2011 Annual Report

MANAGING EDITOR'S NOTE: As we interviewed the scientists involved in the research projects presented in this report, they — to a person — 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' (often repeated) acknowledgements 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

Tomorrow's urban food systems not your typical skate across

STEVEN G. PUEPPKE

"I skate where the puck is going to be, not where it has been." So goes hockey great Wayne Gretsky's most famous quote, one that I hear often in conversations about Michigan State University's (MSU) strategic future. It sounds so simple, but in reality it's hard — really hard — to start with today's food systems, expand your mind to where they will be in 10 or 20 years and conceive of the research that is needed along the way. When I go through this thought exercise, my mind conjures up new and improved crop varieties, machinery that self-maneuvers, robots that replace hard manual labor, food processing and distribution methods that minimize energy and water consumption, smart packaging, and maybe even consumers eager to make wiser nutritional choices.

Here's another thought exercise, one that relates to a different kind of strategic opportunity that doesn't fit the everyday hockey analogy: what does Wayne Gretzky do if a new puck lands on the ice? This is sports nonsense, of course, but it's an apt analogy for the concept of MetroFoods. Just a few years ago, hardly anyone was thinking seriously about the potential to produce food not just on expanses of farmland but on swatches of land tucked into densely populated urban areas. Or under controlled conditions, perhaps in trays stacked up vertically in abandoned city buildings. Now, suddenly everyone seems to be thinking about MetroFoods, as are we in MSU AgBioResearch.

The MetroFoods concept is particularly intriguing for Detroit, a city whose residents lack economic opportunities and who have inadequate access to wholesome food. Yet they reside on a patchwork of literally thousands of vacant lots and near scores of unused but structurally sound buildings. The experts tell us that food could be produced here as it is in a number of other mainly European cities. Seasonally grown fruits and vegetables could be sold locally to consumers and restaurants — or packaged and consumed elsewhere. Spices, essential oils and high value medicinal products could be part of the mix, too.

MetroFoods in Detroit could also become a magnet to attract new kinds of companies to the city. Already in existence, these firms fabricate LED lights that are ideal for plant growth, design highly efficient water and energy systems, and create software to control and optimize indoor plant growth environments 12 months of the year. What better place than Detroit to create an environment of urban innovation for these firms, where novel breakthroughs can be tested and fine-tuned under real-world conditions?

Detroit will ultimately make its own decision on MetroFoods, but here's the question: could AgBioResearch help the city and its partners pull it off? I believe that we can skate to where this new puck will be, provided that we are creative in our thinking, innovative in our approaches and willing to work flexibly with other players.

It's not such a stretch to begin translating our deep, basic discoveries in the plant sciences — the kinds of discoveries you read about in *Futures*, our annual report and on our website — into urban food production systems. Our capacity to help communities arrive at good decisions ought to be just as useful in the city as in small towns and rural areas. Our economists ought to be fascinated by the potential for novel MetroFoods business models. And if we can create plant varieties optimized for food production in fields, we certainly can do the same for other kinds of production systems.

Soil science, microbiology, community health, food safety, packaging, bioenergy — even our expertise in food animal production and in dealing with fish, wildlife and trees — all have important roles to help make the MetroFoods concept a reality in Detroit.

the food production rink.

AgBioResearch Faculty Honors

The awards and recognition that AgBioResearch faculty members receive each year continue to impress. Some of the highlights for fiscal year 2010-2011 are:

Christoph Benning, AgBioResearch biochemistry and molecular biology scientist, received the 2011 Terry Galliard Award at the 19th International Symposia on Plant Lipids. Benning was recognized as an outstanding scientist who continues to make highly significant contributions to the field of plant lipid research.

Bruce Dale, AgBioResearch chemical engineering and materials science researcher, received the Award of Excellence from the Renewable Fuels Association for his extensive work in the areas of indirect land use change and the production of cellulosic ethanol.

A sustainable agriculture project led by AgBioResearch crop and soil scientist **David Douches** earned a 2011 USDA Secretary's Honor Award. The honored initiative (actually three projects in one), the "Barley, Wheat, Potato and Tomato Coordinated Agricultural Projects," comprises a group of researchers and educators from land-grant universities, government agencies and industry groups working together to identify genetic variations in those crops.

Elizabeth Gardner, AgBioResearch food science and human nutrition scientist, received the 2011 Ruth L. Pike Lecture Series: Frontiers in Nutrition Research Award from the Department of Nutritional Sciences at Pennsylvania State University. Gardner was recognized for her significant contributions to the field of nutrition and immunology.

Sheng Yang He, AgBioResearch plant biologist, was named a Howard Hughes Medical Institute and the Gordon and Betty Moore Foundation Investigator for his groundbreaking work studying how plants become susceptible to disease. Also a member of the MSU Plant Research Laboratory, He is the first MSU professor to be so honored.

The MSU Inland Assessment Team, led by AgBioResearch fisheries and wildlife scientist **Dana Infante**, received the 2011 Scientific Achievement Award in Support of Fish Habitat Conservation from the National Fish Habitat Action Plan Board. The team was honored for its work to protect, enhance and restore fish habitat in U.S. freshwater and marine systems.

Adam Lock, AgBioResearch animal scientist, received the 2011 Cargill Young Scientist Award from the American Dairy Science Association for his work involving dairy production, human nutrition and health, and the interface between these two disciplines.

Three AgBioResearch scientists were named fellows of the American Association for the Advancement of Science: **Jianguo "Jack" Liu**, fisheries and wildlife; **Katherine Osteryoung**, plant biology; and **Michael Thomashow**, crop and soil sciences and microbiology and molecular genetics. Lui was honored for pioneering research that integrates ecology, various social sciences and policy to achieve environmental sustainability. Osteryoung was honored for her work on uncovering the full network of genes and proteins controlling chloroplast division in plants. Thomashow was recognized for his research on the identification of stress response pathways involved in freezing and drought tolerance in plants.

Two AgBioResearch scientists were named MSU distinguished professors in recognition of their achievements in the classroom, laboratory and community: **Richard Merritt**, entomology, and **James Pestka**, food science and human nutrition.

Don't expect to see these innovations tomorrow, and don't expect them all to be viable in our state. But these and others will likely find their niche in Michigan's wonderfully complex and resilient food system of the future. You can bet that AgBioResearch will be in there as a partner, listening, innovating and translating our research discoveries into solutions that address society's problems. And as you'll see in this year's annual report, our 300-plus scientists are part of a multifaceted team working together to score goals that count in many aspects of life — both on and off the ice. Enjoy!

Steven G. Pueppke
MSU AgBioResearch Director

food and health

Prevention, vigilance and ongoing research are key to ensuring that crops, animals and humans remain healthy and vital.

From conducting innovative research aimed at better protecting people from diseases such as colon cancer and chronic respiratory diseases to improving the availability of and access to fresh, safe and nutritious food, Michigan State University AgBioResearch scientists are hard at work to provide Michigan growers and commodity groups with the critical information and resources they need to remain competitive in the global economy, and to provide consumers with knowledge that they can use to improve their health and well-being. The projects highlighted in this section provide a snapshot of the groundbreaking research being done in this priority area.

[Weighing in on **colon cancer risk**]

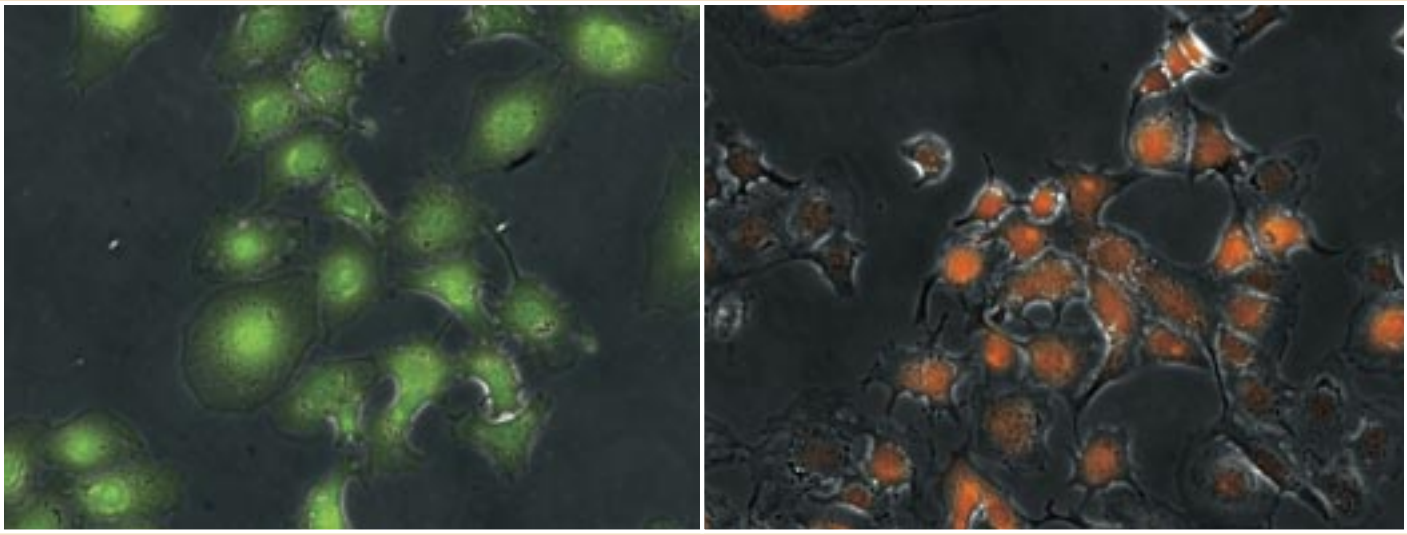


PHOTO: COURTESY OF JENIFER FENTON

Microscopic images of two types of mouse colon epithelial cell lines used to study the effect that obesity and diet each have on colon cancer. Normal colon cells are shown in green *(left)*. Dysplastic, or precancerous, colon cells are shown in red *(right)*.

