safety-facts-and-figures>



THINKING TINY: BLOCKING PATHOGENIC BACTERIA WITH NANOENGINEERED SURFACES



Cornell University

PROBLEM

Bacterial contamination from food-processing equipment can cause foodborne illness.

SOLUTION

Design and fabricate “non-stick” equipment that prevents biofilms from adhering to the surfaces by using nanoengineering to make microscopic indentations.

RESEARCHER

Dr. Carmen I. Moraru, Cornell University
Dr. Diana-Andra Borca-Tasciuc, Rensselaer Polytechnic Institute
Dr. Randy Worobo, Cornell University
Dr. Yifang Cheng, Cornell University
Dr. Guoping Feng, Cornell University
Dr. Lillian Hsu, Cornell University

FUNDING

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Foodborne illnesses can be caused by food coming in contact with bacteria on surfaces in food-processing plants, restaurants, and households. When enough bacteria congregate, they create a “biofilm” that glues them to the surface. Biofilms are impervious to normal cleaning detergents, making them difficult to remove from food-processing equipment.

Dr. Carmen Moraru of Cornell University, Dr. Diana-Andra Borca-Tasciuc of Rensselaer Polytechnic Institute, and their teams collaborated to develop a structural, non-chemical solution to the problem: a non-stick surface. The team covered a metallic surface with a layer of aluminum oxide, with nano-sized pores that are much smaller than bacterial cells. One nanometer is one-billionth of a meter and there are 25,400,000 nanometers in one inch.¹

The team discovered that nanopores of a particular size (15-25 nanometers in diameter) prevent biofilm formation. This is a relatively simple, practical, and science-based method to block attachment by diverse pathogenic bacteria to food-processing surfaces.² This research provides the foundation of an innovative way to prevent foodborne illness and protect public health.

“I went to school in communist Romania during the Cold War, and couldn’t really aspire to doing research. Fortunately, the communist regime fell as I finished my undergraduate studies. I received a scholarship during my PhD program in Germany. This opened up my world and resulted in my commitment to a career in research in order to deliver safe and nourishing food.”

– CARMEN MORARU

¹ <https://www.nano.gov/nanotech-101/what/nano-size>

² <https://www.nature.com/articles/npjbiofilms201522>



What is left on the cutting room floor?

The team requested additional AFRI funding to investigate the next stage of their important research. This step would be applying what they learned by working with aluminum to stainless steel, which is the standard material used in food-processing equipment. This is significantly more technologically challenging. Although rated as “high-priority” and recommended for funding, the follow-up project was ultimately not funded because of very low funding rates.

In addition to food safety, this revolutionary use of nanoengineering has many potential cross-over applications in other areas where biofilm formation causes problems. For example, it could reduce bacterial infections from equipment in the fields of medicine (e.g. needles, catheters, operating tables), dentistry, and water treatment. It could also prevent biofilms from forming on the hull of a ship, thereby reducing drag and fuel costs.

SAFEGUARDING SALAD: REDUCING CROSS-CONTAMINATION IN FRESH PRODUCE PROCESSING



PROBLEM

Fresh fruits and vegetables can become contaminated with harmful bacteria from various sources.

SOLUTION

Create a multi-prong approach of technical methods and protocols to reduce contamination of produce.

RESEARCHERS

Dr. Nitin Nitin, University of California, Davis
Dr. Ian Kennedy, University of California, Davis
Dr. Glenn Young, University of California, Davis
Dr. Gang Sun, University of California, Davis
Dr. Mukund Karwe, Rutgers University
Dr. Rohan Tikekar, University of Maryland
Dr. Alexander Fridman, Drexel University
Dr. Gregory Fridman, Drexel University
Dr. Vandana Miller, Drexel University
Postdocs & Students

