2015
ANNUAL REPORT

AgBioResearch
MICHIGAN STATE UNIVERSITY

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MANAGING EDITOR'S NOTE: As we interviewed the scientists involved in the research projects presented in this report, they provided us with lengthy lists of colleagues, students, organizations and funders integral to their efforts. Including all of this information would easily double the length of the report, so we opted to limit project narratives to key research elements and the importance of the work in its respective field. We do, however, want to convey the interviewees' acknowledgments of the individuals and organizations with which they collaborate and their gratitude for the support they receive in doing their work.

MESSAGE **FROM THE DIRECTOR**

Douglas D. Buhler

This past year marks another impressive slate of Michigan State University (MSU) research advancements in the areas of food, energy and the environment. A small sample of the work led by MSU AgBioResearch scientists is featured in this report. In 2015, these researchers alone secured more than $90 million in grant funding from external agencies, such as the U.S. Department of Agriculture, the Bill and Melinda Gates Foundation, U.S. Agency for International Development (USAID) and the National Science Foundation, with impacts spanning from Michigan to around the globe.

As director of MSU AgBioResearch and MSU assistant vice president for research and graduate studies (the latter is a new post effective October 2015), it is my privilege to help meet the university's research goals and objectives. I've been working with Stephen Hsu, vice president for research and graduate studies, to ensure that MSU AgBioResearch leverages its external funding to its fullest and works to integrate the university's priorities. It's also exciting to be involved with MSU's new Global Impact Initiative, aimed at adding more than 100 new faculty members to enhance research endeavors around energy, health, education, the environment, national security and global development.

The College of Agriculture and Natural Resources (CANR) is strengthening communication with U.S. Congressional members from Michigan. We connect weekly with U.S. Senator Debbie Stabenow, who serves on the Senate committees of Agriculture, Nutrition and Forestry, and Energy and Natural Resources, to inform her and her office staff of ongoing research endeavors at MSU. And thanks to a special invitation from U.S. Rep. John Moolenaar, I had the honor of testifying before the House Agriculture Subcommittee on Biotechnology, Horticulture and Research in 2015. We look forward to the opportunity to have additional MSU scientists addressing important issues before Congress in the year ahead.

The end of 2015 also marked the retirement of Fred Poston, CANR dean and longtime MSU leader. He has dedicated so much not only to the CANR, but to the entire university. I wish him well in his retirement and future endeavors. In the meantime, the CANR has temporarily handed the leadership over to me once again. The search for a new dean is well under way, with an announcement expected in early 2016.

Wishing you a wonderful 2016!

Douglas D. Buhler

MSU AgBioResearch Director

MSU Assistant Vice President of Research and Graduate Studies

MSU AgBioResearch - 2015 NEWS IN REVIEW

Entomological Society of America fellow named

James Miller, Michigan State University (MSU) entomology professor, was elected a 2016 Fellow of the Entomological Society of America for his pioneering research in insect physiology, chemical ecology and behavior that has significantly enhanced insect detection and management.

James Miller (left), with Jeffrey Schenker, associate professor of math.

Among his research accomplishments, Miller helped pioneer the field of chemical ecology; established the wind tunnel as the standard for studying how insects orient themselves; originated the rolling-fulcrum model of animal decision making and the push-pull tactic of pest management. These findings have expanded knowledge of what constitutes suitable habitats for African mosquitoes that spread malaria.

Miller also led a team in discovering that avermectins, medicine used to treat parasitic worms, administered to African cattle just before the rainy season can suppress malaria epidemics.

Interim dean named for CANR

Douglas Buhler, director of Michigan State University (MSU) AgBioResearch and senior associate dean for research in MSU's College of Agriculture and Natural Resources, was named interim dean of CANR, effective Jan. 1, 2016.

Buhler also serves as assistant vice president for research and graduate studies and director of MSU AgBioResearch, positions he will retain during his service as interim dean.

He succeeds Fred Poston, who also has served as MSU's vice president for finance and operations and special adviser to the president. Poston retired Dec. 31, 2015.

AAAS fellows announced

In 2015, four Michigan State University scientists were named AAAS Fellows by the American Association for the Advancement of Science. This national recognition is awarded to researchers for their efforts to advance science or its applications.

Zachary Burton

MSU's AAAS Fellows are:

Zachary Burton, biochemistry and molecular biology professor. For seminal contributions toward understanding the function and evolution of RNA polymerases, enzymes found in all organisms and viruses, and for distinguished contributions to teaching, mentoring and the scientific community.

James Kirkpatrick, dean of the College of Natural Science. For pioneering work in establishing the field of geochemical kinetics and applying nuclear magnetic resonance spectroscopy to understand atomic environments in minerals, melts and cements.

Richard Neubig, chairperson of pharmacology and toxicology. For pioneering work on the quantitative analysis of receptor mechanisms, particularly concerning regulators of G protein signaling, molecular switches within cells, and for insightful leadership in the pharmacological sciences.

Phillip Robertson, director of MSU's Kellogg Biological Station Long-term Ecological Research Program. For distinguished contributions in ecosystem science and production agriculture with emphasis on nitrogen cycling, greenhouse gas production and environmental assessment of biofuel cropping systems.

MSU receives two USAID grants

Michigan State University (MSU) will use two grants, awarded by the U.S. Agency for International Development (USAID) and totaling more than $18 million, to support two African nations as they fight hunger and take charge of their own food security future.

These grants, part of the USAID-funded Feed The Future Innovation Lab for Food Security Policy, a $70-million international project portfolio managed by MSU's agricultural, food and resource economics department, underscore MSU's long history in helping developing nations establish the policies and procedures necessary to drive their own food security efforts. The grants support USAID's work under Feed the Future, the U.S. Government's global hunger and food security initiative.

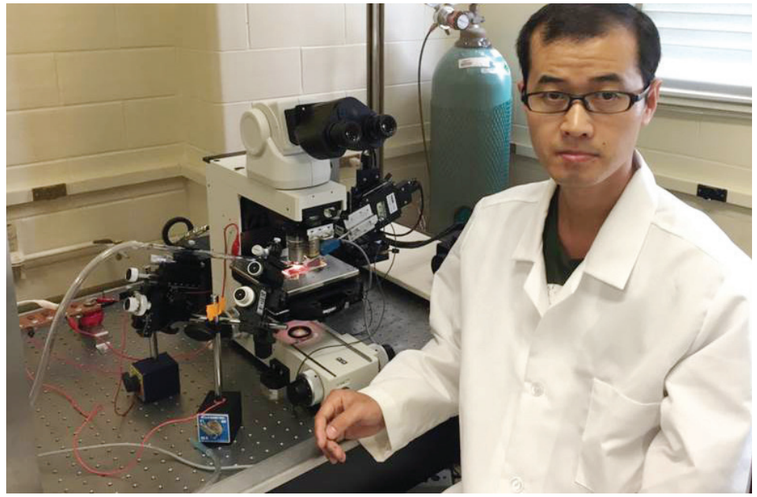
The first grant, $12.5 million, will assist Nigeria to strengthen its own food security policies and subsequently improve nutrition outcomes. To that end, MSU — partnering with the International Food Policy Research Institute (IFPRI) — will help increase the nation's capacity to generate and analyze information and to develop evidence-based policy options. The MSU/IFPRI team also will improve the policy process to ensure a strong empirical evidence base and active dialogue at all levels.

A second, $6 million grant, will be used to help another West African nation, Senegal, to increase its agricultural capacity. The MSU/IFPRI team will work to increase public and private investments in agriculture by helping the government strengthen its policies and enhancing the country's investment environment.

Thomas Reardon, MSU AgBioResearch professor in the Department of Agriculture, Food and Resource Economics, is involved in the work in both countries.

(Continued on page 45.)

Understanding insect response to popular insecticide in effort to develop new compounds



ABOVE: MSU postdoc Peng Xu conducted an experiment in which he identified at least four olfactory receptors in the fruit fly that respond to pyrethroids — indicating for the first time that the insect could smell. The lab team, under Ke Dong's leadership, is already doing similar tests in mosquitoes. *Photo: Courtesy of Ke Dong*

OPPOSITE: Ke Dong, MSU Department of Entomology. *Photo: MSU CABS*

Developed in the 1980s, insecticide-treated bed nets are estimated to be twice as effective as non-treated nets in preventing malaria, a deadly mosquito-borne disease that kills more than 600,000 people in Africa and around the world each year. Some studies have shown a protection rate as high as 70 percent compared with no nets.

Michigan State University (MSU) entomologist **Ke Dong**, who operates the MSU Insect Toxicology and Neurobiology Laboratory, has been studying various aspects of the one class of insecticides approved for use on mosquito bed nets — pyrethroids. The work has been ongoing for the past two decades with continous funding from the National Institutes of Health (NIH). She wants to understand the mechanism by which these compounds control various insects, including malaria-carrying mosquitoes.

This large class of synthetic insecticides is derived from pyrethrum, a compound extracted from dried chrysanthemum flowers. They work by binding to and forcing open the voltage-gated sodium channel in the nervous system, causing overstimulation of the nervous system and eventually death of the mosquito. In 2013, in collaboration with Boris Zhorov (McMaster University, Canada), Dong's lab made a major discovery: there are two receptor sites, not just one, necessary to hold the sodium channel open.

Because of their low toxicity to humans and mammals, pyrethroids have been extensively used against insects, including agricultural pests. However, the widespread use has resulted in pyrethroid resistance. To better understand this problem, Dong's lab, in collaboration with various other groups, has been looking into the genomes of mosquitoes, cockroaches, cattle ticks, tobacco budworms, bedbugs, varroa mites and fruit flies for the mutations that make insects and arachnids resistant to pyrethroids.

"It turns out that there are numerous mutations on the sodium channel causing the resistance," Dong said. "Some mutations are common among many species, and others are detected only in particular species. Discovery of these mutations makes it possible to find solutions to monitor and to come up with new methods to manage pyrethroid resistance in the field."

As part of an ongoing project, Dong plans to work with chemists to help develop new compounds that can bind to the mutant channel. She said that this is challenging because the receptor site was changed, as well as the structure of the sodium channel. They will need to ensure that the compound structure can fit into the mutated sodium channel.

Some of these insecticidal compounds also repel insects. Because of technical challenges, however, little research has been done on how pyrethroids repel insects such as mosquitoes.

"Within the last couple of years, people really started paying attention to new chemistry to control resistant mosquitoes," she said. "Because it's very expensive and time-consuming to develop new pesticides, there was substantial interest in using pyrethroids as spatial repellents — to just keep mosquitoes out of houses where people sleep."

Dong is now studying whether pyrethroid efficacy is due to physical contact with the compound, or if the insects are able to smell the insecticide.

"Mosquitoes have this behavior called excito-repellency, and we want to know if it's spatial or if it's contact," she said. "We are working to determine whether the insects make contact with the nets and leave, or if they get near them, smell the compound and then leave."

Postdoc **Peng Xu** has conducted an experiment in which fruit flies were put under the microscope with electrodes placed in front and in back of their antennae. Each antenna is covered with lots of hair, and at the base of each hair are sensory neurons. The odor can diffuse onto the antenna and bind to the olfactory receptors in the sensory neurons. Dong and her team wanted to determine which receptor/neuron was activated by the chemical.

In the study, various odors were puffed near the insect antennae while the researchers observed the neuron activity. Both the food odor and the pyrethroid caused activity, but there was none when air was puffed at the insect. Dong said this signified for the first time that the fruit fly could actually smell the pyrethroid.

Next they released hungry fruit flies into a secure area with two chambers: one treated with a pyrethroid and the other without a pyrethroid (the control). Apple cider vinegar (which flies like) was placed at the bottom of each chamber. About 90 percent of the flies ended up in the chamber without the pyrethroid, indicating that the pyrethroid kept the flies out. Ultimately, the researchers want to determine which neurons respond to the pyrethroids and to be able to trace them back to a receptor.

"Without any odor, these neurons are spontaneously firing but with low frequency," she said. "When certain compounds are puffed near the active receptor — this neuron just goes crazy."

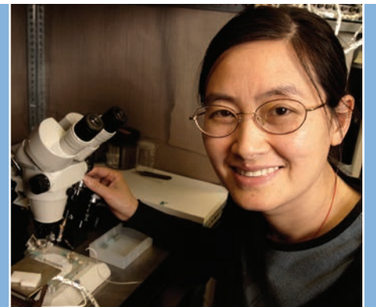
By doing this, Dong and her team have identified at least four olfactory receptors in the fruit fly that respond to pyrethroids. Next they plan to remove the pyrethroid receptor gene from the neuron and repeat the behavioral assay to determine if the insect can still smell.

Graduate student **Elizabeth Bandason** is also working to better understand the molecular basis of the repellency, this time in mosquitoes. Her initial findings are very similar to those the group has observed in fruit flies.

"Mosquitoes basically have a similar phenomenon — there is a spatial repellency going on," she said. "Now we're looking into mosquito olfactory receptors — that will be electrophysiology, molecular work to figure out which olfactory receptor is responding and knock them out to see what happens with behavior and so on."

Dong said there is much more work ahead of the team, but progress is being made. MSU research assistant professor **Yuzhe Du** is the co-principal investigator on this new NIH-funded project. MSU research specialist **Yoshiko Nomura** has also put in considerable effort on these projects.

"Because it's very expensive and time-consuming to develop new pesticides, there was substantial interest in using pyrethroids as spatial repellents..." — Ke Dong



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TOP: Two MSU researchers are collaborating to determine how diet may impact a woman's likelihood of developing high blood pressure later in life. *Photo: Thinkstock*

ABOVE: Claudia Holzman, professor and chair of the MSU Department of Epidemiology and Biostatistics.

OPPOSITE: Jenifer Fenton, MSU Department of Food Science and Human Nutrition.

Collaboration looks at role diet might play in women's blood pressure from pregnancy to later life

Statistics show that one in every three American adults — 70 million people — has high blood pressure. And costs of treatment, including healthcare services, medications and missed days of work, are estimated at some $46 billion each year.

Two Michigan State University (MSU) researchers have teamed up to take a closer look at how diet may affect the likelihood of developing high blood pressure — also known as hypertension — later in life.

Claudia Holzman, professor and chair of the MSU Department of Epidemiology and Biostatistics, and **Jenifer Fenton**, associate professor in the MSU Department of Food Science and Human Nutrition, are collaborating on the project with **Janet Catov,** associate professor from the University of Pittsburgh.

The trio is using data collected from a cohort of women followed over time, first during pregnancy and then seven to 15 years later, in a series of studies funded by the National Institutes of Health. The initial Pregnancy Outcomes and Community Health (POUCH) study enrolled more than 3,000 pregnant women from 52 clinics in five Michigan communities: Flint, Grand Rapids, Lansing, Kalamazoo and Saginaw. It spanned from 1998 to 2004 and assessed maternal health, including blood pressure, in relationship to adverse outcomes such as preterm delivery and low birthweight.

In the follow-up study (POUCHmoms 2011-2014), investigators invited back a subset of the original cohort to reassess their cardiovascular health and, for the first time, their eating habits. The women in the study completed an extensive survey about their food consumption called the Block food frequency questionnaire.

FOOD & HEALTH

"The diet questionnaire is very detailed and asks about average servings of all types of food over the previous year," Holzman said. "It takes about 40 minutes to complete and provides summary feedback so that women can see what their diets look like. Once we amassed all the diet data, I looked for research collaborators with expertise in nutrition and health."