Some 100,000 people in the United States are diagnosed with colon cancer each year and nearly half of them will die from the disease, according to the American Cancer Society. The National Cancer Institute classifies it as the second most deadly type of cancer (lung cancer is the first), afflicting men and women at roughly the same rate: one in 20. Michigan State University (MSU) AgBioResearch scientist Jenifer Fenton, assistant professor of food science and human nutrition, is committed to improving those odds.

After completing a cancer prevention fellowship at the National Cancer Institute in 2007, Fenton came to MSU and since then has been focusing on how obesity, which affects one-third of U.S. adults (Centers for Disease Control and Prevention data) and dietary intake affect colon cancer risk. Fenton and her team, including AgBioResearch physiologist Julia Busik, have made significant progress. They were among the first to demonstrate that high levels of leptin, a key hormone in fat tissue, can promote tumor growth and cancer progression.

"We don't have evidence that leptin is an initiator like ultraviolet light or smoking and carcinogens, but we do have evidence that it may act as a promoter of cancerous cell growth," Fenton said.

Research showed that leptin induces precancerous colon cells to produce more of a growth factor that can increase blood supply to early cancer cells. Before the MSU finding, obesity had been identified as a significant risk factor in diabetes and heart disease, but its role in cancer was much less defined.

"We took serum from mice in three categories — obese, normal weight and those on calorically-restricted diets — and asked, 'Is there a profile or pattern of hormones that can allow us to predict obesity and how might those influence tumor growth?'" she said. "We were able to develop a pattern of four or five hormones. The next step is determining if we see the same thing in humans."

Fenton and Kari Hortos, a professor in the Department of Human Medicine in the MSU College of Osteopathic Medicine (COM) and associate dean of the MSU-COM Macomb University Center, will evaluate a group of patients from a gastroenterology clinic in Macomb. Eventually she wants to establish serum markers that identify people more likely to develop colon cancer and/or polyps (a growth or mass protruding from a mucous membrane).

Inflammation is another important risk factor for many types of cancer, including colon cancer. Fenton is examining the ability of certain dietary compounds to reduce inflammation. Researchers tested fish oil — a popular supplement to reduce inflammation and benefit heart and joint health — with unexpected results.

"In the mice with tumors that were given fish oil enriched with docosahexaenoic acid (DHA) — one of the omega-3 fatty acids — we found significant increases in tumor formation," she said.

"We don't have evidence that leptin is an initiator like ultraviolet light or smoking and carcinogens, but we do have evidence that it may act as a promoter of cancerous cell growth." • JENIFER FENTON

The findings were widely publicized and prompted several hundred phone calls, mainly from people taking fish oil supplements, to Fenton.

"I think there is an important lesson here, and what I told many of the callers is, 'Everything in moderation'," she said. "The [American Heart Association] recommendation is at least two servings of fatty fish per week. If you're healthy and eating fish, there's no need to take a fish-oil supplement. We have a long history of research *not* on supplements but on dietary patterns. There's value in setting an upper limit for supplementations. Of concern to me is the rate at which omega-3's are being added to foods."

The researchers are also studying prebiotics — non-digestible food ingredients that stimulate the growth and/or activity of bacteria in the digestive system. Fenton, in collaboration with Elizabeth Gardner, AgBioResearch scientist and associate professor in the MSU Department of Food Science and Human Nutrition, are studying how galacto-oligosaccharides (GOS), derived from milk, and active hexose correlated compounds (AHCC), from mushrooms, might reduce colon inflammation. Recent studies show that these particular prebiotics enhance immune response to influenza.

"Prebiotics and GOS stimulate the growth of specific bacterial populations, one of which is bifidobacteria," Fenton said. "There are several papers showing that bifidobacteria improve gut health. And we have found that GOS may stimulate early immune responding cells and reduce tumor growth and inflammation in the animal models."

Fenton and her team call their latest approach "innovative."

"It's a shift to a focus on dietary modulation of the cell-mediated immune response, specifically the natural kill cell, to reduce inflammation and colon cancer risk," Fenton said. ●

[Charting a path to **good food**]

Nearly six out of 10 Michigan residents live in a place that has inadequate access to the food necessary for a healthy daily diet, according to Michigan Department of Agriculture data (2009). Ironically, Michigan has the second most diverse agriculture in the nation and is the leading producer of many healthy foods, including dry beans, blueberries, tart cherries and squash.

Proposed solutions to this disparity, and others like it, are outlined in a first-of-its-kind document called the "Michigan Good Food Charter" (www.MichiganFood.org). Created with leadership from the C.S. Mott Group for Sustainable Food Systems at Michigan State University (MSU), the Food Bank Council of Michigan and the Michigan Food Policy Council, the charter provides a sequence of steps over the next decade to stimulate the economy and improve public health through a more local and sustainable food system.

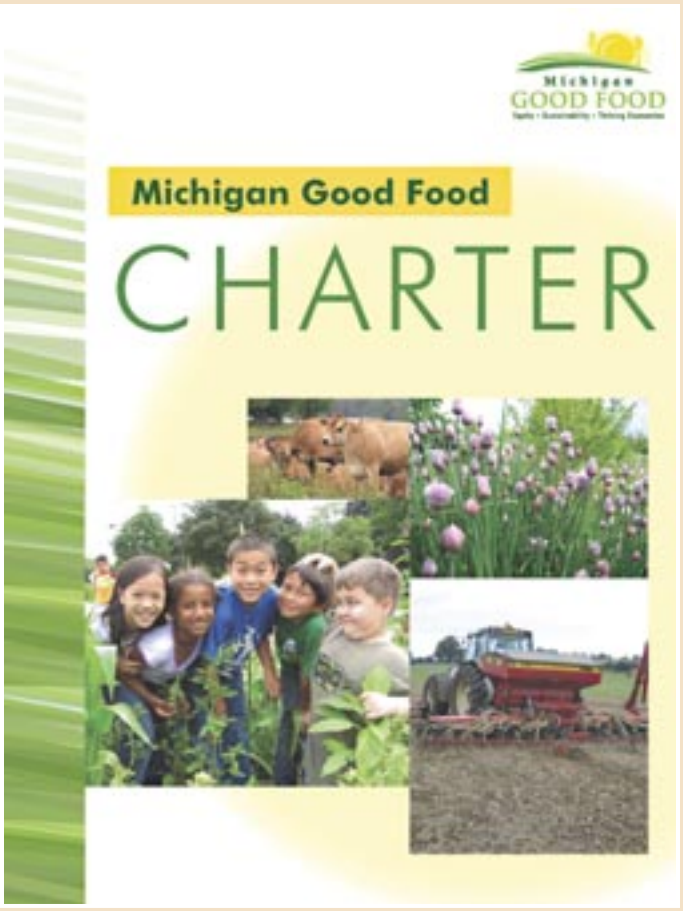
MSU AgBioResearch scientist Mike Hamm, C.S. Mott professor of sustainable agriculture, was instrumental in developing the charter, which is the culmination of 1.5 years' worth of work and input from more than 500 people. It emphasizes the need within Michigan to grow, sell and eat more "good food."

"We took research done at MSU and across the country and looked at current conditions in Michigan to develop an analysis of what can be done to improve the economy, the public health of residents and the future sustainability of natural resources," Hamm said.

The charter identifies six goals to be achieved, if not exceeded, by 2020:

1. Michigan institutions will source 20 percent of their food products from Michigan growers, producers and processors.
2. Michigan farmers will profitably supply 20 percent of all Michigan institutional, retailer and consumer food purchases and be able to pay fair wages to their workers.

IMAGE: COURTESY OF THE C.S. MOTT GROUP AT MSU



The Michigan Good Food Charter envisions a thriving economy based on a food system rooted in encouraging the production and distribution of locally grown, healthy foods.

> **"We took research done at MSU and across the country and looked at current conditions in Michigan to develop an analysis of what can be done to improve the economy, the public health of residents and the future sustainability of natural resources."** • MIKE HAMM

3. Michigan will generate new agrifood businesses at a rate that enables 20 percent of food purchased in Michigan to come from Michigan.
4. Eighty percent of Michigan residents (twice the 2010 level) will have easy access to affordable, fresh, healthy food, with 20 percent coming from Michigan sources.
5. Michigan nutrition standards will be met by 100 percent of school meals and 75 percent of schools selling food outside school meal programs.
6. Michigan schools will incorporate food and agriculture into the pre-K through 12th grade curriculum for all Michigan students. Youth will also have access to food and agriculture entrepreneurial opportunities.

The charter and accompanying documents (available on the website) also describe 25 ways to reach those goals, including details on how to improve school meals and access to healthy foods in underserved areas, preserve farmland and educate youth about career opportunities in agriculture.