FUNDING

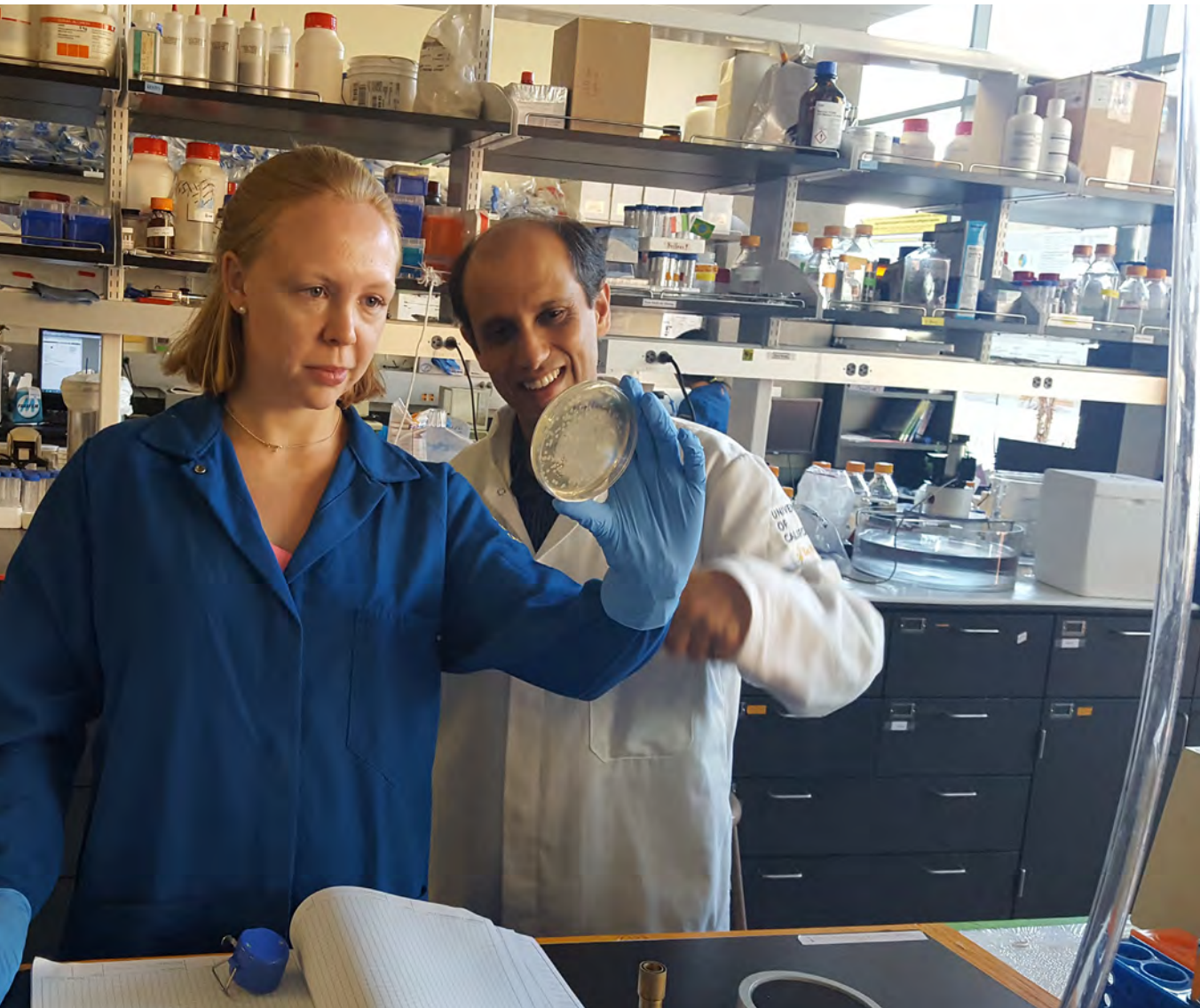
USDA NIFA AFRI

Dr. Nitin and his team are discovering multiple techniques to minimize cross-contamination, which is a leading cause of foodborne outbreaks in fresh produce. They study how to prevent produce from being contaminated by contact with water, equipment surfaces, and people during the washing, conveying, and handling processes. The team focuses on: 1) creating sustainable antimicrobial solutions; 2) developing a “gold standard” for washing procedures; and 3) standardizing process control steps.

One approach is the creation of specially designed antimicrobial plastic films used to prevent bacterial contamination of fresh produce from food contact surfaces such as totes, bins, and conveyor belts. These antimicrobial films inactivate bacteria upon contact and prevent formation of biofilms. The films are reusable and can be activated using a simple household bleach solution. Another approach is the creation of a chemical free sanitation solution for maintaining fresh produce. This solution generates plasma-activated water or mist by treating the water or mist through electric discharges. In addition, the team is discovering how to sanitize fresh produce by combining food grade compounds with mild heat or light to deactivate bacteria in wash water and fresh produce.