That's when Fenton, who has a master's degree in public health in epidemiology and a Ph.D. in nutrition, entered the picture. She and Holzman met while discussing the development of a public health nutrition concentration in the nutritional sciences curriculum revision and discovered they had common research interests. Holzman turned to Fenton because of her background in nutrition and epidemiology and asked about ideas on how to further use the diet data from the POUCHmoms follow-up study.

Fenton suggested that they compare the healthy eating index and the DASH (Dietary Approaches to Stopping Hypertension) diet patterns of eating to examine associations between diet and both prehypertension and hypertension in the POUCHmoms participants. Though many studies have looked at hypertensive individuals, few have focused on those with moderately elevated blood pressure. The diet plan called DASH is often used for people diagnosed with hypertension. It is supported by the National Heart, Lung and Blood Institute and has been shown to reduce blood pressure in clinical settings, with results similar to those from medication.

"DASH has a lot of studies behind it," Fenton said. "This is in randomized clinical controlled studies where they put those people on this diet and they show a similar reduction in blood pressure as effective as first-line therapy in stage 1 hypertension. Diet along with lifestyle changes are the first line of defense now for folks who have blood pressure of 129 and over."

The researchers used the POUCHmoms study data to examine diet quality measured by both the healthy eating index and the DASH diet index. They found that women with the lowest quality diets had higher blood pressure, on average, at follow-up. Also, among women who had moderately elevated blood pressure during the POUCH study pregnancy, those with a low-quality diet at follow-up (seven to 15 years after pregnancy) were more likely to be prehypertensive or hypertensive.

"Previously, moderately elevated blood pressure in pregnancy had been ignored," Holzman said. "We are finding it may identify a group of woman at increased risk of hypertension later in life, and poor-quality diet could be part of this story."

"We think this study is unique," she said. "We're looking at middle-aged women – more often these studies are done with men. In addition, the participants are all from Michigan and have been followed over a long period of time, beginning in pregnancy. We are among a growing group of investigators who view pregnancy as an important window because it offers clues to a woman's risk of future health problems such as hypertension. Our data suggest a high-quality diet might modify that risk later in life."

Fenton said the researchers plan to look more closely at the diet data to determine if there is some component in the high-quality diet that may be linked to lower blood pressure.

"There are foods that are rich in bioactive components that might be responsible for the results we're seeing," she said.

Holzman added it's been known for a while that women diagnosed with hypertension in pregnancy are more likely to develop hypertension later. But when you exclude this group, the women in the bottom quartile of diet quality were the only other group at increased risk of developing hypertension.

"So if you think of exercise, you don't have to be a high-performance athlete to get some benefit," she said. "It may be a similar principle with food. You benefit from eating a moderately well-balanced diet rich in fruits, vegetables and fiber like the DASH and healthy eating index."

Holzman noted that the study does take into account other relevant factors such as race/ethnicity, maternal age, education level, socioeconomic status and smoking. The researchers are eager to submit their findings for peer review and publication.

Though many studies have looked at hypertensive individuals, few have focused on those with moderately elevated blood pressure.

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ABOVE: Katheryn Meek, MSU Department of Pathology and Diagnostic Investigation.

OPPOSITE: DNA, the blueprint for all living organisms, is highly sensitive to damage. An MSU researcher, who has been studying DNA repair for more than 30 years, has made a discovery in her lab that may help understand the mechanism that promotes immune system development. *Photo: Thinkstock*

Molecular-level mapping shows how cells repair damaged DNA, safeguard genetic information

Cell division takes place in the human body several million times per day. With each split, DNA molecules — because of their inherent instability — are highly susceptible to damage, which can lead to genetic mutations. Add in external factors such as UV radiation and carcinogenic substances, and the odds of DNA damage increase even further.

MSU AgBioResearch immunologist and molecular geneticist **Katheryn Meek** has been studying DNA repair for just over three decades. This type of basic research has implications in areas ranging from human medicine to agriculture and biotechnology.

"DNA is the blueprint for all living organisms; thus all organisms have evolved numerous mechanisms to ensure maintenance of an exact copy of their genomes for propagation," she said. "Given its importance to life, it is somewhat surprising that evolution has allowed DNA to be so sensitive to various forms of damage, including oxidation, hydrolysis and methylation."

Meek explained that an entire host of molecular systems are continuously monitoring and repairing DNA at any given time, and that the pathways used to make these fixes are essentially the same in plants, animals and humans.

Her laboratory studies how DNA double strand breaks (DSBs) are repaired. She said DNA breaks, whether single-stranded or double-stranded, can lead to unfortunate outcomes, such as cancer.

"Thus, the maintenance of genome integrity is essential not only for organism survival but also for the inheritance of traits by offspring," she said.

There are two major pathways — non-homologous end joining (NHEJ) and homologous recombination (HR) — that repair DSBs in all organisms. Meek focuses on a large enzyme called the DNA dependent protein kinase (DNA-PK). It initiates NHEJ because it recognizes broken DNA ends and then targets other NHEJ factors to the site of damage. Emerging data implicate DNA-PK as a central regulator of DNA end access. Meek said ongoing studies are looking at how DNA-PK regulates DNA end access to promote end joining with minimal sequence information loss.

Additionally, Meek said, it is becoming apparent that DNA-PK may affect other repair pathways, potentially by limiting access of DNA ends to repair factors. This may have particularly important side effects in species that express very high levels of DNA-PK, and may explain the remarkable variation between species when the gene encoding this enzyme is mutated.

Meek is particularly excited about her recent discovery regarding T and B lymphocytes, the cellular components of adaptive immunity. During development of these cells, a gene shuffling mechanism is utilized that allows the cells to make cell surface receptors and serum molecules (antibodies) that recognize invading pathogens. However, this gene shuffling mechanism requires the introduction of DNA double strand breaks and is inherently dangerous for the cell and the organism. Thus, lymphocytes are particularly susceptible to translocations and mutations that cause cancer. She recently completed an experiment that lends insight into the mechanism of how lymphocytes prevent these genetic mutations by using protein factors to help guide how these intentional DNA breaks are repaired.

"B cell and T cell leukemia is pretty common because lymphocytes make mistakes during this gene shuffling process," Meek said. "There is a whole set of protein factors that help carefully guide those DNA breaks exactly into the pathway they're supposed to go. If that pathway is not available, then the cell should just die; but sometimes these misrepaired DNA breaks can result in a cell being changed from a normal cell into a cancer cell. We know that there is a mechanism to prevent this, but we don't understand really how it works. Now I have a hint of how that works."

Meek has written a paper based on the study findings and has submitted it for publication. She said the work may help to better understand the mechanism that promotes immune system development. Because the system relies on DNA repair in the gene shuffling process that allows people and animals to become immune to invading pathogens, animals and people that have genetic defects in this DNA repair pathway have no immune system. They have a genetic disease called SCID (severe combined immune deficiency), or the "bubble boy disease."

"In the past, my lab has defined the genetic mutations that cause this type of immune-deficiency disease in dogs and horses," she said. "These were useful findings because they helped us better understand the biology of how this pathway works. But now, other groups have discovered or genetically engineered similar mutations in pigs. Since these animals are completely immune-deficient, it is possible to implant human cells into them. This may allow researchers to directly study human cells — either cancerous or normal — in a large animal. These studies have previously been primarily limited to mouse models; having a large animal model opens up really incredible possibilities."

In addition to medical advancements, Meek said DNA repair is also an integral part of agricultural biotechnology. In this process, scientists select for gene variance to achieve desired traits, such as increased yield or improved food quality.

"Being able to manipulate the DNA and really understand how DNA repair works helps scientists more efficiently manipulate the genomes of organisms they're interested in — for instance, making more sustainable crops," she said. "There are many, many laboratories trying to manipulate genomes to make better beef. The things I do in my lab make it easier for those things to happen."

Meek said that understanding how DNA repair works is the first step in being able to genetically manipulate organisms, whether the efforts are to find ways to fight cancer or to produce higher quality foods with fewer environmental impacts.

The importance of studying DNA repair was recently supported by one of the most prestigious scientific awards of its kind. The 2016 Nobel Prize in Chemistry was awarded to Thomas Lindahl, Paul Modrich and Aziz Sancar — three scientists who all examine how cells repair DNA base damage and safeguard genetic information.

Meek is particularly excited about her recent discovery regarding T and B lymphocytes, the cellular components of adaptive immunity.

Program teaches mental health coping to at-risk junior high schoolers

ABOVE: Children of parents with mental health illnesses have a higher risk of developing a mental health disorder than children who do not have a parent or other close relative with a mental health challenge. An MSU researcher has developed a pilot program to help address the needs of these youth. *Photo: Thinkstock*

OPPOSITE: Joanne Riebschleger, MSU Department of Social Work.

According to the World Health Organization, mental health illness is the No. 1 disability in the world. In the United States alone, it is estimated that one in every five adults experiences some type of mental disorder in any given year.

Ironically, mental health challenges tend to be rarely talked about, despite their prevalence. **Joanne Riebschleger**, Michigan State University (MSU) School of Social Work associate professor, is working to change that, especially for children of parents with mental health illnesses. Studies show that these kids have a higher risk of developing a mental health disorder than children who do not have a parent or other close relative with a mental health challenge.

"This is a common illness, and we need to teach people that it is common," she said. "We, as a society, do a much better job of educating our kids about sexually transmitted diseases than we do about mental illness. Both are very important, but we definitely need to do a better job with mental health."

The overarching purpose of the program, now in its fourth year, is to prevent or delay the onset of the participant children's development of mental health disorders.

To that end, Riebschleger has developed Youth Education and Support (YES), a 10-session mental health literacy program for seventh and eighth graders at Waverly Community Schools in Lansing. Participants have parents or other family members with mental illness, substance abuse or co-occurring disorders, such as mental illness and substance abuse. The hourlong sessions are lively and fun, and feature videos, games, crafts and lots of discussion.

"We talk a lot about how everyone is feeling," she said. "Many of these kids think it's their fault — that somehow they triggered their parents' behavior. We teach them that this is a health condition and not an outcome of anyone doing wrong. It's nobody's fault."

The overarching purpose of the program, now in its fourth year, is to prevent or delay the onset of the participant children's development of mental health disorders. Shorter term objectives are to increase youth knowledge of mental health disorders and recovery, as well as to improve coping skills.

Participants are taught that mental health is part of healthcare. Riebschleger said stigmas related to mental health often prevent people from discussing the issue. The program aims to break down those barriers and teach participants how to build a crisis plan in the event that they ever need one.

A mobile in Riebschleger's office on the MSU campus is an example of one of the group exercises. Cards, each hand-labeled and drawn by students, show various coping mechanisms and dangle from the mobile. Ideas range from talking to friends to listening to music, and from going outside to helping others, which was identified as "pushing grandma's wheelchair" in one particular case.

Reports show that the majority of people with mental illness — whether children or adults — do not get the help they need, she said. The program strives to better equip these children, who are at higher risk than those without parents or family members with mental issues, to get the assistance they may need down the road.

"Some of what we tell them is that, even if you get this illness, you're not doomed for life," she said. "Everyone has their own dragon to fight — we all have struggles. We want to help make it more manageable in the event that it does happen."

The program, which has a 90 percent retention rate, continues to collect pilot data, with special emphasis on the development of measures to assess youth knowledge of mental illness and recovery. Emerging data does show, however, that children who have been through a session are doing significantly better three months afterward, she said. The ability of the participants to cope also appears to be in good shape, she added.

YES is a collaborative community-based study developed with support from the Guidance Center — a mental health contract agency in the downriver Detroit area — the Gerstacker Foundation (Midland, Michigan) and two innovative prevention program evaluation enhancement grants from the Substance Abuse and Mental Health Services Administration.

Co-investigators on the YES project are Esther Onaga, professor emeritus from the MSU Department of Human Development and Family Studies, and Betty Tableman, specialist emeritus from MSU Outreach. Waverly Middle School social worker Kristin Hood co-facilitates the YES program and collects pre-, post- and follow-up evaluation data.

Eventually Riebschleger would like to conduct a control group/comparison group study in mental health literacy. She is also working to secure grant funding to create a website geared at helping this same group of youth.

Recently she joined a new international grass-roots group of researchers who are reviewing worldwide literature to determine what types of knowledge are needed by children with a parent with substance abuse issues, mental illness or both. Eventually they want to propose and test a scale in the United States, Norway, the Netherlands and Germany, the home countries of the researchers in the group.

In the meantime, Riebschleger has signed a book contract with Lyceum Publishers of Chicago to co-edit a rural child welfare casebook with Barbara Pierce from the Indiana University School of Social Work. This casebook will be based on real-life child welfare cases and is meant to better prepare future child-welfare workers for practice in rural areas across the United States, Canada and Australia.

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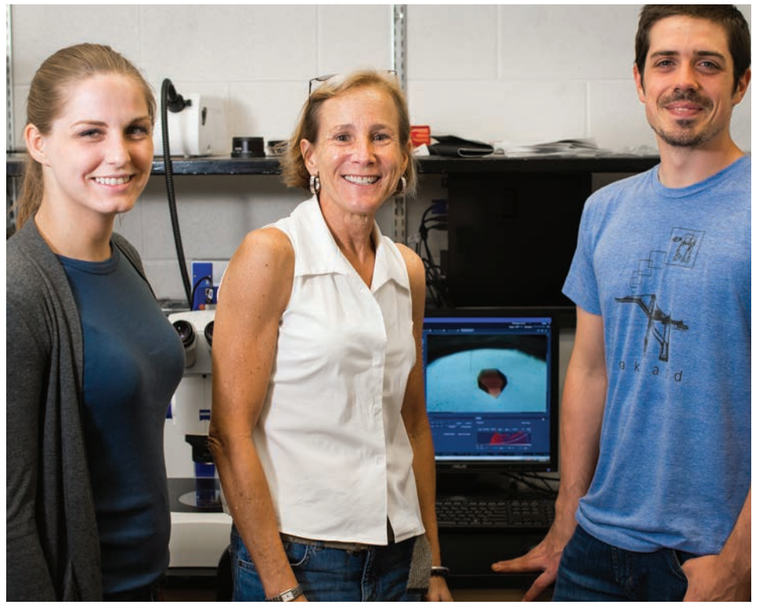
Investigating algae's full potential as an efficient renewable energy source



ABOVE: Cheryl Kerfeld (center), the John A. Hannah Distinguished Professor of Structural Bioengineering, and her team, which includes technical aide Emily Pawlowski and research assistant Ryan Leverenz, have been studying a process by which cyanobacteria protect themselves from too much light. *Photo: MSU CABS*

OPPOSITE: Kerfeld conducts lab experiments to study photosynthesis using cyanobacteria, which converts light from the sun to the chemical energy necessary for growing and functioning. *Photo: Courtesy of Cheryl Kerfeld*

Blue-green algae may look unappealing in nature, settling on the surface of swamps and other bodies of water. But it could be one of the catalysts for developing the bioeconomy of the 21st century, including renewable energy sources that fuel the future.

The algae, also known as cyanobacteria, use photosynthesis to convert light energy from the sun into the chemical energy needed for growth and function. Scientists at Michigan State University (MSU) are learning more about the photosynthetic process from these abundant organisms — with an eye on efficiency.