"By 2050, 70 percent of the world population is projected to live in metropolitan areas, so we're moving toward being a global population that is more and more disconnected from food production," Hamm said. "This disconnect is not necessarily a good thing in terms of the population's willingness to ensure the sustainability of natural resources for future food production."

"Good food" is defined in the charter as being healthy (providing nourishment), green (produced in an environmentally sustainable manner), fair (no one was exploited during its creation) and affordable (all people have access to it).

"With 55,000 farmers, Michigan has a comparative advantage because there is such a high degree of production right now," Hamm said. "We have the environmental variables — climate, air, land, soil, water — and we also have a broad diversity of people who know how to produce a wide range of crops and animals, unlike many other states."

Hamm believes Michigan is well poised to become a leader in ensuring a domestic food supply.

"We export food all around the world and we import, too," he said. "That's all good, but we need to balance that with having a regional infrastructure so that there are markets for farmers in a whole range of venues. That way, farmers can have some assurance that, if they do it well, they will have a reasonable living and lifestyle for their families."

Some may generalize the charter as a local food movement, but its organizers view it as much more.

"We need to enact policies and strategies that make it just as easy to get food from a nearby farm as from the global marketplace," Hamm said. "This will help assure all Michiganders access to good food and all Michigan farmers and food businesses a host of entrepreneurial opportunities." •

[Improving the **safety** and **nutritional value** of **food**]

PHOTO: COURTESY OF KIRK DOLAN LAB

MSU biosystems and agricultural engineering undergraduate student Danielle Habitz *(left)* and food science master's student Claudia Place use a cherry-pitting machine to study the prevention of larvae infestation in fruit.

Food processing involves various methods that either transform raw ingredients into food or food into other forms for consumption, often extending the shelf life of the product. Examples date back to prehistoric times, including smoking and salting meats and fermenting fruit. Techniques became more modernized in the 19th and 20th centuries, largely to meet the needs of the military. But it was pasteurization, discovered in 1862, which brought the industry to a whole new level with the ability to secure the microbiological safety of the food.

Today, the Michigan food processing industry generates nearly $25 billion in overall economic activity and employs some 134,000 workers at nearly 1,600 licensed food processors, according to Michigan Department of Agriculture data (2011).

There to help guide the industry is Michigan State University (MSU) AgBioResearch scientist Kirk Dolan, associate professor in the departments of Food Science and Human Nutrition and Biosystems and Agricultural Engineering. Dolan has been providing valuable insight through his research on topics ranging from securing food safety to adding nutritional value — for the past decade.

"Consumers want foods that are more toward the fresh side and have more nutrients but still have the proper level of safety," Dolan said. "In response, food companies are developing or improving products with higher nutritional levels and, for safety, heating foods at higher temperatures for short periods of time or using a combination of mild temperature with non-thermal processing, such as high-pressure processing. My lab is developing the computational tools needed to predict the fate of these nutrients."

For example, Dolan said his team is currently constructing an instrument to measure the thermal properties of foods heated at elevated temperatures. Additional tools will include the use of commercial software for computations and statistics.

"Computational tools are needed to predict the fate of nutrients in our food," he said. "Engineers working for food companies can't perform trial and error because it wastes too much time. They have to get to market fast and need computational tools that will speed up the design process and improve their competitive status."

Dolan's work is especially beneficial in a state with such major food-processing giants as Kellogg's, Nestle-Gerber and Post. Developing relationships with the companies has helped in ways beyond Dolan's research.

"Our students are getting internships and they're getting hired," he said. "That speaks volumes to the value of our research and the job we're doing in education. We strive to make sure MSU students are well represented at Michigan-based companies. There's no reason why there should ever

be more out-of-state graduates at Nestle-Gerber in Fremont, Mich., than MSU grads. That's not the case now, and hopefully that will never be an issue."

Partnering with researchers from other areas of expertise continues to be a top priority for Dolan. In recent years, his lab has helped:

- Develop a high-fiber, healthy snack made from beans that is similar to honey-roasted peanuts but containing less fat.
- Create a powder made from discarded grape pomace that can be used as a supplement in various products such as cereals and pastries, confections and baked goods.
- Analyze the impact that heating has on destroying *E. coli* K-12 in meat.
- Measure antioxidant capacity of asparagus in new vacuum-sealed packaging aimed at extending shelf life.
- Produce powder from beans to be used as a gluten-free alternative to flour.
- Determine methods to extend the shelf life of cherry juice concentrate, a high-value processed product, while at the same time preserving antioxidant levels.

"As you can see, we're not a lab that does everything within its own four walls," Dolan said. "In my lab, we focus a lot on collaboration. We provide a lot to others and they provide a lot to us. We're digging down deep for the benefit of food companies, whether it's food safety or nutrition."

This past fall, Dolan started teaching a class that instructs students on MATLAB, a computational software program to assist in systems biology and biological engineering.

"Consumers want foods that are more toward the fresh side and have more nutrients but still have the proper level of safety." • KIRK DOLAN

"It's a win-win," Dolan said. "MathWorks [the makers of MATLAB] is happy because it's a marketing tool for them, and MSU is happy because we're developing a course which is very helpful for students and, in turn, will benefit the food industry as well as the areas of biological engineering and systems biology down the road." ●

[Attacking **allergic airway disease** in its infancy]

Asthma rates in the United States have more than doubled in the past 30 years. It is estimated that chronic respiratory disease afflicts more than 8 percent of the population (24.6 million) today compared with 3 percent in 1980. The highest prevalence — nearly 1 in 10 — is recorded in children (ages 0–17), according to the 2009 National Health Statistics Report.

Michigan State University (MSU) AgBioResearch scientist James G. Wagner, associate professor in the Department of Pathobiology and Diagnostic Investigation, has been applying knowledge in airway toxicology to study the effect that air pollution and toxins have on lung function, specifically the incidence of asthma. Some of his recent work focuses on a lesser-known form of vitamin E called gamma-tocopheral (γT) and its potential to alleviate allergic airway disease.

"The vitamin E that most people are familiar with is alpha-tocopheral (αT), which is found in multi-vitamin supplements and its consumption is encouraged for its antioxidant capacity among other benefits," Wagner said. "But our research focused on γT, another form of vitamin E. We found in the rodent model that γT can protect from and reverse allergic inflammatory processes of the lung. We suspect it does so by inhibiting the enzyme cyclooxygenase-2 [COX2], which is a key inflammatory pathway."

One of eight forms of vitamin E, γT is found in such foods as corn and soybean oils, red and green peppers, walnuts, oregano and chestnuts. It has been shown to protect against nitrogen-based free radicals, which play an important role in diseases associated with chronic inflammation, including cancer, heart disease and degenerative brain disorders such as Alzheimer's disease.

Wagner is also exploring a possible connection between γT consumption during pregnancy and the incidence of allergic airway disease in children. He has partnered with pediatric respiratory physician Graham Devereux, of Royal Aberdeen

"... we found that pregnant mice with deficient vitamin E had more pups with worse asthma. But we also found that giving mice extra vitamin E really didn't help at all. So it appears to be more of an issue with deficiency." • JAMES WAGNER

Children's Hospital in Aberdeen, Scotland.

"One of Devereux's initial findings showed that women who had low vitamin E intake had children with more wheeze or allergy airway symptoms at ages 2 and 5," Wagner said. "I asked if that was γT or αT and he wasn't sure, so I suggested we find out together.'"

They tested three groups of pregnant mice receiving the following doses of vitamin E (αT form): recommended intake, less than 50 percent of recommended intake, and four times the recommended daily amount.

"We haven't published the results yet, but we found that the pregnant mice with deficient vitamin E had more pups with worse asthma," Wagner said. "But we also found that giving mice extra vitamin E really didn't help at all. So it appears to be more of an issue with deficiency."

On the basis of preliminary findings, Wagner believes setting a recommended daily amount (RDA) of γT might be beneficial. And although many pregnant women in the United States take a multi-vitamin, Wagner said the vitamin E form in a multi-vitamin is αT, not γT. He said that γT is one of the vitamin E forms that have been relatively ignored over the years.

"Our vitamin E story certainly doesn't end here," he said. "There are six other isoforms [in addition to γT and αT] that are just now being studied and appreciated more. Some of them are called tocotrienols and have been shown to have anti-inflammatory properties at least in the Petri dish."

Wagner is already working with AgBioResearch scientist Norm Hord, associate professor in the MSU Department of Food Science and Human Nutrition, to look at whether consuming foods containing high levels of αT and γT has the same impact on allergic airway disease as the supplements do.

PHOTO: ISTOCKPHOTO/ANTHIACUMMING

Asthma can be difficult to diagnose. A chest X-ray helps determine if there is another type of infection, such as pneumonia, causing the asthma-like symptoms.

"Usually when we mix food for rodents in the lab, we combine powders with corn oil," he said. "In this instance, we substituted the corn oil with walnut oil that contains high γT, and we used almond oil that contains high αT. The animals fed the walnut-oil diet had better lung function than the others."

One challenge with this particular study is determining whether people can consume enough γT through normal dietary intake, Wagner said.