“Our team’s mission is to help people by protecting our food supply. We translate solutions from the labs to the next level to secure safe, fresh produce and a sustainable food system.” – NITIN NITIN

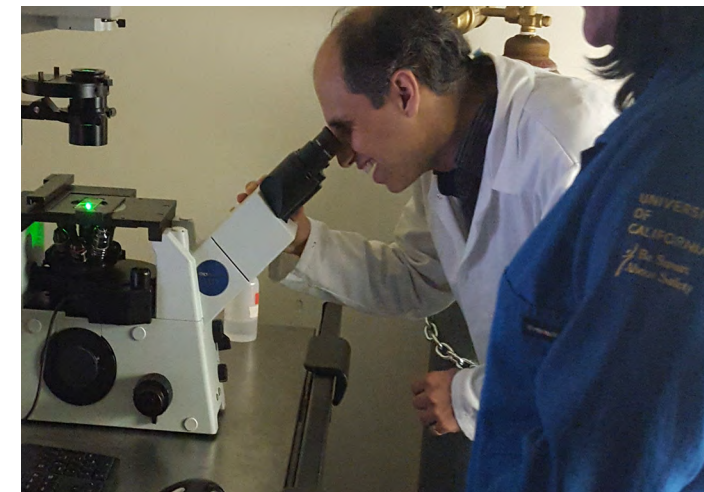




The team is also establishing a “gold standard” for sanitizing and washing fresh produce to reduce cross-contamination. Several different washing methods are currently used. To advance best practices, they study the mechanics of washing and water-flow rates, and how this affects washing efficiency.

Finally, the team is improving the process steps in fresh produce production systems to make the standards more uniform by developing simple yet effective sensing approaches to validate the process conditions.

This multi-prong, innovative approach is attacking cross-contamination from many angles to protect our produce.



TARGETING TROUBLEMAKERS: ENHANCING DRY FOOD SAFETY WITH PASTEURIZATION TECHNOLOGIES

MICHIGAN STATE UNIVERSITY

PROBLEM

Salmonella is persistently showing up, and can be extremely difficult to eliminate, in low-moisture food products.

SOLUTION

Discover, disseminate, and implement techniques that reduce the risk of *Salmonella* surviving in ready-to-eat food products.

RESEARCHERS

Dr. Bradley Marks, Michigan State University
Dr. Elliot Ryser, Michigan State University
Dr. Juming Tang, Washington State University
Dr. Meijun Zhu, Washington State University
Dr. Jeyam Subbiah, University of Nebraska
Dr. Harshavardhan Thippareddi,
University of Georgia
Dr. Denis Gray, North Carolina State University
Dr. Elizabeth Grasso-Kelley, Illinois
Institute of Technology
Dr. Nate Anderson, U.S. Food and
Drug Administration
Dr. Sanghyup Jeong, Michigan State University

FUNDING

USDA NIFA AFRI

Salmonella is a formidable foe in low-moisture foods (e.g., peanut butter, nut snacks, pet foods, milk powder, dried fruits, flour, cereals). Recent outbreaks and recalls due to *Salmonella* in low-moisture foods make processing solutions essential to ensure the microbial safety of these products. Various pasteurization technologies exist but they have achieved limited market penetration, and none provide a universal solution.

The project's overall goal is to enhance the development, improvement, and commercial adoption of pathogen-reduction technologies for low-moisture foods. The team conducts laboratory-scale and industrial-scale experiments that mimic current commercial processes, such as steam pasteurizing, baking, roasting, and using radio frequencies.

The team conducts training workshops and webinars to disseminate the results and best practices to the workforce responsible for the microbial safety of our nation's food supply. An Industry Advisory Group collaborates to ensure that the solutions are useful to the food industry.

This research will help technology companies deliver validated pathogen-reduction solutions. It will also enable processors (particularly small ones) to make informed, science-based decisions about modifying or purchasing technology solutions that reduce the risk of foodborne pathogens in low-moisture food. It will further ensure that regulators can effectively evaluate technology solutions to this challenging food-safety problem. In the latter part of this project and beyond, the primary focus will be delivering decision-support tools and training to U.S. food manufacturers.

“I grew up in a rural community, son of an agricultural extension agent and a teacher. I was very involved in 4-H as a kid, which influenced my desire to serve the public good. No other scientific endeavor is more fundamental to the public good than research to produce and protect a stable and sustainable food system” – BRAD MARKS



PHOTO: MICHIGAN STATE UNIVERSITY



ABOUT SoAR

The SoAR Foundation leads a non-partisan coalition representing more than 6 million farming families, 100,000 scientists, hundreds of colleges and universities as well as consumers, veterinarians, and others. SoAR educates stakeholders about the importance of food and agricultural research to feed America and the world and advocates for full funding of USDA's Agriculture Food and Research Initiative (AFRI). SoAR supports increased federal investments to encourage top scientists to create agricultural solutions that improve public health, strengthen national security, and enhance U.S. economic competitiveness.

A digital version of the *Retaking the Field* series is at www.supportagresearch.org/retakingthefield.

For more information, please contact Andrea Putman at aputman@supportagresearch.org or 571-257-7625.

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