"There is great potential in using cyanobacteria as a way to understand the complex process of photosynthesis." — Cheryl Kerfeld

Cheryl Kerfeld, the John A. Hannah Distinguished Professor of Structural Bioengineering and an AgBioResearch scientist, and her team of researchers have been studying a process by which cyanobacteria protect themselves from too much light.

"Without a molecular mechanism to deal with excess light energy, the cyanobacteria would, essentially, fry," Kerfeld said. "They have to have a way to take in only the energy they need without overloading their systems."

Cyanobacteria have antennae that are used to capture light energy. A protein in the cyanobacteria, known as the orange carotenoid protein (OCP), changes from orange to a protective reddish color when a carotenoid pigment attached to the protein detects too much light. In this activated state, the protein plugs into the cyanobacteria's antennae, helping the organism dissipate excess light energy as heat. The molecular structure of the activated state and the cause of the protein's color change were previously unknown.

A paper published in *Science*, written by Kerfeld's group with lead author and research assistant **Ryan Leverenz**, details the structure of the activated form of the OCP and reveals an unexpected movement of the carotenoid. Kerfeld's team — which includes Leverenz and co-lead author Markus Sutter, among other MSU researchers, the Kirilovsky Lab in France and scientists from Berkeley National Laboratory — is the first to see this behavior. Previously, carotenoids were thought to be static and fixed to a protein scaffold.

"It's known that carotenoids have photoprotective functions, but the OCP is unique in that the carotenoid is also used as part of a switch that's turned on and off by light," Leverenz said. "Now that we can see the switched 'on' form of the protein structurally, which we were able to see in the lab, we're learning more about how it binds to the antennae of the cyanobacteria and how it helps dissipate energy after it binds. Once we fully learn how this process is performed in nature, we hope to apply the principles to design new artificial photosynthetic systems."

Researchers have noticed that, though cyanobacteria possess this unique mechanism for dissipating excess light energy, they don't always perform the task in the most efficient way. Harnessing the energy lost as heat will be important in the development of artificial photosynthetic systems as a reliable energy source.

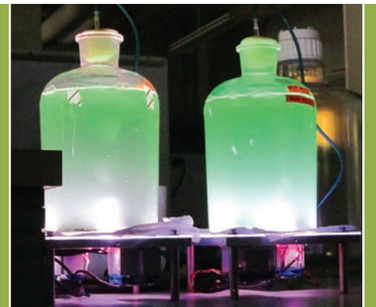
"Our group spends some of our time in California and some in Michigan. With the drought in California, people are very mindful of dripping faucets and their overall water consumption," Kerfeld said. "In Michigan, there's plenty of water, so people don't think about it much at all. It's kind of like that with cyanobacteria. They're so used to having so much sun that they don't bother to be careful about their photoprotective process — they turn it on and forget to turn it off. We want to help cyanobacteria be smarter about photoprotection and not waste so much of that energy as heat. This is important for modifying cyanobacteria to be microbial cell factories."

Cyanobacteria are also being tested for viability as a chemical precursor for plastics, in addition to fuels. Nearly all precursors in the chemical industry are currently petroleum-based, so sustainability and environmental impacts are concerns.

The U.S. Department of Energy has set a goal of generating 25 percent of industrial chemicals from biological processes by 2025. Improving the efficiency of photosynthesis in cyanobacteria can increase yields and address questions surrounding its use as a practical solution to energy challenges.

"There is great potential in using cyanobacteria as a way to understand the complex process of photosynthesis," Kerfeld said. "We have to better understand how photosynthesis is carried out in nature and how that translates to real-world applications, from the perspectives of biology, physics and chemistry. So we need to continue to collaborate as multidisciplinary teams to push this research forward. Our team is really excited about what we've seen so far, but we know there's a lot of work still to be done."

Funding for the project has been provided by the endowment of Kerfeld's position, the MSU-DOE Plant Research Lab and MSU AgBioResearch, with additional funding from the Kirilovsky Lab in France and the Berkeley National Laboratory.



AgBioResearch
MICHIGAN STATE UNIVERSITY

Inventorying U.S. forests to determine complete carbon removal capacity

By 2050, the United States seeks to reduce its carbon emissions by 80 percent, a goal set forth by the Obama administration as part of a comprehensive plan to address climate change. For carbon that does enter the atmosphere, the planting of trees and the prevention of deforestation can help.

Carbon, in the gaseous form of carbon dioxide, is taken in by trees and thus removed from the environment. Researchers such as Michigan State University (MSU) AgBioResearch scientist **David MacFarlane** have been working to measure the amount of carbon in trees, hoping to learn the capacity of these natural resources as carbon-removal mechanisms.

RIGHT: Members of David MacFarlane's research team cut trees into small sections in the field to make laboratory work easier. Water is removed from these samples in the lab to determine the carbon weight. They are working to quantify the amount of carbon in trees, hoping to learn the capacity of these natural resources as carbon-removal mechanisms. *Photo: Courtesy of David MacFarlane*

OPPOSITE: David MacFarlane, MSU Department of Forestry.

ENVIRONMENTAL STEWARDSHIP

The U.S. Forest Service enlisted six universities across the country — MSU, the University of Maine, the University of Georgia, Virginia Tech University, the University of Montana and Oregon State University — in a five-year project to collect data on various tree species and their carbon content.

"For a long time, scientists have known that trees are related to the global carbon cycle," MacFarlane said. "So when people started talking about how we could offset emissions from human activities, one of the ways is to grow trees. This has to be converted from the idea phase to learning how much carbon is actually in trees. This project started in 2011, and we've been collecting a large amount of data."

A national forest inventory is taken by the U.S. Forest Service's Forest Inventory and Analysis (FIA) program on a network of permanent sample plots across the country. The plots help researchers estimate the number of trees, the timber volume of various species, the speed of growth and other valuable information describing U.S. forests. FIA's early inventories focused on national and regional timber stocks. Now, MacFarlane said, scientists' viewing forests as living ecosystems that serve many purposes is expanding the scope of FIA.

Trees are composed largely of carbon dioxide and water, with small amounts of nutrients from the soil as well. To get an accurate measurement of the amount of carbon in various types of trees, researchers must cut down trees of different sizes and species. They then cut each tree into manageable pieces, measure the green weight of each piece and, in the lab, remove the water by heating the wood. The final step is to determine the carbon content of the dry mass.

"It turns out that, in general, a chunk of a tree is about half water," MacFarlane said. "The dry mass is about half carbon. So if you know the mass of a tree, you can use that rule of thumb and say about a quarter of that green mass is carbon. But the only way to truly know the mass of a tree is to weigh it. We don't want to cut down a whole bunch of trees unnecessarily just to weigh them, so we have to be smart about it and collect as much data from each tree as possible."

Mathematical equations have already been developed for determining carbon content. According to MacFarlane, however, there hasn't been enough data collected to make the equations reliable.

"The universities on the project have monthly conference calls to talk about progress, and this is when we share the new data," MacFarlane said. "We didn't have a lot of great data from across the country, so the equations that were developed previously were just sort of cobbled together. They've tweaked the equations slightly, and now they have two methods, but the two get different answers. Without a comprehensive dataset, we can't be very accurate in our estimates."

In response, the group developed a plan to target species that are prevalent across the country. Each researcher would study similar trees and how they grow in various areas of the United States, reporting any new findings back to the team.

In December, MacFarlane traveled to Portland, Maine, to the National Forest Inventory Symposium. The weeklong meeting featured researchers from the Forest Service showcasing findings from their work. MacFarlane and his colleagues presented on testing existing equations with new data, as well as new models for improving estimation. He believes that, as the dataset grows and the equations are refined, the public will take notice.

"It's nice to plant trees and talk about the good it does, but what people really want to know is, 'How good is it?'" MacFarlane said. "Public investment in forest carbon offset projects is significant. We can start treating carbon offsets like a commodity. We know how much a bushel of wheat costs. It varies, but we can quantify it pretty easily and assign a dollar value to it. But how much do forests offset carbon emissions? As we collect more data, we'll continue to learn."

To get an accurate measurement of the amount of carbon in various types of trees, researchers must cut down trees of different sizes and species.

AgBioResearch
MICHIGAN STATE UNIVERSITY

Curtailing environmental harm through efforts in conservation criminology

ABOVE: Meredith Gore's research melds the fields of conservation, natural resources management, criminal justice, and risk and decision sciences. Her work extends around the globe, including a project in Michigan that aims to improve management of furbearing animals, such as river otters. *Photo: Thinkstock*

OPPOSITE: Meredith Gore, MSU Department of Fisheries and Wildlife and the School of Criminal Justice.

Interdisciplinary research is a cornerstone of innovation at Michigan State University (MSU). The opportunities for faculty members to partner with colleagues across the various MSU colleges are plentiful — and encouraged. Input from experts in many fields will be crucial to developing solutions to the world's most pressing challenges.

With topics such as climate change dominating news headlines and the political sphere, MSU and other research institutions will be asked to provide leadership and answers. **Meredith Gore**, an associate professor in the MSU Department of Fisheries and Wildlife, is one of the researchers leading the charge.

The MSU conservation criminology program was established in 2008 and is the only one of its kind in the world.

In an effort to curtail environmental harm, Gore has been working in the area of conservation criminology, a joint effort between the university's Department of Fisheries and Wildlife and the School of Criminal Justice. Her educational background is in anthropology and natural resource policy, but human behavior has always been a significant interest.

"I have always wanted to know more about humans and how we interact with the environment," Gore said. "Unfortunately, a lot of negative consequences to the environment come as a result of negligent and sometimes illegal behavior from humans. My work, both in Michigan and abroad, deals with conservation while using criminology theory and methods of analyzing data that help to build a better understanding of the human dimension."

The MSU conservation criminology program was established in 2008 and is the only one of its kind in the world, Gore said. Graduate students can earn a certificate by taking three courses that integrate conservation, natural resources management, criminal justice, and risk and decision sciences. These fields also shape Gore's research, including a project in Michigan that aims to improve management of furbearing animals.

Michigan has a long history of furbearer hunting and trapping, creating a substantial economic industry. The Michigan Department of Natural Resources (DNR) indicates that the state is third in the nation in hunter participation, with nearly 800,000 licensed hunters and $28 million of economic impact.

The DNR uses a comprehensive dataset to inform its management policies, taking into account the population size of animals and other biological factors. But there are still missing pieces to these management recommendations. Studying four furbearers in particular — American marten, bobcat, fisher and river otter — Gore wants to better inform the DNR's models by accounting for noncompliance with rules.

"This project is aiming to produce new human dimension data to include in these models," Gore said. "If stakeholders are not complying with rules, what does that look like? Where is it occurring? One of the really challenging things with furbearer management is that the state has to rewrite its management recommendations on an almost annual basis. It can be confusing to resource users, and it's time-consuming. If the model were more holistic, we could have more stable and sustainable policy."

Involving communities in her research leads to the best results, Gore said, because there are cultural considerations that are important. Many families in Michigan have a history of hunting and trapping, which are often passed down through generations. Failing to capture information from those spending time outdoors would be remiss.

"Trappers and hunters can be the first line to where these animals are and whether they're being managed sustainably," Gore said. "They provide really valuable information, so they are a critical part of this project in data collection."

Gore and her team use a survey method called the randomized response technique. This allows individuals to answer questions under the condition of confidentiality. The research team's goal is not to fine or penalize hunters and trappers, Gore said, but to ensure that accurate data regarding resource use is collected.

She also compiles risk maps for species based on population estimates, habitat, the extent of illegal exploitation and other factors. She hopes to learn the scale of illegal take and contribute evidence that can inform policy and create a sustainable future.

Funding for the project comes from the DNR and MSU AgBioResearch. Gore believes the collaborative effort between MSU and the State of Michigan will benefit all citizens, regardless of whether they hunt.

"Every person is affected by environmental harm," Gore said. "We are either a cause of an environmental harm, or we can be negatively affected. This research tries to resolve those negative impacts. Unfortunately, environmental harms are increasing through climate change, illegal activity, etc. The bioeconomy is really important in Michigan, and we have amazing natural resources. If we're not measuring threats to the bioeconomy accurately, then we're not going to reduce risks."

AgBioResearch
MICHIGAN STATE UNIVERSITY

Developing alternative approach to assess stream health, use data more efficiently

ABOVE: Pouyan Nejadhashemi reviews data on stream health with students. Through collaborations with the Michigan Department of Natural Resources and the Great Lakes Commission, biological data was collected from streams in Flint, Muskegon and the Upper Peninsula, among others. *Photo: Courtesy of Pouyan Nejadhashemi*

OPPOSITE: Pouyan Nejadhashemi, MSU Department of Biosystems and Agricultural Engineering.

Roughly 2.5 percent of global water is fresh water. Only 1.2 percent of that is surface water such as rivers, lakes and streams. With more than 7 billion people around the world relying on fresh water for drinking, agriculture, recreation and more, the need to preserve this vital resource is greater than ever.

In the United States, the Environmental Protection Agency (EPA) passed the Clean Water Act in 1972 in an effort to "restore and maintain the chemical, physical and biological integrity of the nation's waters." The new law established protocols for regulating water pollution, and although more than 40 years have passed, water quality improvements are moving slowly.

Nejadhashemi and his research group have developed models that factor in aquatic life, soil, land use, climate change, erosion, plant growth and many other variables.

ENVIRONMENTAL STEWARDSHIP

The 2011 EPA Biological Assessment revealed that nearly 42 percent of U.S. streams are in "poor" biological condition, which is measured by the health of native fish and invertebrate populations. Only 53 percent were determined to be in "fair" or "good" condition. The remaining 5 percent have not been assessed.

But there are significant factors of stream health that are ignored in these figures. Are enough individual sites being monitored to accurately gauge aquatic ecosystems? How will climate change affect fresh water resources? How can this information be pieced together to inform policy decisions? **Pouyan Nejadhashemi**, an associate professor in the Department of Biosystems and Agricultural Engineering (BAE) at Michigan State University (MSU), believes that one of his research projects may hold the answers.

"It's simply not feasible from cost and resource perspectives to regularly monitor thousands of individual locations on each body of water," Nejadhashemi said. "That would be a waste of resources, particularly for some areas that may be in good condition. So we needed to develop an alternative approach that takes into account hundreds of variables to assess stream health condition. Then we can use that data to make better decisions, focusing limited resources on the areas of greatest need."

Nejadhashemi and his research group — including Matt Einheuser, Matthew Herman and Sean Woznicki — have developed models that factor in aquatic life, soil, land use, climate change, erosion, plant growth and many other variables. Historically, models have done a poor job at considering several variables concurrently, leaving researchers to make generalizations based on relatively small amounts of data.

"There have been significant knowledge gaps in determining stream health in the past, and we used the wrong criteria to assess stream health," Nejadhashemi said. "I think of it like going to the doctor for a health checkup. The doctor performs several tests to determine if you're healthy. You can't simply evaluate your overall health by checking only your eyesight. That's what we've been doing with stream health historically, so we've needed to use new techniques along with several indicators to measure stream health more accurately."

Through collaborations with the Michigan Department of Natural Resources and the Great Lakes Commission, biological data was collected from streams in Flint, Muskegon and all the way to the Upper Peninsula. These rich datasets were incorporated into the stream health models using fuzzy logic techniques, which are based on "degree of truth" rather than the absolute truth value.