"Some researchers believe that your body will more easily absorb the vitamins in a natural state, such as in food, as opposed to a supplement," he said. "I'm not so sure I believe that, not yet anyways." ●

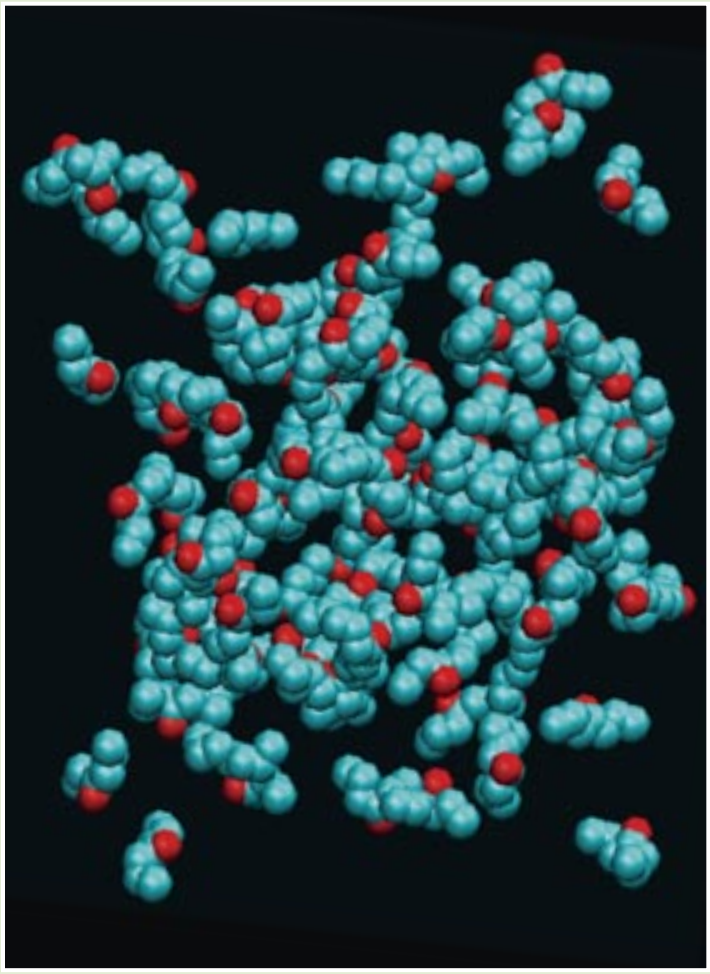
enhancing profitability

in agriculture and natural resources

Agriculture's essential role in growing and sustaining Michigan's economy is undeniable — the sector generates an estimated $71.3 billion annually and employs about 1 million Michigan residents.

Michigan State University AgBioResearch scientists from a range of disciplines are working to provide growers, commodity groups and natural resource managers with the critical information and tools they need to remain viable and competitive. Their research is broad in scope, ranging from the development of bioderived fuels and improved organic dry bean production systems to enhanced disease control for key crops and better berry varieties. This section features some of the significant work being done in this area.

[Engineering the **biofuels of the future**]



GRAPHIC: COURTESY CARL LIRA

Computer-based simulation of assemblies of molecules can estimate important properties of bioderived compounds such as vapor pressure and density.

The United States burns approximately 377 million gallons of gasoline and 121 million gallons of diesel fuel every day, according to the U.S. Energy Information Administration. Those eye-popping numbers are driving the quest for more biorenewable fuels. Michigan State University (MSU) AgBioResearch scientist Carl Lira is helping with that effort by designing and testing bioderived chemicals and additives.

"We are not going to flip a switch and one day go off of fossil fuels and onto biofuels," said Lira, an associate professor in the Department of Chemical Engineering and Materials Science in the MSU College of Engineering. "We will transition to biofuels. As we go along that path, we have to look at the properties of components as well as how the additives and fuels will be made and delivered. We also have to have vehicles that will work with them."

Most of the media buzz is about ethanol/gasoline fuels, but Lira works primarily with diesel fuels. He collaborates with other researchers on the synthesis of alternative fuels, computer simulations of possible additives, blending and characterizing properties, combustion characteristics and engine tests.

"There has been more work with ethanol and biobased gasoline fuels than diesel fuels, but bioderived diesel will be an important aspect in the future," said Lira, who has been working on thermodynamic properties of chemicals for almost 25 years. He began working with bioderived chemicals about 10 years ago and with bioderived fuels about four years ago.

One aspect of his research includes cold flow properties. A problem with traditional biodiesel fuels is their behavior at low temperatures: they tend to gel and turn solid. This means that traditional biodiesel fuels cannot be used in Michigan or much of North America during a large portion of the year.

"We are trying to understand how to determine a minimum temperature of a blend as well as to synthesize blends that will function at low temperatures," Lira said. "As a multicomponent liquid begins to cool, before it solidifies there is an intermediate point where the solution begins to look cloudy — the cloud point. That's where small crystals are coming out of the solution. The cloud point is something we can measure. We want to know how the cloud point changes with different additives.

"The long-range goal is to know if an arbitrary petroleum fuel and an arbitrary additive are put together how the resulting fuel will work in the vehicle," he continued. "Are you going to have trouble with how it behaves when it's stored and delivered? Will the fuel lines in the vehicle plug up? Testing the cloud point tells us the trends that we would see."

Another project uses computer simulations to predict vapor pressures and densities of various biocompounds.

"There has been more work with ethanol and biobased gasoline fuels than diesel fuels, but bioderived diesel will be an important aspect in the future." • CARL LIRA

"Vapor pressure and density are important at engine start-up," Lira explained. "We hope to develop a method to understand how to predict both of these factors in any given compound."

In addition to collaborations with other faculty members, Lira has worked with Ford Motor Company engineers on determining the properties of bioderived diesel fuels and making some for testing.

"So far it's just two or three different fuels, but if the engine is tuned properly, the fuels work just fine," he said.

Lira has also done work for the Defense Logistics Agency, the U.S. Department of Defense's largest logistics combat support agency. He said the military is interested in biofuels, but their strategic plan calls for using only one type of fuel in all vehicles from planes to trucks. Lira and his research group are looking at how bioderived products might be blended into the standard military fuel.

"We are taking a series of additives that we create or that could be created and are looking at the molecules and then asking, 'What chemistry could be performed on these materials in a simple, inexpensive way to make a biobased blend?'," he said.

The use of biofuels will increase, and Lira sees the importance of research to create optimum fuels.

"Our understanding of structural relationships is going to be a fundamental thing that's needed as we move into the future," he said. "New pathways and molecules will be the core that we need for the development of the best biofuels." •

[**Spilling the beans:** Research yields **answers** for **organic bean growers**]

Demand for organic products is growing, and as a result, the need for information to help organic farmers improve production is increasing. Michigan is the top organic dry bean producing state in the United States, accounting for 37 percent of the acres planted and 47 percent of the sales, according to the latest U.S. Department of Agriculture data. Michigan State University (MSU) AgBioResearch scientists, aided by two doctoral students, are working with organic bean growers to maintain that status.

A key focus of this effort involves research on organic dry bean production systems. This includes development of organic dry bean varieties, particularly black and navy beans, and research on the production system overall, which includes cover crops and their impacts on nutrient and pest management. Because organic beans are produced and processed without the use of synthetic fertilizers and pesticides, growers must exercise a high level of pest and nutrient management.

"It's a system," said Karen Renner, AgBioResearch crop and soil scientist and project leader. "You cannot work with one part of the production system and expect your research results to benefit the organic farming community — you have to look at the whole system because that's what the farmer is looking at."

Other AgBioResearch scientists on this project are: James Kelly, professor in the MSU Department of Crop and Soil Sciences; Christy Sprague, associate professor and Extension specialist in the MSU Department of Crop and Soil Sciences; and Chris DiFonzo, professor and Extension specialist in the MSU Department of Entomology. Doctoral students Erin Taylor and Jim Heilig are carrying out many aspects of the project.

"Farmers are going on word-of-mouth when it comes to organic bean variety choices and management," Heilig said. "There is no central resource on what are best practices for

"You cannot work with one part of the production system and expect your research results to benefit the organic farming community — you have to look at the whole system." • KAREN RENNER

Michigan producers. We want to gain information to support their farming operations."

Kelly and Heilig are evaluating 36 lines of beans to see how they perform in organic systems at the Saginaw Valley Research and Extension Center (one of 14 AgBioResearch centers located across the state) and in a grower's organically certified field. They also have a low nitrogen field site on campus where they study the genetics of nitrogen fixation.

"Beans fix nitrogen in root nodules to supply some of their nitrogen needs," said Kelly, who has 30-plus years of expertise in bean breeding. "The top five bean varieties may be the same for both organic and conventional farming, but we need to study interactions to see if some varieties are better suited for organic. We are searching for beans that fix nitrogen well because it is a key nutrient in plant growth and/or partition nitrogen into seed. These beans could have higher protein and may be more desirable to processors and consumers."

Organic bean varieties also need to withstand multiple trips through the field by mechanical weeding devices. Researchers are evaluating various weed management techniques in organic production systems because weeds compete with the crop for water, nutrients and light, and reduce crop yield and quality.

Cover crops are an important component of organic production systems because they suppress weeds and insects, improve soil quality and release nutrients for crop growth. Researchers are evaluating medium red clover, rye and oilseed radish as cover crops to improve bean yields and pest and nutrient management.

The research team has partnered with MSU Extension staff members, including Dale Mutch with the W.K. Kellogg Biological Station (another of the statewide AgBio-Research centers) and Dan Rossman, Extension educator in Gratiot County, to help locate organic growers for farm trials, collect data and harvest some sites.

"These people are knowledgeable and will be an integral part of getting the final information out to growers," Sprague said.

The researchers see the results of their project contributing to sustainable farming practices across all farming systems.

"To me, 'sustainable' can be a conventional system or it can be organic," Renner said. "All of us believe in the land-grant system and are working to provide information that will benefit the state's food producers. MSU has had successful partnerships with agricultural producers for the past 150-plus years, and we hope that continues." ●

PHOTO: ERIN TAYLOR

It is important to evaluate the roots of bean plants, especially to assess their ability to fix nitrogen, which plays an important part in determining seed yields.

PHOTO: COURTESY JAY HAO

Potato common scab is a soil-borne disease that reduces tuber quality. It occurs in all production areas and is most severe in soils with a pH above 5.5.

[Getting to the root of soil-borne diseases]

About 90 percent of the 2,000 major diseases of the principal crops in the United States are caused by soil-borne plant pathogens. They result in losses to farmers estimated at $4 billion a year, according to published research. For root diseases of mature crops, there currently are few effective and economical post-plant strategies for disease control. Statistics like these are inspiring Michigan State University (MSU) AgBioResearch scientist Jianjun "Jay" Hao in his work with managing plant-microbe interactions in soil.

"My research program emphasizes studies on the epidemiology and control of plant diseases caused by soil-borne pathogens and the relationships between pathogens, plants and other microorganisms in soil," said Hao, an assistant professor in the MSU Department of Plant Pathology. Hao is also looking at the use of naturally occurring beneficial organisms for improving plant and soil health. His research focuses on soil-borne plant diseases caused by *Sclerotinia sclerotiorum* in soybeans, the *Streptomyces* species — which causes common scab in potatoes — and *Phytophthora capsici* in vegetable crops. Some of the biological control products that he is investigating include plant-derived products, such as extract of giant knotweed, extract of chestnut and essential oil extracts from various plants. His work is beneficial to both organic and conventional farmers.

"Being able to manage soil-borne pathogens is environmentally friendly and good for organic production as well as sustainable conventional agriculture," Hao said. "In some cases, like with potato common scab, there are no effective disease strategies."

His research received a boost when he came across a field near campus that seemed naturally to suppress pathogens.

"The field had been used for more than 20 years by potato breeders as a disease screening nursery," Hao said. "The breeders wanted the soil-borne pathogens to be high. However, they noticed that the diseases were getting lower and lower, so they could not use it for variety testing — but it is perfect for my research."

Hao has successfully characterized the soil that is suppressive to potato common scab and established a program for fundamental soil-borne disease study. His research also has resulted in the discovery of a group of innovative biological agents for disease control. One of the bacterial strains, *Bacillus amyloliquefaciens* (BAC03), shows strong antimicrobial activity against several important soil-borne pathogens. Hao and his research team have studied it extensively in the greenhouse and the field for disease control, primarily in potato. When biological control agents or various materials are applied to soil infested with the pathogen *Streptomyces* scabies, BAC03

"Being able to manage soil-borne pathogens is environmentally friendly and good for organic production as well as sustainable conventional agriculture." • JIANJUN "JAY" HAO

suppressed diseases in radish, tomato, turnip, beet, cucumber, pepper and carrot plants.

"Ninety percent of the time, our isolate was stronger in disease control than the commercial one," Hao said. "It not only suppressed the disease but also promoted plant growth."

More importantly, Hao said, plant defense against the pathogen may be triggered by inoculating the soil with BAC03.

"This is demonstrated by a simple split-root experiment, where the plant roots were divided and placed in two separate pots," he explained. "The *Bacillus* spp. stimulated the immune system of the plant on one side and went to the other side of the plant, so treating even part of the plant with the *Bacillus* will benefit the whole plant."

Hao is part of a multi-state group of researchers, called W2147, brought together by the USDA to share information on managing plant-microbe interactions. The strategy behind the group is that no single research institution has sufficient resources and diversity of expertise to solve the diverse disease problems associated with agriculture. Because many of the pathogens occur in multiple states, a coordinated research effort could provide more cost-effective outcomes. Hao is currently the secretary of the group and was the chair of the conference in 2009. He is the only representative from Michigan in the group.

Like many other AgBioResearch scientists, Hao, a plant pathologist by training, sees the long-term benefits of his research.

"I realize that managing, not controlling, plant diseases encompasses both ecology and microbiology, because pathogens are part of the ecosystem," he said. "By working on that, we will be able to manipulate the pathogens for less impact on production without too much chemical input to the soil ecosystem. The outcome will support healthier agricultural production." •

[Growing profits with new berry varieties]

Summer is a "berry" good season for Michigan fruit. The state leads the nation in growing blueberries, producing 109 million pounds in 2010. Michigan's strawberry production will never outpace California's production, where more than 80 percent of the U.S. crop is grown, but Michigan farmers produced 2.9 million pounds of strawberries in 2010, according to U.S. Department of Agriculture data.

Jim Hancock, a Michigan State University (MSU) AgBioResearch small plant breeder specializing in strawberries and blueberries, is working to bring these fruits to consumers in greater quantities and for a longer period of time.

"We are trying to extend the season for Michigan's blueberry growers," said Hancock, a professor in the MSU Department of Horticulture.

There is almost a year-round supply of fresh blueberries. Product comes from Chile in the winter, and then the U.S. harvest starts in Florida and Georgia in April. Michigan's harvest is at the end of the season, starting in late June.

"We own most of the production at the end of the growing season," Hancock said. "The later Michigan goes and the longer the berries can be stored, the better the prices because our only competition is from growers in the Pacific Northwest."

The focus of his blueberry breeding project is to develop mid- to late-season varieties with extremely high fruit quality. He has developed two late-season varieties and one midseason variety with a long storage life.

"These have been a big hit," Hancock said. "In fact, the varieties — Aurora, Draper and Liberty, which were released in 2005 — are the most widely planted blueberry varieties in the world."

However, there's a streak of perfectionism in Hancock.

"One of the late-season varieties has good flavor but not great flavor," he said. "I'd like to have a late one with exceptional flavor." Hancock often is evaluating as many as 10,000 blueberry plants at any given time.

PHOTO: FALL CREEK FARM AND NURSERY, INC.

PHOTO: ISTOCKPHOTO/RINELLE

Combining genomic tools such as DNA sequencing with field research studies makes it possible to develop blueberry and strawberry varieties that meet grower and consumer demands.

Breeding for flavor involves crossing varieties with good flavor and then tasting the berries and measuring sugars and acidity in the fruit. In addition, Hancock runs a volunteer taste panel for opinions on flavor.

"The panel gives me a better handle on what people really like," he said. "I found that my palate wasn't sweet enough for a lot of people. Consumers want a little tart, but they want more of a perception of sweetness."

The focus of the strawberry breeding project is on developing repeat flowering or ever-bearing varieties. "Ever-bearing" means that during the season the variety would have three crops of berries or a continuous harvest lasting a couple of months. In the Midwest and East, there is not an ever-bearing strawberry that is commercially viable.

As with blueberries, the goal is great flavor. And the plants have to be resistant to diseases caused by soil pathogens, such as black root rot.

"We have determined that temperature rather than the amount of daylight is most important to flowering," Hancock said. "This was a fundamental shift in how we viewed new varieties."

A multi-state trial of his new strawberry selections will take place next year, and Hancock hopes that at least one of them will look good enough to be released as a variety.

Advances in genomic technology are assisting fruit breeders, and Hancock is excited about the possibilities.

"The idea is to develop molecular tools that plant breeders can use to enhance breeding efficiency," Hancock said. "This is a dream come true for me. We can use some of this genome information right away. It's now possible to do things with less money, and I certainly have a greater appreciation of molecular tools."

> "We have determined that **temperature rather than the amount of daylight is most important to flowering.** This was a **fundamental shift** in how we viewed **new varieties."** • JIM HANCOCK

Hancock also credits the success of the blueberry and strawberry breeding programs to a widespread collaborative group.

"There are dozens of people from many states contributing in various ways," he said. "Ultimately our own imaginations must put everything together, but a lot of people have worked unselfishly on these projects." ●

environmental stewardship

and natural resources and policy

Developing economically and environmentally sound approaches to address environmental and natural resources challenges is increasingly important.

Practices, policies and science-based knowledge must constantly evolve to promote stewardship and sustainability in light of new opportunities for increased productivity, resource-saving technologies and enhanced quality of life. The projects featured in this section reflect some of the innovative work being done by Michigan State University AgBioResearch scientists in this area to help communities, natural resources managers, producers and policymakers at all levels make informed decisions and wise choices.

["Going green" with more **urban trees**]

PHOTO: JANE L. DEPRIEST

The ability to quantify carbon sequestered by trees planted on the MSU campus since 1990 was helped by the detailed records that the university keeps on campus trees — even their GPS locations.

"Go Green!" is a favorite slogan at Spartan athletic events, and Michigan State University (MSU) has taken that theme to heart with its "Be Spartan Green" environmental stewardship initiatives. An MSU AgBioResearch scientist is helping to advance this "green" philosophy with groundbreaking research on urban treed spaces.

"We have to pay more attention to how we utilize trees outside of forests because the planet is becoming more urbanized and more deforested, so trees are becoming more of a precious resource," said David MacFarlane, an associate professor in the MSU Department of Forestry, who specializes in forest measurements and modeling.