"Stream health is a complex issue that is nonlinear in nature," Nejadhashemi said. "We can use fuzzy logic to add a linguistic interpretation to stream health conditions, which helps create more easily understandable results."

Fuzzy logic allows the research team to create if-then statements. For example, if pollutant concentration is high, then stream health is poor. Using thousands of individual data points across hundreds of locations, this simplification proves invaluable.

After introducing future climate scenarios into the stream health models, the researchers then develop risk maps showing which sections of water are in greatest need of remediation. Researchers and outreach professionals can use these maps to inform policy that utilizes resources efficiently.

"These are extremely valuable tools for all stakeholders engaging in water resources planning," Nejadhashemi said. "At this point, we may be spending time and money on areas that may not be in critical need of attention. But with the added information from our models, we have a better chance at making evidence-based recommendations. We would like to expand this project beyond Michigan to be a part of comprehensive national policy for protecting fresh water resources, which not only focuses on water quality but also natural habitats."

This project is funded by the U.S. Department of Agriculture National Institute of Food and Agriculture and MSU AgBioResearch.

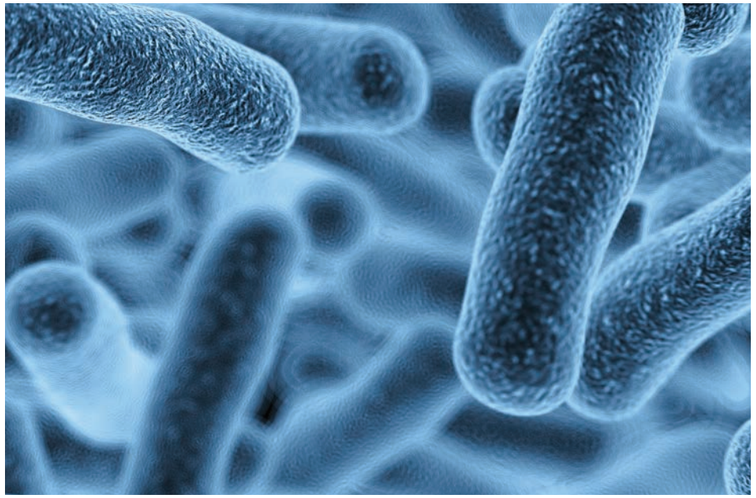
AgBioResearch
MICHIGAN STATE UNIVERSITY

Studying signaling and gene regulation in bacteria

Countless communities of bacteria called microbiomes live on and inside the human body. They can also develop on food and within drain pipes, to name just a few other places. In fact, one study estimates that there are 10 times more bacterial cells than human cells within the body. And another shows as many as 20,000 species of bacteria in 1 quart of seawater.

To discover ways to break down and fend off infectious bacteria, scientists must understand how cells integrate signals from one another and the environment, and how they respond by changing gene expression, metabolism, motility and morphology. Unraveling how these mechanisms work will likely spur advancements of medical, agricultural and environmental importance.

Michigan State University (MSU) AgBioResearch scientist **Lee Kroos** is conducting basic research on *Bacillus subtilis* and *Myxococcus xanthus,* soil bacteria that are model organisms for understanding cell-to-cell signaling and changes in gene expression that cause cell differentiation. *B. subtilis* is well-studied by the scientific community, in part because of its ability to form spores. Spores are extremely difficult



RIGHT: *Bacillus subtilis* is a well-studied soil bacterium. An MSU study is looking at *B. subtilis* in an effort to establish new paradigms for other more difficult-to-work-with and less well understood microorganisms. *Photo: Thinkstock*

OPPOSITE: Lee Kroos, MSU Department of Biochemistry and Molecular Biology.

SECURE FOOD AND FIBER SYSTEMS

to kill and facilitate the spread of some infectious bacteria. *M. xanthus* is known for the rapid formation of multicellular structures, some consisting of up to 100,000 cells, called fruiting bodies.

Kroos, professor in the MSU departments of Biochemistry and Molecular Biology, and Microbiology and Molecular Genetics, studies the biochemical and genetic simplicity of these bacteria during development to explore the molecular mechanisms of signaling and gene regulation. Ultimately, he aims to establish new paradigms based on these well-documented bacteria that can be applied to other more difficult-to-work-with and less-well-understood microorganisms.

"Manipulation of microbial communities to improve life and solve global problems will depend on knowledge of how bacteria interact with one another and their environment," Kroos said. "Microbial communities affect global processes such as cycling of elements between soil, water and air, and primary productivity of the oceans. They have impacts on ecosystems and all the organisms that inhabit them."

In 2014, Kroos published a paper that provides key insight into the formation of fruiting bodies. *M. xanthus* are predatorlike and feed on other bacteria. When they run out of food, the microbes go through a developmental process by which thousands of cells aggregate to form the fruiting body. The long, rod-shaped bacterial cells then convert into round spores. With funding from the National Science Foundation, Kroos and his team discovered that there are two coordinated signaling pathways responsible for prompting the cells to change shape.

"You have these two transcription factors — things that control gene expression — one that responds to starvation and the other that responds to the cells being close together," he said. "If you have both signals, we found that the two transcription factors bind cooperatively to the DNA to regulate genes that are needed for sporulation. It's a way to integrate the signals with these transcription factors."

Like *M. xanthus*, *B. subtilis* also undergoes development when starved. The cell is partitioned into two compartments — the mother cell and the forespore — each of which expresses distinct sets of genes in an ordered temporal fashion under the control of different subunits of RNA polymerase.

The signaling between the forespore and the mother cell is based on an enzyme that is present in nearly all living organisms. In human health, it regulates diverse signaling pathways and is implicated in some disease processes. In a study funded by the National Institutes of Health, Kroos and his research team isolated a stable form of the enzyme along with its substrate to create the first such data-based model of its kind.

"Nobody else has been able to isolate a stable complex like that," he said. "We have done cross-linking studies where we form cross-links between the two proteins. We can tell where those cross-links are. It's allowed us to build a model of the enzyme-substrate complex. There is currently no other model for such a complex. It's a model, not a structure – but structures of these things are extremely hard to obtain."

In the midst of drafting a manuscript on the project, Kroos is excited about the possibilities. He said other scientists will be able to use this model in efforts to figure out how to inhibit the enzyme, thereby stopping sporulation of related bacteria and making them less infectious. He said that could be a step toward designing a new antibiotic.

Kroos has devoted much of his 27-year career at MSU to studying these two bacteria. *M. xanthus* is part of the myxobacteria family, which has been used as biological control agents. They also make lots of compounds, including a new anticancer compound used in breast cancer treatment. *B. subtilis* is not pathogenic to humans, but it is related to *Bacillus anthracis*, which causes anthrax.

Kroos said the research is important because limited understanding of how microbes control complex behaviors in response to one another and their environment impedes our ability to harness the microbes for pollution and climate control, and for increased bioenergy and food production.

He said more work needs to be done in educating the general public about such things as beneficial bacteria. Therefore, in addition to training postdocs and graduate and undergraduate students in the lab, Kroos conducts outreach with various community organizations.

Ultimately, Kroos aims to establish new paradigms based on these well-documented bacteria that can be applied to other more difficult-to-work-with and less-well-understood microorganisms.

AgBioResearch
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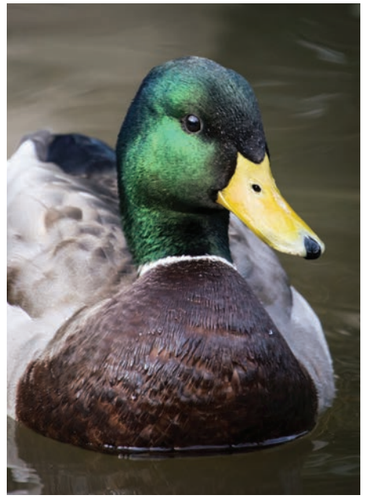


ABOVE: Two species of waterfowl — the mallard and the blue winged teal — are being studied in order to assess variation in pathogen load in virus-infected birds. The research seeks to better understand why some wild birds called supershedders carry the bulk of pathogen load. *Photo: Thinkstock*

OPPOSITE: Jen Owen, MSU Department of Fisheries and Wildlife.

Examining internal and external factors affecting pathogenic loads and 'supershedders'

More than 60 percent of all human infectious diseases originate in animals, and within the past century, an unprecedented number of diseases have emerged that pose significant risks to wild and domestic animal and human populations. Many of them originate in wild birds.

Jen Owen, an associate professor in the Michigan State University (MSU) Department of Fisheries and Wildlife, is working on a project funded by the National Science Foundation (NSF) to assess variation in the pathogen load in virus-infected birds. It is an NSF Career grant, one of the most prestigious awards given to early-career faculty members. Unlike many others, these grants require both a research and a teaching component and an integration of the two.

Through the project, Owen is looking to better understand why some individuals within a population carry higher pathogen loads than others. She is particularly interested in "supershedders," the ones in a population that, for unknown reasons, are responsible for most of the pathogen load.

"We're looking to see if there is a genetic basis for supershedders by using transcriptomics and RNA sequencing," she said. "We want to see if there are genes that are differently expressed in supershedders than in non-supershedders."

Owen said there is a significant knowledge gap in disease epidemiology when it comes to understanding the intrinsic and extrinsic factors that determine variation in infectiousness. Knowing more about the basis for pathogen load variation and why some individuals shed much larger amounts will provide information to develop more realistic epidemiological models that lead to cost-effective, targeted prevention and control strategies, she said.

The project has the following objectives:

- Use genome-wide technologies to investigate how gene expression affects variation in viral shedding using low-pathogenic avian influenza virus and two species of waterfowl — the mallard (Anas platyrhynchos) and the blue-winged teal (A. discors).
- Test how variation in host body condition — caused by food restriction — affects how a bird responds to West Nile virus, using the American robin (Turdus migratorius) as a focal species.
- Develop simulation models to demonstrate how environmental factors influence disease outbreaks.
- Adapt the models to allow non-STEM (science, technology, engineering, mathematics) students in college general science classes to learn about disease dynamics. Through a user-friendly computer interface, students will be able to manipulate environmental stressors associated with climate change and/or other natural disturbances, and then track disease outcomes that are host- and pathogen-specific.

Through previous research, Owen found that waterfowl infected with avian influenza virus exhibit significant within-species variation in how much virus they produce/shed — i.e., how infectious they became. Furthermore, she and her research team found that, contrary to their predictions, healthy birds shed more disease organisms than unhealthy birds. But they also found that, regardless of environmental conditions, 20 percent of birds within a population shed 80 percent of the virus. These individuals are the supershedders.

"There is clearly something beyond the environment, some intrinsic basis for this pattern," she said. "It is likely happening in the bird's gut, where low-pathogenic strains of influenza virus bind to host cells."

Owen, her students and three colleagues at MSU LearnDAT (Learning Design and Technology) are developing a computer simulation program for non-STEM students. Owen is a faculty member with the MSU Center for Integrative Studies in General Science (CISGS), and she decided to focus on human malaria — a disease she had not previously studied — because there is more data available on malaria, and it is a better fit for the environmental science curriculum in the CISGS program.

"I'm very passionate about teaching non-majors and getting them to understand the role of science in everyday life and making those connections," she said. "Disease fascinates students, and once you start talking about infectious diseases like malaria, you quickly get their attention and genuine interest."

The computer simulation will depict an African village in an area in which malaria is endemic. Students will be able to adjust aspects of the climate such as temperature and rainfall, as well as socioeconomic status in the village. Students will see how changes in climate and levels of poverty affect risk of infection as well as recovery and treatment. She also wants students to be able to understand how the health of the people is linked to the health of the environment.

"We don't talk about any of these things in isolation because they're all connected," she said. "The idea is that this module for human malaria simulation is adapted to be applied to a new environmental organismal biology class some of my colleagues and I will be developing."

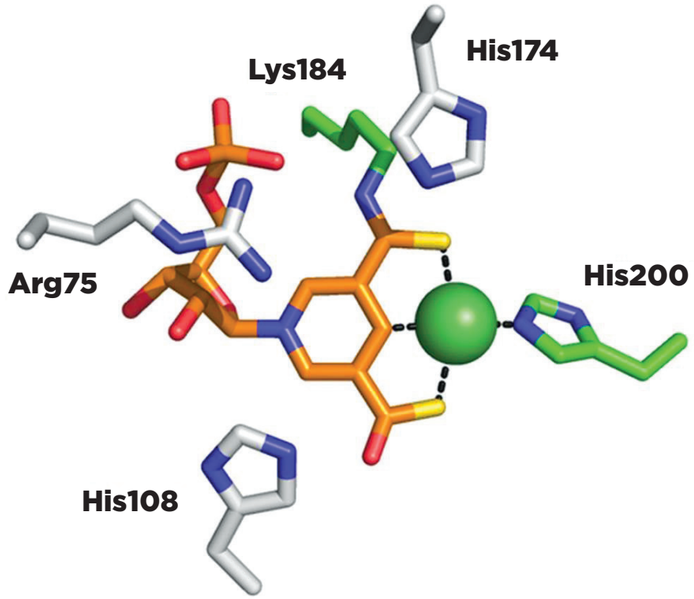
Owen said she hopes to provide non-majors with a yearning to pursue science. In general, she said, their view of the subject is low because of negative experiences and misperceptions. Owen has had previous success in this regard, usually having at least one student every other semester switch from a non-science major to a science-related one. Owen said the key is educating students on how science is relevant in everyday lives, such as pointing out daily examples in the news.

She believes that implementing a computer simulation exercise, such as the one on malaria that illustrates concepts taught throughout the semester, will leave students better equipped to answer relevant and thought-provoking questions and improve the large-class learning experience.

The new course she is developing, called "Emerging Infectious Disease and Global Climate Change," is expected to be offered within the next two years or so. Owen is also in the midst of writing a book about the ecology of infectious diseases in wild birds.

"We're looking to see if there is a genetic basis for supershedders by using transcriptomics and RNA sequencing." — Jen Owen

Defining enzyme structure a step in the right direction to better understand bacteria function



ABOVE: The green sphere in the cofactor diagram represents nickel. Robert Hausinger has been interested in nickel-containing enzymes for decades. His team has discovered a bond from the nickel ion to a carbon atom and two sulfur atoms, known as a pincer complex, which had previously never been identified in biology. *Image: Courtesy of Robert Hausinger*

OPPOSITE: Robert Hausinger, MSU Department of Microbiology and Molecular Genetics.

In the world of bacteria, *Lactobacillus plantarum* is as versatile as they come. The microorganism produces a large amount of lactic acid and can interconvert between its two forms, L-lactate and D-lactate, through the use of an enzyme known as lactate racemase. But *L. plantarum* is not just impressive on the molecular level — it has many applications on a much grander scale.

Making silage, a fermented animal feed, or fermented foods such as sauerkraut for humans are just a couple of *L. plantarum*'s capabilities. But the headliner may be the potential it holds in the area of human health.

Using the sophisticated method of mass spectrometry and Hu's expertise in crystallography, the team elucidated the lactate racemase enzyme structure in the lab.

SECURE FOOD AND FIBER SYSTEMS

Studies on *L. plantarum* as a probiotic — live bacteria that can be helpful in digestion and immune system function — have been promising. And there's a significant market. Consumers have responded well to the growing scientific support for a wide range of probiotic supplements, foods and beverages, making it a global industry worth more than $28 billion per year.

"I've seen articles mentioning *L. plantarum*'s ability to enhance iron uptake, produce bacteriocin, and decrease levels of triglycerides and other lipid-associated components, including cholesterol," said **Robert Hausinger**, a professor of microbiology and molecular genetics at Michigan State University (MSU).

Although Hausinger hasn't yet delved into the human health applications of *L. plantarum*, his laboratory is studying a key component of the bacteria — lactate racemase. After reading a report from a Belgian group in 2014, which identified lactate racemase as a nickel-containing enzyme, Hausinger was intrigued.

A team consisting of Hausinger; Benoît Desguin, a postdoctoral researcher from the Belgian group; and **Jian Hu**, an assistant professor in biochemistry and molecular biology at MSU, has since made some important discoveries.

"I've been interested in nickel for a long time," Hausinger said. "I've done a lot of work over the years with another enzyme called urease. It contains nickel, and to put that nickel in place there's a protein assembly 'machine' in the cell. There's an entirely different approach used in lactate racemase. In particular, what happens is that the enzyme has a cofactor that's not just nickel — it has a niacin [vitamin B3]-derived organic component to it as well. That cofactor — the organic and inorganic components — is attached to the protein. That was surprising and unusual."

In a paper published in the July 3, 2016, issue of *Science*, Desguin, the lead author, detailed the process by which the group defined the structure of the lactate racemase enzyme and its cofactor, something never seen before. Seeing the makeup of the enzyme will help researchers learn more about how it helps *L. plantarum* and other bacteria function.

Using the sophisticated method of mass spectrometry and Hu's expertise in crystallography, the team elucidated the lactate racemase enzyme structure in the lab. The researchers saw that the cofactor they found contains an organic and inorganic component, including a nickel ion bonded in a planar manner to a carbon atom and two sulfur atoms. The discovery marks the first instance of this unique configuration, known as a pincer complex, in biology. Inorganic chemists work with pincer complexes regularly.

"Desguin was able to identify exactly where the cofactor was bound to the protein and characterize it," Hausinger said. "It's really elegant work that he and **Tuo Zhang** [a postdoctoral researcher with Hu] did to sort out how it all fits together. Additionally, the great thing is that now the studies by research inorganic chemists with pincer complexes have biological significance and can have a great impact on the work we're doing."

The Hausinger team believes it has just scratched the service of understanding lactate racemase and the roles of the novel cofactor in *L. plantarum* and other bacteria. Hausinger is excited to continue the research with a broad array of partners.

"Making this connection among various scientific disciplines is what led to this discovery," Hausinger said. "We are continuing to work with scientists in Belgium. Inorganic chemists across the country are also interested in this research. Hopefully, it will lead to a better understanding of lactate racemase's chemistry. That could have significant implications on other biological reactions."

The project is funded by the National Science Foundation, the Department of Microbiology and Molecular Genetics at MSU, and MSU AgBioResearch.

AgBioResearch
MICHIGAN STATE UNIVERSITY

A FRESHER VEGETABLE:

Re-evaluating how food is stored

ABOVE: Elliot Ryser, MSU Department of Food Science and Human Nutrition. *Photo: MSU CABS*

OPPOSITE: The MSU research team found that in-package gases were more effective at inhibiting microbial growth on produce than sanitizers used during the washing process. *Photo: Thinkstock*

Every day, millions of people buy packaged fresh-cut produce from their local grocery stores, secure in the knowledge that what they bring home will, indeed, be fresh when they eat it. But that freshness does not last forever. All packaged food — fresh-cut vegetables in particular — has a limited shelf life. A team of Michigan State University (MSU) researchers is working to extend that shelf life while improving food safety.

MSU AgBioResearch food scientists **Elliot Ryser, Eva Almenar, Janice Harte** and **Randy Beaudry**, together with colleagues from Rutgers University and Ohio State University, are studying the impact and increasing the efficacy of sanitizers and gases used in packaging fresh-cut produce through a $2 million grant from the U.S. Department of Agriculture (USDA) National Institute of Food and Agriculture.

Chemical compounds are used to treat produce before packaging to neutralize any harmful pathogens that may be present, such as Salmonella or *E. coli*. The use of these sanitizers is required by federal regulation before the produce can be sold. Most produce packages are also filled with gases, such as carbon dioxide, to inhibit the growth of microbes. The MSU team was tasked with finding the right balance between the compounds and gases to ensure maximum food safety without sacrificing freshness.

A series of pathogen outbreaks and product recalls — most notably a 2006 E. coli outbreak in fresh spinach that resulted in over 270 hospitalizations and three deaths — were the impetus for this project.

"This is part of a much larger USDA project to look at safety in fresh fruits and vegetables," said Ryser, professor in the MSU Department of Food Science and Human Nutrition. "After being treated with sanitizers, many products are packaged under various atmospheres and exposed to fluctuating temperature conditions, which can increase the chances that they become contaminated or lose their freshness. Our findings will be built into USDA's risk assessment program to improve food safety."

Combating pathogens begins as soon as the produce is harvested. The produce is washed before packaging with water that has been mixed with sanitizing agents such as chlorine and peracetic acid to remove pathogens. These compounds remove 90 percent to 99 percent of the pathogens from the produce itself. Though that eliminates the vast majority of pathogens, a colony of 1,000 Salmonella cells on a single tomato is capable of contaminating an entire batch. Ryser's lab studied this spread of pathogen from inoculated to non-inoculated produce in tomatoes, onions, celery and cantaloupe.

Ryser and his team found that controlling the temperature at which produce is stored is critical to controlling pathogen spread. The produce can undergo significant temperature fluctuations during transportation from the field to the store. Often vegetables are briefly kept in warmer areas such as loading docks or unrefrigerated rooms for cleaning, during which time pathogens — which may have been present in non-harmful quantities — can rapidly proliferate.

"If the temperature increases, you have the potential for pathogen growth," Ryser said. "Retailers recognize there are issues here, and our research is going to help them resolve those issues."

Controlling the climate in which produce is stored is only one part of the solution. Almenar, associate professor in the MSU School of Packaging, worked with her team to evaluate the in-package gases used to inhibit microbial growth in produce.

"To minimize microbial growth of both pathogens and molds, we use in-package gases with lower oxygen and higher carbon dioxide," Almenar said. "Such mixtures can reduce the shelf life of the food, however, so we were tasked with finding the right balance that maximizes both microbial control and freshness."

Fresh vegetables and fruits respire inside the atmospherically limited packaging, consuming an already limited amount of oxygen and producing additional carbon dioxide. Eventually they deplete the package's oxygen supply, at which point fermentation begins to take place, eventually rendering the produce both damaged and decidedly unappetizing.

Striking the right balance between controlling microbial growth with carbon dioxide and providing enough oxygen to extend the shelf life of the produce was the focus of Almenar's work. Testing a wide range of gas combinations in celery, onions and tomatoes ultimately led to the discovery of the ideal mixtures that achieved both goals.

"Our work found that specific gas mixtures in conjunction with the right sanitizers can result in safer produce while maintaining the fresh quality that consumers desire," Almenar said. "We have also seen that in-package gases are more effective than sanitizers at reducing microbial activity on produce."

To ensure that the produce meets consumer expectations, Harte, associate professor in the Department of Food Science and Human Nutrition, conducted a series of surveys and sensory panels. Her team had consumers compare stored produce, such as celery and onions, with produce fresh from the field and rate them on texture, color, aroma and other characteristics.

"Even if the produce is safe, if it doesn't appeal to consumers in the store, they won't buy it," Harte said. "It wasn't enough that we simply controlled the microbial growth on the food — we had to make sure that the produce was marketable, that controls were something retailers could put into practice without hurting their sales."

The research has resulted in a series of safer produce packaging protocols without sacrificing the freshness that makes fresh-cut produce an important part of a healthy diet.

"Assuming that industry adopts these new strategies, our produce will be safer and have a longer shelf life," Ryser said. "There is, of course, no silver bullet when dealing with pathogens, but we can significantly inhibit their growth and spread, and keep them from reaching dangerous levels."

The research has resulted in a series of safer produce packaging protocols without sacrificing the freshness that makes fresh-cut produce an important part of a healthy diet.

AgBioResearch
MICHIGAN STATE UNIVERSITY

Adapting human medical technology to predict plant diseases

ABOVE: Brad Day, MSU Department of Plant Pathology.

OPPOSITE: The MultispeQ device is capable of taking a wide range of readings on a plant. Uploaded to PhotosynQ, the data could help predict the next major plant epidemic.
Photos: MSU CABS

Not only do agricultural producers have to contend with unpredictable weather patterns, changing economic circumstances, and a dynamic and diverse population of pests bent on devouring their crops — they also face the perennial issue of plant diseases. The diseases are spread by a wide range of pathogens — including fungi, bacteria, nematodes and viruses — and the potential damage is alarming.

For instance, a 2000 outbreak of fire blight carved a wide swath through Michigan's orchards, resulting in an estimated $42 million in losses and destroying between 350,000 and 450,000 apple and cherry trees. The disease broke out and spread rapidly. Growers spent much of the following years replanting and restoring their orchards. Last year an outbreak of white mold in Michigan soybeans destroyed approximately $50 million worth of crops.

Developing technology to ensure that growers have the capability to fight the next such epidemic has been the subject of ongoing research at Michigan State University (MSU) and in agriculture and natural resources programs around the country. Now, MSU researchers from human medicine, plant genetics and plant pathology have joined forces to adapt the latest technology for tracking and predicting the next major plant epidemic.

Martin Chilvers and **Brad Day**, MSU AgBioResearch plant pathologists, are leading the multidisciplinary team.

"We aim to provide point-of-contact plant disease diagnosis, which will facilitate rapid disease management decisions to minimize crop losses and improve grower profitability," said Chilvers, assistant professor in the MSU Department of Plant, Soil and Microbial Sciences. "The data we collect will also aid in longer term management solutions. For the general public and globally, this will translate into increased food security."

To diagnose plant diseases, however, the team needed an expert who could identify the genetic markers of plant disease. Day has spent his entire career combing plant genomes in an effort to understand how plants resist pathogens. His work has generated an enormous amount of tertiary data that has led to new potential uses.

"I looked at this huge amount of collateral data we had on all these different species and asked, 'Are there any alternative uses for this?'" said Day, associate professor and associate department chair for research in the MSU Department of Plant, Soil and Microbial Sciences. "Plant pathogens cause about $60 billion in losses each year in the U.S. alone. Being able to understand where they come from and how they spread would be a major accomplishment."

Day, whose work is primarily focused on fundamental lab research, needs help to deploy that data in the field.

Evangelyn Alocilja, professor in the MSU Department of Biosystems and Agricultural Engineering, developed a biosensor for detecting pathogens in humans. After conversations with Day, however, the two researchers realized that the potential for her technology could reach beyond human medicine. By adjusting the sensor's probes, Alocilja was able to use Day's genomic data to reconfigure the device to target specific plant pathogens.

"The biosensor could allow early and quick screening of plants in the field, which would warn growers about impending outbreaks," Alocilja said. "Early recognition of pathogens would give them time to implement disease control methods before the pathogens reach epidemic proportions."

Though the biosensor can detect pathogens, putting that data into a larger geographical context requires an additional tool. That tool, dubbed PhotosynQ, is in the final stages of development by **David Kramer**, MSU Hannah distinguished professor in photosynthesis and bioenergetics. The PhotosynQ system is composed of two equally important components:

A handheld device, called MultispeQ, that allows the user to collect data on plant and soil health.

PhotosynQ proper, a web-based database where users from all over the world can upload the information scanned with their MultispeQ devices.

"PhotosynQ can collect information that people are taking globally, and we can use that to see where incidences of plant disease are occurring," Day explained. "Sitting here in East Lansing, we can look at data being uploaded by a farmer in Malawi and maybe see the first signs of an epidemic. From there, we can do fundamental research on the ground to try to stop it before it becomes a serious problem."

The more people using PhotosynQ around the world, the better the chances of spotting an epidemic before it truly begins. Kramer plans to produce the device in large quantities and distribute it to growers at a minimal cost.

"If we can get thousands of devices to people and have them collect data on plant variety, environmental conditions, management techniques, etc., we can generate a massive data set," Kramer said. "The more data we have, the better the picture of global plant conditions that emerges from it. That's what we're trying to do with PhotosynQ — lower the barriers to getting the instruments and the data out there to people."

By combining research from plant pathology, plant genetics and human medicine with cutting-edge technology, the MSU team is pushing the boundaries of what is possible in plant epidemiology. Predicting the next plant epidemic could have far-reaching benefits across agriculture.

"Here at MSU, we're working on deploying next-generation nanotechnology for the detection of plant pathogens. That's really cool," Day said. "This is a way to not only combat disease but to make our data accessible regardless of geography. It's a great opportunity."

By combining research from plant pathology, plant genetics and human medicine with cutting-edge technology, the MSU team is pushing the boundaries of what is possible in plant epidemiology.

AgBioResearch
MICHIGAN STATE UNIVERSITY

Market research reveals why consumers are drawn to wineries in Michigan

ABOVE: Dan McCole, MSU Department of Community Sustainability.

OPPOSITE: Wineries play an important role in Michigan's booming tourism industry. An MSU research team has conducted intensive market research and produced data to help Michigan wineries better understand the needs of their clientele. *Photos: MSU CABS*

In 1980, Michigan was home to 10 wineries and just over 200 acres of vineyard land. Today, those numbers have skyrocketed to more than 200 wineries and nearly 3,000 acres dedicated to wine grape production, representing more than $790 million in annual production value.

The center of Michigan's viticultural production lies along the Lake Michigan shoreline, from Leelanau and Grand Traverse counties in the north to Berrien and Van Buren counties in the south. The recent proliferation of wineries and vineyards, however, has brought wine and grape production to statewide prominence. Though the industry ranks fourth in the United States in economic impact, challenges remain. **Dan McCole**, Michigan State University (MSU) AgBioResearch tourism and sustainability researcher, is working to help overcome some of the issues.

The harsh winter of 2013-14 exacted a toll on Michigan's vineyards. Near-total ice cover on Lake Michigan dramatically reduced grape yields and inhibited the growth and development of high-quality fruit. According to some estimates, Michigan grape growers lost 50 percent of their crop. Through a four-year project sponsored by the U.S. Department of Agriculture, McCole's research team is working to help vineyard owners find new wine grapes with the hardiness to withstand the effects of extreme cold and the capability of pleasing wine consumers.

"There have been a number of viticultural advances that allow vineyards to produce hybrid wine grapes that can survive harsher weather and ripen in the course of a shorter growing season," said McCole, an associate professor in the MSU Department of Community Sustainability. "We are doing a study now to learn more about consumer preferences for wines made with these cold-hardy grapes so that wineries can make data-based decisions about which grapes they use in their winemaking."

To do this, McCole and his team hit the road, traveling to a number of wineries featuring wine made from cold-hardy Marquette grapes. Marquette is a hybridization of pinot noir and the American native grape *Vitis riparia*, developed at the University of Minnesota in 2006. McCole's team wanted to study consumers' willingness to pay for wines made from Marquette to determine market viability. Presenting visitors with four different Marquette wines, the team began by asking participants to estimate how much they would be willing to pay per bottle on the basis of appearance and aroma. After that, they were given a sample and asked to amend their estimates on the basis of taste. Finally, the team informed the participants of Marquette's potential value to the industry as a cold-hardy grape, after which they were asked to make a final adjustment to their estimates.