The research began with an urban timber inventory, something no one had done. In a 13-county area in southeastern Michigan, MacFarlane and several students employed the same procedure used for commercial forest inventories to measure the level and quality of wood in urban trees.

Results of the inventory showed that the quality of wood in urban trees was better than expected and that annual tree removals in the 13-county area could yield lumber equivalent to 5,500 homes per year, or an energy equivalent of 97 megawatts per year — that's enough to run the MSU power plant for a year.

MacFarlane pointed out that this is a nonpoint resource.

"These are all little bits and pieces at various locations, so it seems logistically difficult to try to bring it all together," he said. "However, that was an early argument against curbside recycling, and now we routinely do that, so maybe wood could be added to the materials recycled at curbside."

The results of the research sparked the interest of MSU officials. They asked what could be done to obtain renewable fuels to substitute for coal in the campus power plant. This summer, one of MacFarlane's students worked with MSU foresters to figure out how much useable wood might be in the thousands of acres of off-campus forests that MSU owns. Some of that wood is now being used to fuel the power plant.

"It's not from urban trees, but our research sparked the idea," MacFarlane said.

The other part of MacFarlane's research relates to the carbon storage capacity of trees and their role in helping to offset carbon dioxide (CO_2) emissions into the environment. In 2009, he undertook a project to quantify the carbon sequestered by trees on the main campus. This was spurred in part because MSU has been a member of the Chicago Climate Exchange (CCX), a voluntary carbon market, since 2007.

The MSU Office of Campus Planning Administration keeps detailed information on most trees on campus, including GPS coordinates, species, date planted and what happens to the tree during its life. Using this information and following CCX's urban carbon offset protocol, MacFarlane determined that in 2009, about 66 tons of CO_2 equivalents were offset by about 5,000 planted trees. MSU then claimed the first-ever urban forest CO_2 emissions offset credits registered with the CCX in April 2010. The offsets were subtracted from emissions reported from the campus power plant.

"We have to pay more attention to how we utilize trees outside of forests because the planet is becoming more urbanized and more deforested, so trees are becoming more of a precious resource." • DAVID MACFARLANE

MacFarlane also will use insights from this research in Kenya starting in January. He recently received a Fulbright Scholarship and is taking a six-month sabbatical to undertake his work there.

"Kenya needs to plant more trees and protect its forests, but it doesn't have the full capacity to implement such projects scientifically," MacFarlane said. "Through new research, workshops and lectures, I hope I can help raise the bar of what the country can do."

MacFarlane likes to do research that is relevant to the state — and also to MSU.

"Students, staff and faculty all got excited about working on these projects, which fit in with the idea of getting everyone involved," he said. "That's what you would have to do in a real city to move green issues forward. It's good for MSU and Michigan to be a place where this kind of research is done." ●

[Managing grasslands in commodity-producing landscapes]

As the world population balloons to an estimated 9.3 billion people by 2050 (U.S. Bureau of Census data), enormous pressure will be placed on grasslands. Understanding the relationship of people to grassland systems is part of a three-pronged project being undertaken by Michigan State University (MSU) AgBioResearch scientist Carolyn Malmstrom.

"Grasses are the key group of plants that support humanity," said Malmstrom, an associate professor in the MSU Department of Plant Biology. "About two thirds of the calories eaten around the globe every day come directly from grasses such as wheat, rice or millet, or from the meat and milk of animals that have eaten grasses."

The primary goal of Malmstrom and members of her lab for this AgBioResearch project is to support the development of effective strategies for grassland restoration in commodity-producing landscapes.

One key focus of the project is to examine strategies for restoring grassland communities. Malmstrom's team is evaluating the influence of seed source (i.e., local, non-local, wild-collected or cultivated) on plant performance in Michigan prairie restorations and examining differences in prairie function among prairie types (i.e., restored, remnant) across the Midwest.

"The Midwest originally had many acres of native grass prairies," Malmstrom explained. "Settlers plowed those up and planted field crop grasses — wheat and corn — so the landscape experienced a huge transformation from domination by perennial native grasses to cereal crops. That shift was profound and had many ecosystems impacts. Now as a society we're thinking about switching back — putting native perennial grasses back in the landscape for conservation and biofuel production. We need to consider the ecological consequences."

A related research focus of the group, therefore, is to examine the ecology of virus interactions with biofuel grasses.

"The development of perennial grass-based bioenergy systems offers opportunities for American agriculture to not only increase crop production but also to enhance wildlife habitat and protect soil resources," she said. "For example, if we use switchgrass in cellulosic biofuel production, there may be ecological benefits because switchgrass requires fewer inputs than corn."

Malmstrom points out, however, that with these potential benefits come other considerations.

"As we select grasses to grow faster and perhaps be more easily digestible, we are probably going to make them more

PHOTO: CAROLYN MALMSTROM

AgBioResearch scientist Carolyn Malmstrom and her team are working with rancher collaborators in California to conduct trials of the effects of various grazing regimes on invasive weed abundance.

attractive to other consumers, such as insects," she said. "One of the groups that we are concerned about is the vectors [organisms that transmit infections from one host to another] that move viruses around. Some of the important vectors are aphids and leaf hoppers — insects that feed on plant saps."

Malmstrom's research found that, as grasses are selected for digestibility and growth rates, their susceptibility to viruses and attraction to sucking insects — especially aphids — increased. She emphasized that this finding points to the need for more systematic testing when selecting for traits for biofuels and a better understanding of what to watch for in vector or virus susceptibility.

The third focus of the project is working with ranchers in the western part of the United States on how to manage landscapes to promote either native species or less noxious introduced species to maintain rangeland quality. Malmstrom and her team are using remote sensing technology to help quantify how grasslands respond to a variety of management treatments.

"Our approach in this area has been to work closely with landowners to make sure that the new analytical tools and information being provided relate to the needs of producers and the people making management decisions," she said.

Malmstrom added that, as work continues to support the development of effective strategies for grassland restoration in commodity-producing landscapes, researchers must be mindful of the balance between maximizing crop production, protecting the environment, and keeping pests and pathogens at bay.

> "The development of **perennial grass-based bioenergy systems** offers opportunities for American agriculture to **not only increase crop production** but also to **enhance wildlife habitat** and **protect soil resources.**" • CAROLYN MALMSTROM

"A key characteristic of a perennial system is that it can be a residence for many beneficial organisms, such as pollinators and butterflies, but it can also provide residence for pests and pathogens," she said. "So the question is under which circumstances do we promote one group more than the other? How do we find that balance? That's the ultimate goal." ●

[Creating a **viable market** for **ecosystem services**]

What do food crops, clean drinking water and the beauty of vegetated landscapes have in common? All of them are benefits that people derive from nature, what scientists call "ecosystem services." Despite wide recognition, however, these services typically are not valued through existing markets. Michigan State University (MSU) AgBioResearch scientist Scott Swinton is working to measure the economic value of ecosystem services linked to agriculture and identify ways that policy can communicate those values to farmers.

Ecosystem services are divided into four broad categories: provisioning, such as the production of food, fiber, fuel and drinking water; regulating, such as the role of plants and vegetation in maintaining a sustainable climate for human life and the life of the species we depend upon; cultural, such as recreational opportunities and inspirational or sacred places in nature; and supporting, such as supplying nutrients to plants and crop pollination, which enable the other three types of services.

"The general idea of ecosystem services is that it's focused on people," said Swinton, a professor in the MSU Department of Agricultural, Food and Resource Economics. "Where an economist fits into this picture is finding ways to improve the supply of ecosystem services to society.

"Markets work when you have private goods and services that can be bought and sold," he explained. "You can buy apples or wheat or milk, but you can't buy cleaner stream water. Many of the regulating and cultural ecosystem services tend to lack markets because they involve things that can't be privately owned. Yet people care about them and clearly derive benefits from these things. There's an important role for policy in this arena.

"The big question is, under what conditions would farmers adopt environmentally beneficial, low-input technologies?" he continued. "One part of answering this question is determining what farmers need, and the other part is designing policies that could support that need."

To address this challenge, Swinton conducted a study in 2007 to investigate why farmers weren't adopting some of the environmentally beneficial row crop practices such as cover crop planting, small grain rotation and reduced fertilizer rates.

The research was followed by focus groups and a survey of 3,000 Michigan corn and soybean farmers in 2008. What Swinton found is that farmers are well aware of low-input technologies, but they see implementing these practices as adding to their costs.

PHOTO: MIKE GANGWER, USDA NRCS

Farmers at a Clinton County, Mich., field day evaluate no-till cover crop planting.

"Cover crops require extra labor for planting and seed costs, and are sometimes hard to kill when it's time to plant the main crop," Swinton explained. "Reduced fertilizer levels create the risk that yields might be lower if growing conditions are very good. We did find, however, that large numbers of Michigan growers would adopt these practices if provided an incentive."

The study findings helped Swinton, fellow AgBioResearch economist Frank Lupi, and their team develop supply curves, which show how much land Michigan farmers would be willing to put into these practices for various levels of payment.

Another part of Swinton and Lupi's research involved asking Michigan residents if they would be willing to pay for the kinds of ecosystem services that these changed farm practices would

> **"The general idea of ecosystem services is that it's focused on people. Where an economist fits into this picture is finding ways to improve the supply of ecosystem services to society."** • SCOTT SWINTON

require. Results revealed that Michigan residents would be willing to pay for reduced numbers of eutrophic lakes and reductions in greenhouse gas emissions. That payment could support potentially 20 to 50 percent of Michigan corn-soybean land going into low-input practices.