Though the study is not yet complete, preliminary results suggest that information about the grape's value to the industry does have an impact on consumers' willingness to pay.

The cold-hardy grape research is just one example of how McCole is helping the winery industry as a whole. Most Michigan wineries, in contrast with their counterparts in California, are small operations, primarily selling from tasting rooms rather than major retail outlets. Most simply cannot afford to engage in lengthy, detailed market research. McCole and his team stepped in to help the state's wineries better understand their customers.

A number of important characteristics about Michigan winery customers emerged from this work, some surprising. For example, most customers are casual drinkers without extensive background knowledge about wines. They are drawn less by the desire to test their refined palettes than by the enjoyable atmosphere or the social experience of wine tasting.

"This is an important finding because, though winery owners are reading stories about wine drinkers in trade magazines, these aren't their tasting-room customers," McCole said. "Our wineries need to focus on the aspect that their customers find the most important — the experience of the visit itself."

The data allowed McCole to better understand the economic impact of wine tourism in the context of other wine-related activities, such as winemaking and grape production. This study has helped the Michigan Department of Agriculture and Rural Development (MDARD) incorporate the importance of wine tourism in its planning. McCole's team is now working to replicate and validate this study in Minnesota and Wisconsin. Furthermore, MDARD has requested that the study be conducted again next year to provide an update.

The long-term sustainability of the winery industry is of crucial importance to Michigan communities, McCole pointed out.

"Wine is a great example of how communities can be more sustainable," he said. "Wine grapes are in growing demand. The processing is usually done locally, creating jobs in the communities that grow them, and wineries attract tourists, which create other complimentary business opportunities such as breweries and art galleries. Suddenly you have a vibrant community that retains its young people and continues to grow."

The winery industry is expanding not only in Michigan but around the country. Since 1940, it has expanded from 1,000 locations to more than 8,000 with no indication of slowing down in the near future.

"Tourism and travel have great potential to help communities," McCole said. "It helps diversify local economies and gives communities a reason to protect their natural resources, but that's not the whole picture. There is so much research to show that traveling together strengthens relationships and families. In our busy lives, where everyone has a device in their hand and a thousand demands on their time, vacations and day trips to places like a winery are often a rare chance to spend time together."

"Tourism and travel have great potential to help communities. It helps diversify local economies and gives communities a reason to protect their natural resources ..." — Dan McCole

AgBioResearch
MICHIGAN STATE UNIVERSITY

THE SAME FOR LESS:

Genetic science holds the key to better feed efficiency in dairy cattle

As the eighth largest dairy-producing state in the country*, Michigan is home to more than 400,000 dairy cows spread across farms with herds numbering less than 100 up to thousands. Feeding such a large number of animals is a challenging task. With each animal eating approximately $5 in feed every day, Michigan dairy farmers spend over $730 million each year to keep their herds well-nourished and to produce enough milk to meet consumer demand.

Michael VandeHaar, Michigan State University (MSU) AgBioResearch livestock nutritionist, and his colleagues are working to bring that cost down by combining genomics and nutrition science to breed cows that require less food to produce the same volume of milk.

RIGHT: In order to ascertain which genetic markers corresponded to feed efficiency, an MSU research team has collected feed intake data from dairy herds not only at MSU, but from across the United States, Canada, the United Kingdom and the Netherlands.

OPPOSITE: Michael VandeHaar, MSU Department of Animal Science.
Photos: MSU CABS

"We think it is reasonable that we could reduce feed costs by 50 cents per cow per day ..."

— Michael VandeHaar

Following the discoveries made by the Human Genome Project, which had numerous implications for animal science, livestock breeders have begun taking advantage of the wealth of dairy cow genetic information to select bulls capable of passing along to their progeny desirable traits such as size, milk production and disease resistance. Being able to genetically select bulls for feed efficiency, however, has been comparatively more difficult. Because cows on commercial dairy farms are fed in groups, acquiring data on how much an individual animal consumes has been nearly impossible.

"Genomics will now allow us to do just that," said VandeHaar, professor of dairy nutrition and metabolism in the MSU Department of Animal Science. "We can study the DNA of cows in university dairy herds and look for genetic markers for feed efficiency and deliver that information to the industry."

In 2010, VandeHaar and fellow MSU AgBioResearch scientist **Rob Tempelman** — with research partners at the University of Wisconsin-Madison, Iowa State University, the University of Florida, Virginia Tech and Wageningen University in the Netherlands — were awarded a $5 million grant from the U.S. Department of Agriculture (USDA) National Institute of Food and Agriculture to find genetic markers for feed efficiency. Five years later, as the project nears conclusion, success is well within their grasp.

VandeHaar and his colleagues collected feed intake data from 7,000 cows from university herds in Michigan, Wisconsin, Iowa, Florida, Maryland, Virginia, New York, Alberta, Scotland and the Netherlands. The team identified which animals ate less than expected, on the basis of their production, and took genetic samples for analysis. Most samples were analyzed by industry partner GeneSeek (a subsidiary of the Lansing-based Neogen Corporation), and the data were submitted to the USDA Animal Improvement Laboratory in Beltsville, Maryland, where much of the genomic data on the U.S. dairy herd is kept. The lab staff processes the samples and sends VandeHaar and Tempelman the list of individual elements, called single-nucleotide polymorphisms (SNPs), that make up each animal's genome. The team can then analyze those SNPs through statistical modeling to determine which are related to feed efficiency.

The team has genotyped 5,000 of the cows so far and is currently analyzing the remaining animals, as well as collecting feed intake data on 1,000 more cows. Once the process is complete, they will have a final equation for feed efficiency that they can pass on to the industry.

VandeHaar's colleagues in Wisconsin are developing extension and educational tools to communicate their findings to breeders, producers and dairy nutritionists. In addition to communicating the new information uncovered on cow genetics, the team's extension plans also include providing the industry with a state-of-the-art web-based tool to analyze feed efficiency and grouping practices on commercial farms.

The results of their combined efforts will reduce feed costs without sacrificing production.

"Though it's difficult to put a dollar figure on it at this point, we have seen results from an Australian team that did a similar project," VandeHaar said. "We think it is reasonable that we could reduce feed costs by 50 cents per cow per day, which, if you can do that for all the cows on a farm for a year, adds up to some pretty significant savings."

Though the numerous other traits used by breeders to select bulls will continue to be important, VandeHaar and his team are adding one more tool to their toolbox.

"Breeders must still select for the cows that produce the most milk — that's not going away," VandeHaar said. "We're adding an additional trait that can help them select for the most efficient cows — cows that will reduce their feed costs."

VandeHaar predicts that their results will be ready for industry-wide implementation within two years.

"The day is coming when the genetic values for feed efficiency we found will be included in the bull selection process," he said. "That is going to make a difference in the dairy industry, and to know our group was a part of that is incredibly fulfilling."

**According to the USDA National Agricultural Statistics Service.*

AgBioResearch
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REDUCE, REUSE, REMEDIATE:

Helping nurseries get the most out of their water

ABOVE: In order to keep plants healthy and marketable, nurseries must frequently irrigate container plants and administer fertilizers. An MSU research team is working to develop ways to remediate and recycle those resources in an effort to reduce costs and environmental impacts. *Photo: Thinkstock*

OPPOSITE: Bert Cregg, MSU Department of Horticulture. *Photo: MSU CABS*

From flowers to Christmas trees, nursery plants are big business for Michigan — they're the basis for a $1.2 billion industry that accounts for more than 36,000 jobs.* Maintaining enough plants to meet consumer demand requires a lot of water, and providing water carries costs to both the environment and the grower.

Many nurseries grow plants in containers — pots or baskets that restrict the sprawl of roots and allow plants to be efficiently stocked and sold. An unintended consequence of this approach, however, is that such plants need more water and fertilizing nutrients to keep them healthy than those grown in the ground.

The inputs also increase the potential for pollution in the form of runoff. Excess water can wash out of the nursery and into lakes, rivers or groundwater, carrying the phosphorus- and nitrogen-rich fertilizer with it. Such runoff has been the basis of significant environmental hazards in recent years, most notably the toxic algal blooms in Lake Erie near Toledo in 2014.

A team of researchers from Michigan State University (MSU) AgBioResearch is working to address both the environmental and financial concerns by developing a system to purify and recycle water and fertilizers.

"One of the main challenges that container nurseries face is that they use a lot of inputs that are concentrated in a small area, which is an almost ideal scenario for runoff," said **Tom Fernandez**, associate professor in the MSU Department of Horticulture. "What we want to do is look for ways that they can reduce the application of those inputs, remediate the water so that it isn't carrying anything that could be environmentally hazardous and ultimately recycle it back through the nursery."

Fernandez and fellow MSU AgBioResearch scientists **Bert Cregg** and **Bridget Behe** are part of Clean WateR3, a multi-institutional research partnership founded in 2008 through a U.S. Department of Agriculture Specialty Crops Research Initiative grant to help greenhouse and nursery growers use water efficiently and sustainably. By combining technological, pathological and marketing expertise, the team is working to create a system that benefits growers, consumers and the environment.

Fernandez and his students are conducting experiments on nursery beds to determine the efficiency and impact of various irrigation techniques. The beds are designed so that runoff water can be captured on the surface and approximately 1 foot below. The volumes of pesticide and fertilizer are then assessed. The team will compare the chemical and physical impact of 10 common nursery pesticides, and determine the minimal level of necessary irrigation.

Reducing the volume of inputs is important, but remediating those already present is of equal significance. Fernandez is testing several subsurface bioreactor systems — layers of organic material such as woodchips or bark — deposited beneath the growing surface to naturally cleanse runoff water of chemical impurities.

"When you look at pesticides and fertilizers, they're all made of organic compounds," Fernandez said. "All of those elements are used by microorganisms as food sources, so if we run the water containing those compounds through their habitat, they'll break down and metabolize them into a nontoxic form."

Cregg is studying the impact of the technologies on nursery plant health and growth.

"We're approaching this from a fairly basic plant health perspective," said Cregg, associate professor in the MSU Department of Horticulture. "Our main concern is the impact that recycled water could have on plant growth and whether the fertilizer or pesticide chemicals it might bring will have a negative impact on them."

While Fernandez's team collects runoff, Cregg will study the impact of that water on the plants grown in the nursery beds, comparing the water treated through remediation techniques to that of untreated water.

"We're looking for changes in large-scale plant characteristics such as growth, coloration and rates of photosynthesis," Cregg said. "The best case is that we don't find anything — that's good news for growers. On the other hand, if we find a problem now, that means we can work to adapt the technology to address that problem now so that growers don't have to."

Behe is studying how consumers incorporate information about the water usage and sustainability of greenhouse and nursery products into their purchasing decisions.

"My whole research program has been positioned to provide information on the consumer to small, medium and large growers," said Behe, MSU professor of horticultural marketing. "Everyone in the channel of distribution benefits from an understanding of consumer behavior."

Behe uses eye-tracking technology, which employs infrared light to follow the motion of a subject's pupils, to determine which parts of a product display consumers look at most.

"Our eye movement is deliberate and task-specific," Behe said. "You look at things differently depending on whether you are driving a car, looking at a work of art or deciding what type of plant to buy. With the eye tracker, we can see who is looking at a piece of information and how they are looking at it, and relate that to whether they decide to make a purchase."

By studying how consumers read plant displays that highlight water use information, Behe can begin to understand how important it is to the economic success of nurseries and greenhouses. This is important to many states, especially where water use is tightly regulated.

"Most nurseries today are not wasteful," Behe said. "We're trying to understand how to help them tell that story to their customers in more effective ways."

Improving the capacity for recycling and remediating water has numerous potential benefits.

"It's been very satisfying in the past few years to see that we can substantially reduce the amount of water and nutrients that move off-site, and now — through this project — we have the chance to improve on that further," Fernandez said.

* *Michigan Nursery and Landscape Association*

By combining technological, pathological and marketing expertise, the team is working to create a system that benefits growers, consumers and the environment.

AgBioResearch
MICHIGAN STATE UNIVERSITY

THE AIR WE BREATHE:

Studying the impact of air pollution in rural environments

ABOVE: Agricultural settings have been shown to have some of the highest concentrations of particulate matter in the air, due to dusty conditions. *Photo: Thinkstock*

OPPOSITE: Jack Harkema, MSU Department of Pathology and Diagnostic Investigation with an MSU mobile air quality laboratory near Dexter, Mich. The lab monitors air pollution in the area, an agricultural community near Ann Arbor. *Photo: MSU CABS*

Air pollution is a well-known, much-documented problem in the industrialized world. Those who do not live in major cities see media images of thick, dirty air and crowded streets of people wearing masks over their noses and mouths.

Linked to increases in heart disease, respiratory disease, lung cancer and a host of other health complications, air pollution plays a role in 3.7 million premature deaths each year, according to 2012 data from the World Health Organization. Contrary to the popular portrayal, however, the effects of air pollution are not limited to urban environments. Michigan State University (MSU) AgBioResearch toxicologist **Jack Harkema** is studying the impacts of air pollution on rural populations.

Air pollution is a mixture of elevated concentrations of potentially harmful gaseous chemicals, like ozone and nitrogen dioxide, and very small particles (particulate matter or particulates) that result from emissions from both human sources, like motor vehicles or industrial smoke stacks, and natural sources, like wildfires or volcanoes. If inhaled these pollutants may cause injury to our lungs or other organs like our heart and blood vessels.

Airborne particulates are defined according to their size into three basic categories: coarse, fine and ultrafine. Fine particles range in size from 2.5 to 0.1 microns in diameter, and ultrafine particles are less than a tenth of a micron in diameter. Both are invisible to the naked eye and even the largest size of fine particles are still 30 times less than the diameter of a human hair. The larger coarse particles with diameters greater than 2.5 microns and smaller than 10 microns are common to rural atmospheres. Fine and ultrafine particles are commonly emitted by automobiles, power plants and industries, while coarse particles are more likely to originate from organic compounds commonly found in the earth's crust.

"In agricultural settings, you see some of the highest airborne concentrations of particulate matter due to dusty conditions generated by common agricultural practices," said Harkema, university distinguished professor in the MSU College of Veterinary Medicine and the Institute for Integrative Toxicology. "A lot of people think air pollution is just an urban issue, but we now know that it causes real problems in rural settings, too."

Harkema's work in this area blossomed in 2011, when an $8 million grant from the U.S. Environmental Protection Agency (EPA) established the Great Lakes Air Center for Integrated Environmental Research (GLACIER). Combining the multidisciplinary expertise of researchers from MSU, the University of Michigan, Ohio State University and the University of Maryland, GLACIER is one of four EPA Clean Air Research Centers established to study the health impacts of air pollutants. Each center has a distinctive focus within this research area. GLACIER focuses on understanding the health effects of air pollutant mixtures, especially in susceptible populations like those suffering from chronic cardiovascular, respiratory or metabolic conditions.

Though much of their work has focused on urban air pollution — primarily in communities in and around Detroit — recent research has shifted to rural environments.

Air pollution can be simulated to a degree in the laboratory, but collecting data in the field provides a much clearer picture of the conditions that people are likely to face. Boarding semi-trucks converted into high-tech mobile laboratories, Harkema's team traveled to Dexter, Michigan, an agricultural community west of Ann Arbor, to study the effects of coarse particle exposure on heart rate and blood pressure in healthy individuals.

Harkema's long-time collaborator Robert Brook, a cardiologist in the School of Medicine at the University of Michigan, was the principal investigator of the study in Dexter. Together, Brook and Harkema coauthored a seminal scientific paper, reporting for the first time that brief exposures to real-world coarse particulate matter in a rural community can cause elevations in heart rate and blood. These effects on the cardiovascular system were similar to those they found in human subjects after short-term exposure to fine particles in an urban industrial community near Detroit. Though these cardiovascular changes did not compromise the health of these healthy subjects, the investigators speculated that such particle-driven health effects could potentially have detrimental consequences in people suffering from chronic heart disease.

"We're now finding, like other laboratories, that air pollution affects many other organ systems in the body and may exacerbate pre-existing chronic diseases, such as diabetes and obesity," said Harkema. "Originally, for example, we thought cigarette smoke caused only lung cancer, but we've since learned that it also contributes to breast cancer, coronary heart disease and other systemic problems. I think particulate matter could work in a similar way."

As areas of the developing world continue to scale up their agricultural industries, Harkema said coarse particulate matter will only become a more serious environmental issue. Fortunately, scientists like Harkema are working to find ways to mitigate its adverse health effects. Every five years, the EPA conducts a review of all of the data on air pollution and its health effects, updating its standards accordingly. Brook and Harkema's recent findings on particulate air pollution will help it set the air quality standard for particulate matter that aims to protect the health of susceptible populations.

"We're now trying to understand how exposure to small amounts of fine and coarse particles triggers alterations in blood pressure and heart rate," said Harkema. "This is not just a small regional problem, it's worldwide. The work we do here has an impact on protecting human health in urban and rural communities around the world through better air quality standards and guidelines based on sound science."

Air pollution can be simulated to a degree in the laboratory, but collecting data in the field provides a much clearer picture of the conditions that people are likely to face.

Providing tools to low-income teen moms to help prevent childhood obesity

More than one-third of adults and one in six children in the United States are obese, according to the Centers for Disease Control and Prevention. Obesity is linked to a multitude of health problems, such as heart disease, stroke, diabetes and many types of cancer. Estimates of the annual medical cost of obesity in the United States top $147 billion.

Individuals who come from low socioeconomic backgrounds may be more likely to struggle with their weight for several reasons, including a lack of access to nutrition information. **Kami Silk**, the associate dean of research for the College of Communication Arts and Sciences at Michigan State University (MSU), is examining the beginning stages of life. She is studying the relationship between obesity in infants and their mothers' access to information on appropriate feeding practices.

RIGHT: An MSU study is researching the relationship between obesity in infants and their teen mothers' access to information on appropriate feeding practices. The moms are provided daily text messages for a period of six weeks. Communications include tips, knowledge quizzes and nutrition recommendations. *Photo: Courtesy of Kami Silk*

OPPOSITE: Kami Silk, MSU College of Communication Arts and Sciences.

"Infants who are overweight are more likely to be children who are overweight, and that cycle continues into adulthood."

— Kami Silk

Working with **Mildred Horodynski**, a professor in the MSU College of Nursing and an expert on childhood nutrition, Silk has created the Tools for Teen Moms project. The initiative is aimed at 80 low-income first-time teen moms.

"Compared with older parents, teens are more likely to introduce solid foods too soon," Silk said. "They are also more likely not to breast-feed. Overall, they are more likely to engage in unhealthy infant feeding practices that can lead to obesity. Infants who are overweight are more likely to be children who are overweight, and that cycle continues into adulthood. There are lots of programs out there that encourage healthy infant feeding habits, but we are using technology to reach these girls."

A technology platform developed by Gary Hsieh, a former MSU assistant professor in telecommunications now with the University of Washington, delivers daily text messages to the teen mothers over six weeks. Communications include tips — from messages such as putting down a cell phone while feeding the child to behavior suggestions — as well as knowledge quizzes and nutrition recommendations. A web component is also available, allowing mothers to pose questions to nutrition experts.

The project is in its second year and is funded by the National Institutes of Health and MSU AgBioResearch. Information is collected from surveys with mothers, analytics from the web platform and anthropometric measures such as the baby's height and weight at baseline, three months and six months. Silk and Horodynski will analyze the data and compare the growth of infants whose mothers received the nutrition information with those in the control group whose mothers did not.

Mothers were recruited from four counties in Michigan — Genesee, Ingham, Jackson and Kent — with assistance from the Maternal Infant Health Program (MIHP) in Michigan. MIHP is Michigan's largest program for Medicaid-eligible pregnant women, with 150 locations statewide that promote healthy pregnancies and infants. The organization provides home visitation to mothers and coordinates care through Medicaid. Silk said the recruiting partnership with MIHP has been invaluable, and she and Horodynski hope to expand their project to increase the dissemination of information for teen moms.

"A lot of people, particularly adolescents, use technology in recreational and perhaps superficial ways," Silk said. "Tools for Teen Moms has a very functional purpose. It's a great example of doing something that is both entertaining and educational. If we can demonstrate that it helps young moms engage in healthy infant feeding practices, that's a huge impact. There's scalability in this project to implement it on a much larger level."

Retention of mothers for the project has been good, which Silk notes as an indicator of high-level engagement. No intensive data analysis has been completed yet, but researchers are hopeful that their observations will match the numbers. Final height and weight measurements of infants will be taken in spring 2016. If results show the project has been successful, the Tools for Teen Moms team will begin applying for grants to broaden its reach.

"This research addresses a very practical, real-world problem — the obesity epidemic," Silk said. "But it also provides support for teen moms who oftentimes don't have great support systems. Many aren't living at home; some of them are even living in group homes with their children. Being a teen mom can be isolating. This project is providing them with a community of support and information to help their infants grow into healthy children."

AgBioResearch
MICHIGAN STATE UNIVERSITY

Studying monetary incentive programs and their impact on social norms

ABOVE: Interviewers on the Tibetan Plateau found that inhabitants have depended on herding sheep and yaks for years, which, along with their cultural beliefs, has created a desire to live harmoniously with nature. MSU researchers are trying to determine whether incentive programs erode these reasons for conservation.
Photo: Courtesy of Maria Lapinski

OPPOSITE: John Kerr, MSU Department of Community Sustainability.

Environmental conservation has been a controversial issue around the world for decades. Attitudes and opinions on the importance of conservation vary, in large part, because of unique cultural differences. To combat environmental challenges, governments have introduced a number of financial incentive programs for those who participate in protecting nature. These initiatives were created to preserve the environment, but they don't come without questions.

Why do some view protecting natural resources as an important part of their cultural identity, even without financial incentives? What happens to other reasons for environmental protection when financial incentives are introduced? What are the long-term impacts on the social system when the incentive money runs out? These are questions that Michigan State University (MSU) AgBioResearch scientists **Maria Lapinski, John Kerr** and **Jinhua Zhao** want to answer.

"We come at this project in very different ways, so we've had to develop an interdisciplinary model that encompasses a number of variables," Kerr said. "The turning point of the project was a three-day retreat, where the team tried to take a look at finding a way to serve all of our interests. That's when we began developing a model that takes the social, economic and environmental factors into account."

The data will represent how social norms, coupled with financial incentives, affect conservation behaviors, with a particular focus on grazing management and protection against illegal hunting.

Lapinski, a communication scientist in the Department of Communication, and Kerr, a researcher with a focus on economics from the Department of Community Sustainability, have been working on a project in Sanjiangyuan, China, a region in the Qinghai Province on the Tibetan Plateau. Alongside **Jinhua Zhao**, an MSU AgBioResearch scientist and researcher in the Department of Agricultural, Food and Resource Economics, they are studying how financial incentive programs influence behavior and social norms.

The location of the project was determined when Zhao introduced Lapinski and Kerr to Lu Zhi, a professor of conservation biology at Peking University in China. Zhi is the founder of the Shan Shui Conservation Center and a world-renowned giant panda and snow leopard researcher. Sanjiangyuan will soon be a part of China's payment for ecosystems services program. It is ecologically important because it holds the headwaters of Asia's three largest rivers: the Yellow, the Yangtze and the Mekong.

Close to 1 million people inhabit the region, with roughly 90 percent being ethnic Tibetans and having a strong tie with Tibetan Buddhism. Interviews conducted by the project team found that inhabitants have depended on herding sheep and yaks for years, which, along with their cultural beliefs, has created a desire to live harmoniously with nature. This was found in the first phase of the project, which included interviews with 80 nomadic herders.

"These payments for ecosystems services happen all over the world, including right here in Michigan," Lapinski said. "What we know from financial research is that once you start incentivizing certain behavior with money, it can change the way people think about that behavior. We know that money can erode psychological motivation and attitudes, but we know less about how money can change the whole social system and what we call social norms."

Phase two of the project involves household surveys that yield quantitative data, such as measures of social norms and responses to hypothetical scenarios, as well as income and education levels. The data will represent how social norms, coupled with financial incentives, affect conservation behaviors, with a particular focus on grazing management and protection against illegal hunting. Data is being collected currently.

In the summer of 2016, the final phase, which includes field experiments, will take place. These studies will simulate the introduction of financial incentive programs while accounting for cultural context and social norms about herding and illegal hunting.

"In the experiment phase, we want to really understand how they feel about conservation and how that changes when an incentive program is introduced," Kerr said. "We started the project with experiments on campus with MSU students dealing with cooperation. Individuals were placed in a group setting with four people and put in a scenario where they have to take an action that is best for them or best for the group. We introduced variables in the second phase, such as adding an incentive to cooperate that made it at least as beneficial to cooperate as not cooperate. In the third phase, we took that payment away."

Lapinski is unsure if the findings from the initial experiments at MSU will translate to China.

"One of the things we found in the first experiments was that financial incentives can erode the power of norms," Lapinski said. "In other words, we sometimes feel pressure to do what others are doing, but when financial incentives are involved, that tends to be less of a factor in decision making. One of the interesting things about the next phase is that we're taking this to a new culture. We aren't sure if we'll find the same things, but we have some insights into what can happen.

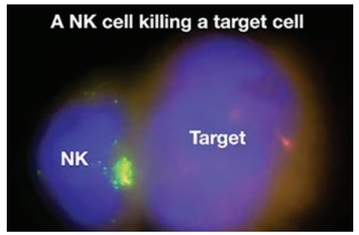
"If there is money from a government entity or a nonprofit, it will run out, so what happens then? Our prediction is that if you introduce a financial incentive, it will erode positive social norms once that incentive is taken away. That's what we're looking at and what we want to include in our experiments next summer. Then we can take the last step and think about how payment programs can be designed to avoid ruining existing social norms."

The project is funded by the National Science Foundation's Interdisciplinary Behavioral and Social Sciences Research competition, in addition to the Sustainable Michigan Endowed Partnership at MSU.

AgBioResearch
MICHIGAN STATE UNIVERSITY

LOOSENING THE BELT:

Fighting influenza with higher calorie diets



ABOVE: NK cells are among the body's first lines of defense against infection, able to identify threats and respond long before specific antibodies can be formed. The efficacy of NK cells is diminished under calorie restriction, which leaves the body more susceptible to diseases like influenza. *Photo courtesy of Elizabeth Gardner.*

OPPOSITE: Elizabeth Gardner, MSU Department of Food Science and Human Nutrition. *Photo: MSU CABS*

Every year, the World Health Organization estimates that between 250,000 and 500,000 people are killed by seasonal influenza, or flu, epidemics, with another 3 million to 5 million developing severe cases that warrant hospitalization. Though the virus cuts across every demographic, the very young, elderly and chronically ill remain at the greatest risk.

Making matters worse, common flu vaccines lack the same effectiveness in those at-risk groups compared with other segments of the population. In a continued effort to reduce the common disease's impact, Michigan State University (MSU) AgBioResearch nutritional immunologist **Elizabeth Gardner** is developing a novel approach: during flu season, slacken dietary restrictions and eat a few more calories.

"This finding had particular implications for human health because a lot of the patients who are hospitalized with the flu are older, thinner people."

— Elizabeth Gardner

In 1558, Venetian nobleman Luigi Cornaro first wrote about the virtues of dietary restriction as a means of improving health and increasing lifespan. In the intervening centuries, many scientists have investigated this claim, which has lately reemerged as "calorie restriction." As a nutritional paradigm, calorie restriction has been shown to improve the health and longevity of animals in a laboratory setting. In this scenario, calories are simultaneously reduced while significant amounts of key nutrients are delivered through vitamin and mineral supplements. Experiments conducted on numerous species, from drosophila fruit flies to non-human primates, have shown continual support for the method. A 2-year human trial is in progress. Recent findings, however, have shown that calorie restriction does not affect all parameters of health positively.

The aging benefits of calorie restriction have largely been shown to be linked to its ability to increase immunity. Mice under a calorie-restricted diet show significantly less incidence of tumors and respond better to other age-related problems. It was also reported that calorie restriction improved the immune response to the flu vaccine.

"We had the hypothesis that calorie restriction could be a simple dietary intervention to improve the immune response to flu," Gardner said. "Back in 1996, I started a study that took both young and aged mice and infected them with flu virus. To my surprise and dismay, we found that the calorie-restricted animals died within four to six days after infection, which was about half the time of the non-restricted animals. In every circumstance, there wasn't a calorie-restricted animal that lived longer."

Troubled by the results, Gardner began investigating the cause. The four- to six-day window during which the mice succumbed constituted the time during which the body's primary immune response — the general response, before the body develops a pathogen-specific counterattack — is battling the illness. During this phase, the body's primary defense against the virus is the natural killer (NK) cells, a type of white blood cell that can identify and target infections without the presence of antibodies. Gardner discovered that, in mice under calorie restriction, both the numbers and the functionality of NK cells are diminished. This loss was correlated to diminishing body mass brought on by one of the flu's most common symptoms, anorexia.

Though most commonly associated with the eating disorder anorexia nervosa, anorexia generally refers to any decreased sensation of appetite. Loss of appetite is a common symptom of the flu, and mice are no exception. Shortly after infection, the mice stopped eating. Both calorie-restricted and non-restricted mice lost body weight as a result, but the non-restricted mice had enough mass initially to hang on and eventually begin fighting the infection. The calorie-restricted mice, having less mass to start with, simply lost too much. For older mice, mortality came even more quickly.

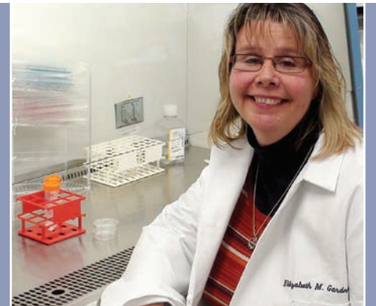
"We started to look at how we could address this from a nutritional perspective," Gardner said. "This finding had particular implications for human health because a lot of the patients who are hospitalized with the flu are older, thinner people. Someone with less body mass is much more susceptible to the worst effects of the flu."

With support from the National Institute on Aging, Gardner and her lab have been conducting studies on mitigating the effects of the flu on calorie-restricted subjects. For the next round of experiments, they fed calorie-restricted mice a higher calorie diet for two weeks prior to inoculating them with the flu virus. NK cells are known to perform poorly under reduced-caloric conditions, and Gardner hoped that by increasing calorie intake, she could bolster their effectiveness.