"The hard part is making the link between what farmers do and what non-farmer residents experience," Swinton said. "The preconditions are there. Farmers are willing to implement some of these practices for certain payments. Residents are actually willing to pay amounts of money that would support significant change. The missing piece is a way to make that connection."

Although there is still much ground to cover in creating a viable market-based mechanism for agricultural systems, Swinton believes that there is a growing awareness of the need to look at cropland from a broader public benefit perspective rather than simply considering the immediate goods it provides.

"Successfully creating these types of markets has to make tangible economic sense to all the groups that are affected," Swinton said. "Being able to demonstrate the full range of ecosystem values and their economic benefits is one part of the equation. Another is to find ways of equitably capturing values and benefits over the long term so that incentives can be put in place to promote sustainable agricultural systems." ●

[Using **plant-based ecosystems** to **protect water resources** and **human health**]

Plants are commonly viewed as a source of food or medicinal ingredients, or as ornamentals that add beauty and color to our surroundings. For Michigan State University (MSU) AgBioResearch scientist Dawn Reinhold, plants are also a crucial component of natural treatment systems that can be used to protect both the environment and human health.

"Plants play a very active role in helping to mitigate various pollutants," said Reinhold, an assistant professor in the MSU Department of Biosystems and Agricultural Engineering. "Plants are often overlooked when people are studying the environmental fate of chemicals and contaminants, but we've demonstrated time and again in our research that plants have a direct effect on improving the outcome of environmental fate by decreasing pollutant concentrations in waters and soils, which can potentially affect human health."

A key research focus for Reinhold is the understanding and engineering of plant-based ecosystems for the protection and treatment of water resources. She and members of her lab are examining the abilities of food crops to phytoaccumulate (a process by which a plant takes up chemicals) antimicrobials from biosolids (nutrient-rich organic materials resulting from the treatment of sewage sludge, often used as fertilizer) and wastewater used for irrigation, and what the relevance of this phytoaccumulation is to the environmental fate of chemicals and human health risk.

Two of the most common antimicrobial agents used in consumer products are triclosan and triclocarban. According to the scientific literature, these compounds have been used as antimicrobial agents in soap since the 1960s. In recent years, the use of antibacterial agents in consumer products has skyrocketed — they are found in soaps, lotions, cosmetics, toothpaste, deodorant and other personal hygiene products.

"Most of these products get washed down the drain, and are not transformed in conventional wastewater treatment plants," Reinhold said. "Untransformed, these chemicals enter the environment through wastewater treatment effluent and biosolids. Triclosan is one of the most frequently detected chemicals in streams across the United States, and both triclosan and triclocarban are found in high concentrations in sediments and sewage sludge, where they can persist for years. These agents

"... plants have a direct effect on improving the outcome of environmental fate by decreasing pollutant concentrations in waters and soils, which can potentially affect human health." • DAWN REINHOLD

adversely affect ecosystems and, at high concentrations or with continuous exposure, can potentially affect human health."

To help address this problem, Reinhold and members of her lab first conducted vegetated soil column studies to look at biosolids application, which introduces triclocarban and triclosan to soil and water resources. Pumpkin, zucchini and switchgrass were grown in soil columns to which biosolids were applied. Leachate from soil columns was assessed every other week for triclocarban and triclosan. At the end of the trial, concentrations of the two agents were determined for soil, roots, stems and leaves.

"Our results showed that plants can, indeed, reduce leaching of antimicrobials to water resources," Reinhold said. "Further, our outcomes indicated that phytoaccumulation of antimicrobials in pumpkin and zucchini reduce concentrations of antimicrobials in agricultural fields, and that the consumption of these crops from fields where biosolids are applied present minimal risk to human health."

In the next phase of this research, Reinhold and her team are screening 12 to 15 vegetable and fruit crops using hydroponics (the cultivation of plants in a nutrient solution rather than in soil) to investigate the relevance of bioaccumulation of antimicrobials from irrigation waters to human health risk and environmental fate.

"To build on our biosolids work, we want to evaluate the hypothesis that food crops will phytoaccumulate antimicrobials when irrigated with municipal wastewater treatment plant effluents and that, though it will affect the fate of antimicrobials in agricultural fields, phytoaccumulation of antimicrobials will not present a significant health risk," Reinhold said. "Repurposing treated municipal wastewater for irrigation could also help remedy the negative impact that antimicrobials have on aquatic ecosystems when it's discharged into surface waters."

Once their hydroponic study is complete, Reinhold and her team will do some modeling to predict plant uptake, microbial degradation and the fate of the chemicals in these systems. The results from the modeling will then be expanded into a greenhouse study that uses wastewater and biosolids so that estimates can include both sides of the bioaccumulation coin.

PHOTO: SHANNON HENDERSON

Watermelon *(left)* and celery *(right)* are two of more than a dozen fruits and vegetables being studied by AgBioResearch scientist Dawn Reinhold's lab to assess their uptake and bioaccumulation of antimicrobials from irrigated waters.

"The ecosystem is much more sensitive to these chemicals than humans," Reinhold said. "This makes sense if you think about it because antimicrobials are designed to kill microorganisms, and river and soil communities are built on microorganisms. Our findings demonstrate that soils and plants have a greater capacity to handle these wastes and break down the antimicrobials — and can do so without acute human health risks — whereas the capacity of aquatic systems to assimilate antimicrobials without adverse effects is currently being exceeded. So we're looking at the concentration levels of these compounds and asking whether this is something we need to be concerned about. And in aquatic systems, it definitely is." •

secure food and fiber systems

Sustaining a safe, secure food and fiber system and keeping people and animals healthy make up a large and important part of the Michigan State University AgBioResearch mission.

In research initiatives ranging from working to mitigate the risk of Lyme disease in humans and controlling the spread of Johne's disease in cattle to investigating plants' ability to produce valuable chemical products and better understanding the root cause of infertility in dairy cows and humans, AgBioResearch scientists continually discover innovative ways to help protect and enhance our food and fiber supply and improve human and animal welfare. The stories in this section showcase some of the significant research being done in this area.

[Ticking off the reasons why Lyme disease may spread to some places but not to others]

PHOTO: GRAHAM J. HICKLING

The blacklegged tick *(pictured above)* is responsible for 95 percent of the Lyme disease cases in the United States. These cases are generally in the Northeast and upper Midwest.

Lyme disease is the No. 1 vector-borne disease in the northern hemisphere, with more than 30,000 cases reported each year, according to Centers for Disease Control and Prevention (CDC) data. The blacklegged tick (also called the deer tick) — the only tick species that spreads the Lyme disease bacterium to humans in the eastern United States — is actively spreading to new areas, and confirmed cases of the disease will continue to increase as time goes by.

Interestingly, even though the tick is established in various regions of eastern North America, the majority of confirmed disease cases and evidence of the pathogen occur predominantly in the northern part of the tick's territory. Understanding the factors that limit the disease to the northern regions may help predict how the disease will spread so that public health measures can be directed toward mitigating disease risk.

The public's ability to recognize the importance of other tick-borne diseases, especially in the Southeast, has been hindered by an excessive focus on Lyme disease and contradictory pieces of information about it. Public health officials, ecologists, medical entomologists and citizens all stand to benefit from reduced disease risk in the future because of the work of Michigan State University (MSU) AgBioResearch scientist Jean Tsao and collaborators from several universities and research programs across the country.

Early findings from Tsao's research suggest that ecological factors important to the Lyme disease story can't be defined by findings from one geographical area, so quantifying the abundance and ecology of the tick and the disease-causing pathogen is taking place at multiple test sites located across the eastern United States and the Southeast. Sampling will continue for another year; the following year will be devoted to analyzing data and running lab assays on infections.

"Findings from this research can be used to help reduce the confusion and answer questions about whether Lyme disease exists in the Southeast and, if it does, at what level," said Tsao, an associate professor in the MSU Department of Fisheries and Wildlife. "Data will provide details about where, when, how much and how many infected ticks exist in the Southeast. If we can show that the risk is miniscule, then discussions about tick-borne diseases can shift from Lyme disease to other ones caused by highly abundant ticks in the Southeast. The CDC and public health officials can use the data, too, to increase risk awareness of tick-borne diseases other than Lyme disease."

There is currently no vaccine for Lyme disease, and using practices such as spraying pesticides or reducing the population of the deer herd to reduce the potential for contact with an infected tick aren't socially acceptable.

"If we find out that certain hosts are more important than others, perhaps new interventions can be developed, but part of it is the public's willingness to implement certain practices," Tsao said. "Having data available will help authorities make decisions about reducing disease risk and managing its spread."

Tsao's research has already demonstrated that tick density is much lower in the South, and ticks there express different host-seeking behaviors that reduce their contact with humans. Though adult ticks in the South, like their northern cousins, appear to feed mainly on deer, the nymph (teenage) stage feeds mostly on lizards, with only some feeding on common northern hosts such as mice, chipmunks and shrews.

"Is it because of the climate, or is it that they just like lizards better?" Tsao asked. "What we've found is that the ticks behave differently and there's a lot of genetic diversity. We may need to revisit the hypothesis that there is more than one tick species, or perhaps the [same] species just behaves differently in the Southeast."