The findings were starkly different from those of the original experiment. The mice that were given more expansive diets prior to infection showed NK cells in higher numbers and with greater efficacy to allow them to survive.

Though increasing calorie intake immediately before contracting the flu was shown to improve the chances of recovering, that approach isn't practical.

"Unlike in the experiment, we have no idea when precisely we'll get the flu," Gardner said. "We do, however, know when flu season is. If you are on a calorie-restricted diet, bumping up your calorie intake by about 10 percent during the four months of flu season ensures that you have adequate caloric stores to maintain your ability to fight the disease."



AgBioResearch
MICHIGAN STATE UNIVERSITY

MSU AgBioResearch CENTERS

For research center locations and contact information, visit **agbioresearch.msu.edu/centers**

MSU AgBioResearch - 2015 NEWS IN REVIEW *(Continued from page 3.)*

Grant to help global hunger, food security

The U.S. Agency for International Development (USAID) awarded Michigan State University a $5.8 million cooperative agreement to improve potato production in Bangladesh and Indonesia. The grant supports USAID's work under Feed the Future, the U.S. government's global hunger and food security initiative.

As part of the Feed the Future Biotechnology Partnership Project, MSU will partner with the University of Minnesota and Idaho-based J.R. Simplot Comp., along with in-country partners in both Bangladesh and Indonesia, to make improved potato varieties available to smallholder farmers. Such varieties can help protect against yield loss and improve livelihoods for those who depend on the crop to survive.

Researcher named honorary citizen


Joan Rose

Michigan State University researcher **Joan Rose** was named an honorary citizen of Singapore for her significant contributions in developing a safe and sustainable water system in the island nation.

For the last 14 years, Rose, Homer Nowlin Chair in Water Research, has worked with researchers and government officials in Singapore to help build the country's water infrastructure and monitor water quality.

Grant to examine disease-resistant crops

A national team of 20 scientists led by Michigan State University Horticulture professor and AgBioResearch scientist **Rebecca Grumet** has been awarded a $6.5 million grant to accelerate the development of disease-resistant cucurbit crops through leveraging applied genomics.

The researchers will create a collaborative, national initiative to develop breeder-friendly genomic tools to help with the production of watermelon, melon, cucumber and squash. The grant was issued by the U.S. Department of Agriculture's National Institute of Food and Agriculture Specialty Crop Research Initiative.

Using genomics is the most cost effective as well as the most environmentally-favorable solution to the problems of disease resistance since it allows growers to apply less fungicide. Cucurbit producers and processors consistently identify diseases as a primary constraint, causing severe reductions in yield, quality and profitability.

MSU, Exxon to work on algae-based fuels

A new $1 million relationship between Michigan State University (MSU) and ExxonMobil will expand research designed to progress the fundamental science required to advance algae-based fuels.

David Kramer, MSU's John Hannah Distinguished Professor in Photosynthesis and Bioenergetics at the MSU-DOE Plant Research Laboratory, says that the overall goal of the partnership is to improve the efficiency of photosynthesis in microalgae to produce biofuels and bioproducts.

Fellow of Soil Sciences Society of America announced

Michigan State University Geological Sciences professor **Bruno Basso** was elected a 2016 Fellow of the Soil Science Society of America for his contributions to agronomy through education, national and international service and research.

Basso's research integrates crop modeling with remote sensing and unmanned aerial vehicles to understand variability of crop yield at the field and landscape scale. Basso has participated as principal investigator and co-principal investigator in several international projects. He is the author of more than 150 scientific publications and holds an adjunct position at the Queensland University of Technology in Australia. He is also a Fellow of the American Society of Agronomy.

EPA grant to examine contaminants on fish


Cheryl Murphy

A grant of $800,000 from the Environmental Protection Agency will help a research team led by Michigan State University (MSU) determine the effects of certain contaminants on fish.

Specifically, the team will study contaminants' effects on the developing brains of larval fish, in particular looking at behaviors that are important to survival, such as finding food and avoiding predators, and which genes are important in regulating these behaviors.

Cheryl Murphy, an associate professor of fisheries and wildlife and MSU AgBioResearch scientist, is the lead on the project.

CRIS names director


Michael Holsapple

Michael P. Holsapple was named director of the Center for Research on Ingredient Safety (CRIS) at Michigan State University (MSU).
CRIS is an independent, academic, science-based center within the Institute for Integrative Toxicology. The mission of CRIS, working in collaboration with the MSU Department of Food Science and Human Nutrition, is to serve as a reliable and unbiased source for information on the safe use of chemical ingredients in consumer packaged goods.

With more than 30 years as a toxicologist and leader in academia,

industry as well as in non-profit charitable organizations, Holsapple is uniquely-suited to lead MSU's new center. He will be building on MSU's internationally renowned knowledge base in food safety and toxicology.

Holsapple, who has been an affiliate professor at MSU since 1994, most recently served as the executive director for Global Immunotoxicology at Covance Laboratories, Inc. He was also a senior research leader in systems toxicology at the Battelle Memorial Institute in Columbus, Ohio.

Plant Research Lab names new director

Christoph Benning, Michigan State University professor of biochemistry and molecular biology, will become the director of the Michigan State University/ U.S. Department of Energy (DOE) Plant Research Laboratory (PRL) beginning Aug. 16. He succeeds Michael Thomashow, University Distinguished Professor of plant, soil and microbial sciences, and microbiology and molecular genetics. Thomashow has led the lab for the past nine years.

Benning is one of the world's foremost experts in plant lipid metabolism. He led a collaborative effort with colleagues from the Great Lakes Bioenergy Research Center that resulted in a significant early step toward producing better plants for biofuels. He was named a fellow of the American Association for the Advancement of Science in 2014 and was recently named an MSU Foundation Professor in recognition of his exceptional contributions to research and instruction.

The PRL brings together experimental biologists to foster the development of cooperative research programs involving multidisciplinary approaches. It is dedicated to answering fundamental questions in plant biology with the goal of providing a broad and thorough scientific education in modern plant biology. The PRL is affiliated with the MSU College of Natural Science and seven MSU departments on campus through joint appointments of its faculty.

Grant to explore mint genome

Michigan State University (MSU) netted a $5.1 million National Science Foundation grant, led by MSU AgBioResearch plant biologist **C. Robin Buell**, to explore the diverse world of mints.

Mints, or Lamiaceae, are the world's sixth-largest family of flowering plants. If the secrets of this wide-ranging species can be unlocked, mints can be improved and potentially new synthetic molecules and products may be developed.

The in-depth study will map mints' genome and identify key genes that drive their diversity. Mapping the genome will allow researchers to identify evolutionary and developmental mechanisms that control growth and reproduction. It could also lead to the development of synthetic molecules for new uses, such as new medicines, foods, fragrances and oils by mixing genes from different biochemical pathways.

Researcher serves on White House forum

Bo Norby, Michigan State University College of Veterinary Medicine associate professor of large animal clinical sciences, was selected to attend the White House One Health Forum on Antibiotic Stewardship.

Bringing together key federal and private-sector stakeholders involved in the development, promotion and implementation of antibiotic stewardship activities, the event looks to ensure the responsible use of antibiotics nationwide.

Professor named founding editor-in-chief

Michigan State University (MSU) professor **Patricia Soranno** was named founding editor-in-chief of the Association for the Sciences of Limnology and Oceanography's new journal, *Limnology and Oceanography Letters*.

A professor in the MSU Department of Fisheries and Wildlife, Soranno is a broadly trained aquatic ecologist. She has spent the past 20 years conducting research that integrates freshwater ecosystems into a landscape perspective from local to continental scales. Her research, which is supported by MSU AgBioResearch, applies principles of landscape ecology and limnology to both basic and applied problems in freshwater ecosystems.

Previously, Soranno has served as an associate editor for the journals *Ecosystems, Frontiers in Ecology and the Environment, Scientific Data* and *GigaScience*.

Researcher elected to the NAS

A professor at Michigan State University (MSU) and a leading MSU AgBioResearch plant scientist has been elected to the National Academy of Sciences.

Sheng-Yang He, an MSU Distinguished Professor in the MSU-DOE Plant Research Laboratory, Department of Plant Biology, Department of Microbiology and Molecular Genetics, and Department of Plant, Soil and Microbial Sciences, was selected as part of the 2016 class. He earned the honor for his seminal contributions to the understanding of plant-pathogen interactions.

Scholar elected to society

Sustainability scholar and University Distinguished Professor **Jianguo "Jack" Liu** has become the first from Michigan State University to be elected to the American Philosophical Society — the oldest "learned society" in the United States.

The society, founded by Benjamin Franklin in 1743, promotes useful knowledge in the sciences and humanities through excellence in scholarly research, professional meetings, publications, library resources, and community outreach. Liu, along with 33 others, was elected at the society's semiannual meeting in Philadelphia.

MSU faculty honored for exceptional contributions

Michigan State University (MSU), with support from the MSU Foundation, honored four faculty members with the designation of MSU Foundation Professor, in recognition of their exceptional contributions to research and instruction.

The professorships are part of an initiative to attract and retain highly successful faculty members. Each recipient typically receives five years of supplemental research support and holds the MSU Foundation Professor designation permanently.

(From left) **Andrew Christlieb, Dean DellaPenna, C. Robin Buell** and **Christoph Benning**

The new MSU Foundation Professors are **Christoph Benning**, professor of biochemistry and molecular biology, **C. Robin Buell**, professor of plant biology, **Andrew Christlieb**, professor of mathematics and **Dean DellaPenna**, University Distinguished Professor of biochemistry and molecular biology. All four are faculty in the College of Natural Science. Benning, Buell and DellaPenna are also MSU AgBioResearch scientists.

Researcher named NSF committee chair

Katherine L. Gross, Michigan State University distinguished professor of plant biology and director of the W.K. Kellogg Biological Station, has been appointed chair of the Advisory Committee for Biological Sciences (BIO) of the National Science Foundation (NSF).

The BIO advisory committee provides advice and recommendations to the NSF on support for research, education and human resources in the biological sciences. As the chair, Gross will serve as the lead liaison to the NSF Biological Sciences director and will oversee a committee of more than 20 members. Committee members include representatives from many divisions of biology; a cross-section of institutions, including industry; and balanced representation of women and underrepresented minorities.

MSU AgBioResearch 2015 PUBLICATIONS

Futures Magazine

Published twice annually, *Futures* is a free magazine that provides an in-depth look at research that is applying science in practical, real-world ways that boost Michigan's economy, sustain the state's natural resources and enhance people's quality of life.

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agbioresearch.msu.edu

Spring/Summer 2015

2015: International Year of Soils

Did you know that in every handful of soil, there are approximately 7.3 billion living organisms? That's an astonishing figure — one that oddly mirrors the world's global population. Learn more about soil in this issue of *Futures*. The United Nations dubbed 2015 the "International Year of Soils" in an effort to increase awareness and understanding of the importance of soil for food security and essential ecosystem functions.

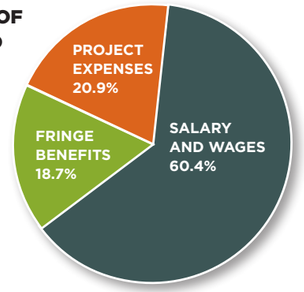
Fall/Winter 2015 - 2016

Debunking stereotypes: Empowering the next generation of scientists

The iconic image of the mad scientist is etched in all of our memories, but is that what people really think of scientists? Find out that answer and much more about the stereotypes science and scientists face in this issue of *Futures*. We touch on the role of scientists in the 21st century and how things will change, given the growing world population.

FINANCIAL REPORT — 7-1-2014 — 6-30-2015

DISTRIBUTION OF APPROPRIATED FUNDS



INCOME:

Federal Appropriation		
Hatch	$	5,264,547
McIntire-Stennis	$	307,892
Hatch RRF	$	1,241,293
Hatch Animal and Disease, Section 1433	$	99,023
Total Federal Appropriations	$	6,912,755
State Appropriations	$	32,508,300
Total Appropriations	$	39,421,055
Grant – Federal, State and Private*	$	92,168,267
TOTAL INCOME	$	131,589,322

EXPENSES:

Salaries	$	23,799,222
Fringe Benefits	$	7,354,000
Project Expenses	$	8,267,833
Grants – Federal, State and Private*	$	92,168,267
TOTAL EXPENSES	$	131,589,322

PERSONNEL:

(Full-time equivalents funded from appropriated funds)

Research Staff	
Professors	53.79
Associate Professors	29.11
Assistant Professors	10.13
Research Associates and Specialists	7.24
TOTAL RESEARCH STAFF**	100.27
Support Staff	
Administrative Professionals	38.87
Supervisors	18.20
Clerical	13.24
Technicians	2.39
TOTAL SUPPORT STAFF	72.70

**Grants are reported using most recent three-year average*

***Does not include department chairpersons and unit administrators*

MSU AgBioResearch

Director's Office:

As of 1-7-2016

Douglas Buhler, Director
CANR Interim Dean

George Smith, Associate Director
CANR Interim Associate Dean for Research

Michael Jones, Assistant Director of Natural Resources Programs

Carolyn Adams
Research Support Coordinator

Lori Bramble
Research Support Coordinator

James Dau
Communications Coordinator

Jackie DeSander
Administrative Assistant

Tonia DuMont
Administrative Assistant

Linda Haubert
Projects Administrator

Bill Humphrey
Research Support Coordinator

Cameron Rudolph
Communications Manager

Mary Weinzweig
Business and Finance Manager

Holly Whetstone
Senior Communications Manager

Phone: 517.355.0123
Email: info@agbioresearch.msu.edu

Affiliated Deans:

As of 1-7-2016

Douglas Buhler, Interim Dean
College of Agriculture and Natural Resources

Christopher P. Long, Dean
College of Arts and Letters

Prabu David, Dean
College of Communication Arts and Sciences

Leo Kempel, Dean
College of Engineering

James R. Kirkpatrick, Dean
College of Natural Science

Neal Schmitt, Interim Dean
College of Social Science

John Baker, Dean
College of Veterinary Medicine

Unit Administrators:

(UNITS RECEIVING FUNDING)

As of 1-7-2016

Titus O. Awokuse, Chairperson
Department of Agriculture
Food and Resource Economics

Janice Swanson, Chairperson
Department of Animal Science

Thomas D. Sharkey, Chairperson
Department of Biochemistry and Molecular Biology

Darrell Donahue, Chairperson
Department of Biosystems and Agricultural Engineering

Donald Morelli, Interim Chairperson
Department of Chemical Engineering and Materials Science

James Dearing, Chairperson
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School of Criminal Justice

F. William Ravlin, Chairperson
Department of Entomology

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Amy E. Bonomi, Chairperson
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Charles Reid, Director
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Daniel Grooms, Chairperson
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MISSION STATEMENT:

The mission of MSU AgBioResearch is to engage in innovative, leading-edge research that combines scientific expertise with practical experience to generate economic prosperity, sustain natural resources, and enhance the quality of life in Michigan, the nation and the world.

The mission, supported by more than 300 scientists working in agriculture, natural resources, engineering, social and natural sciences, human ecology and veterinary medicine, has enabled MSU AgBioResearch to be one of the most successful organizations of its kind in the country. This success is due to the efforts of outstanding researchers; close partnerships and collaborations with MSU Extension, seven MSU colleges, federal and state agencies, commodity groups and other key stakeholders; and exceptional legislative support.