The project has yielded sufficient data verifying lower risk of Lyme disease in the Southeast, but surveying will continue to generate a fuller sense of the degree of variability among all the various factors at each field site.

"Having data available [on Lyme disease] will help authorities make decisions about reducing disease risk and managing its spread." • JEAN TSAO

"My students, collaborators and I are extremely fortunate and excited to be able to work on such a multifaceted project to understand how Lyme disease risk varies geographically," Tsao said. "Furthermore, findings at the regional and national levels also will help us better understand and, therefore, better mitigate the risk of Lyme disease for Michigan citizens as the tick spreads into more areas in the state." •

[Focusing on the calf is No. 1 way to manage Johne's disease]

In the United States, it's estimated that about 8 percent of the beef herds and 68 percent of the dairy herds have at least one animal infected with *Mycobacterium avium ssp. paratuberculosis* (MAP) — the bacterium that causes Johne's disease (National Animal Health Monitoring Systems study, 2007). Johne's disease is a contagious, untreatable and fatal gastrointestinal disease that's been found in every country that has conducted testing on its domesticated ruminant livestock species.

The slow, progressive nature of Johne's disease makes diagnosing animals challenging, especially during the early preclinical stages of the disease. The lining of an infected animal's intestines thickens over a period of years, gradually compromising its ability to digest feed. As the disease progresses, milk production levels decline, and the animal loses weight and experiences intermittent bouts of chronic diarrhea. The final stage is death. Though infection typically occurs in calves, animals generally don't express clinical signs of Johne's disease until later in life.

Dan Grooms, Michigan State University (MSU) AgBioResearch veterinarian and food animal division head in the MSU College of Veterinary Medicine, was the lead researcher on a nearly decade-long project called the Michigan Johne's Disease Control Demonstration Project. The objective of the work was to identify which management practices are the most effective at controlling the spread of Johne's disease. Grooms summarized the bottom-line conclusion of the research in four words: focus on the calf.

"It sounds too simple, but if we can simply reduce the risk of calves becoming exposed to the bacterium that causes Johne's disease, then we can make significant progress in reducing the impact of the disease on both dairy and beef operations," he said.

The Michigan Johne's Disease Control Demonstration Project was a partnership between the MSU College of Veterinary Medicine, the MSU Diagnostic Center for Population and Animal Health, MSU Extension, the Michigan Department of Agriculture and Rural Development, and the U.S. Department of Agriculture in collaboration with nine Michigan veterinary clinics. Findings from the Michigan farms involved in the study were pooled

" . . . if we can simply reduce the risk of calves becoming exposed to the bacterium that causes Johne's disease, then we can make significant progress in reducing the impact of the disease . . . " • DAN GROOMS

with data collected from 17 other states as part of a larger, multi-state project, the National Johne's Disease Control Demonstration Project.

The goals of the Michigan Johne's Disease Control Demonstration Project were to evaluate the effectiveness of Johne's disease control strategies, develop new knowledge about control strategies through field research studies, develop education resources and promote the Michigan Voluntary Johne's Disease Control Program.

Nine herds — one beef operation and eight dairy herds — were enrolled in the project. Selected farms represented a variety of management styles and were located across the state.

PHOTO: DAN GROOMS

Identifying cattle infected with Johne's disease is a critical component of managing the disease. Michigan has three USDA-approved Johne's disease laboratories to assist with diagnostics.

Farms were enrolled in the project between 2002 and 2005 and participated in the program for four to seven years.

Each herd underwent whole-herd testing to measure baseline levels of Johne's disease infection. From there, a disease risk assessment was conducted, and management practices were put in place to help control on-farm spread of the disease.

All herds participating in the project tested positive for Johne's disease; the percentage of cows infected in each herd ranged from 6 percent to 14 percent.

"Each of the herds was infected with Johne's disease at the time of enrollment," Grooms said. "At the end of the project, the farms had reduced the prevalence of Johne's disease in their herds and the number of cattle detected with clinical signs of the disease, and increased overall herd health.

"In every herd that participated in the project, significant changes were made to how the calves were managed, and the incidence of Johne's was reduced significantly," he added. "By focusing resources and efforts on reducing MAP transmission from older animals to young calves, producers can effectively manage Johne's disease and reduce its impact on farms."

Findings from this work will have a far-reaching and positive effect on the future of the beef and dairy industries.

"The program has provided and will continue to provide background for educating producers on the positive correlation that exists between implementing effective management decisions to control Johne's disease in their operations and the profitability of their businesses and overall improved animal welfare in their herds," Grooms said.

A copy of the project report can be viewed and/or downloaded by visiting http://cvm.msu.edu/johnes. ●

[Profiling **plants** to identify new **high-value substances**]

PHOTO: RANDY BEAUDRY

MSU horticulture undergraduate Patrick Abele *(above)* collects leaf material for *Stevia* extraction.

In the emerging field of metabolomics — the CSI* of studying small molecules (metabolites) — Michigan State University (MSU) is a pioneer. The mass spectrometer, which is an analytical instrument in MSU AgBioResearch scientist A. Daniel Jones' laboratory, is busy working 24 hours a day measuring unique chemical fingerprints left behind by cells.

Plants are the most chemically prolific organisms on the planet and produce a wide range of chemical compounds. Society places high value on many of these substances for medicinal purposes, insect or disease resistance, flavors and aromas (perfumes). Plants utilize these chemicals to attract pollinating insects or repel damaging pests and predators. Though scientists have developed ways to efficiently breed plants to produce high yields, they haven't been as successful at figuring out how to cultivate a plant's high-value chemical products.

Little is known about the majority of chemicals produced by plants, which can number into the thousands, the purposes they serve or how they're produced. One example is *Stevia*, a group of natural sweeteners produced by the *Stevia* plant. *Stevia* is much sweeter tasting than sugar, so smaller amounts can be used to achieve the same levels of sweetness.

AgBioResearch horticulturists Randy Beaudry and Ryan Warner, in collaboration with Jones' lab, developed a procedure using a mass spectrometer to perform molecular profiling of thousands of *Stevia* plants. This technique will help identify individual plants that consistently and reliably produce sweet-tasting compounds and guide plant breeding efforts to improve the quality and yields of *Stevia* sweeteners.

Jones is also working with AgBioResearch colleagues Robert Last and Cornelius Barry and University of Michigan professor Eran Pichersky on a project that focuses on the specialized cells found on surfaces of the tomato plant that produce the scent that lingers after one brushes up against it. The chemicals responsible for this smell make up an arsenal of chemical defenses, many of which accumulate in trichomes (tiny hair-like glands) lining the leaves and stems. Knowledge of the genes responsible for these chemicals may provide clues to what regulates the production of chemicals in other plants.

"By understanding how trichomes produce these chemical compounds, we may be able to breed or engineer plants that make more of a specific substance," said Jones, a professor in the MSU Department of Biochemistry and Molecular Biology. "We could reintroduce some of the genes from wild relatives of tomato into conventional tomato varieties to make them more insect-resistant."

Genes that researchers discover may eventually be used to launch another biotech revolution — generating new industries that make valued components from plants.

"Figuring out how plants produce these high-value substances in large quantities could help make the agricultural and biotechnology industries in Michigan and across North America more competitive," Jones said.

** refers to the Crime Scene Investigation TV series*

"By understanding how trichomes produce these chemical compounds, we may be able to breed or engineer plants that make more of a specific substance." • A. DANIEL JONES

Another initiative involving Jones is the Medicinal Plants Consortium funded by the National Institutes of Health. Led by AgBioResearch biochemist Dean DellaPenna, the consortium is seeking to understand what plant genes are responsible for making medicinal compounds. The common periwinkle flower, for example, produces tiny quantities of two compounds used to treat certain cancers. Developing an understanding of the genes involved in producing these compounds offers promise for improving medicines and decreasing their costs of production.

"The beauty of this collaborative project is that we have a web-based resource [research conducted by AgBioResearch plant biologist Robin Buell] of 'here are the DNA sequences expressed by different tissues, with a count of how many times these gene products show up'," Jones said. "Comparing our chemical analyses with gene expression helps identify the genes responsible for valuable chemicals."

Plant breeders are poised to realize the most benefits from all this research in the short term, thanks to the extensive genetic diversity of economically important plants.

"We're just measuring compounds; the technology doesn't care where they come from," Jones explained. "We expect to learn a lot about how different individuals respond — whether they're humans, plants, microbes or livestock — to guide future practices.

"There are thousands of things we can measure, and if we learn enough about what we're measuring, in the future we might be able to determine if your diet or lifestyle is good for you, whether it's better to eat organic or conventionally produced food, or be able to reach an earlier diagnosis of a disease state that might not be easily understood from clinical lab tests," he continued. "If we do it right, we should be using these tools to make agricultural production both more economical and beneficial. There's no reason why we can't do both." ●

[Solving the **infertility puzzle** using **bovine eggs**]

Dairy producers have been trying to figure out the secrets to managing infertility in dairy cows for decades. Unlike heifers, which have a 70 percent conception rate, the average conception rate for lactating dairy cows is 30 percent to 35 percent. To produce milk, dairy cows must give birth to a calf once every 12 to 14 months, so it's no surprise that one of the highest priorities facing the dairy industry is figuring out how best to help producers get cows pregnant.

For Michigan State University (MSU) AgBioResearch scientist George Smith, the first step to understanding the root cause of infertility in dairy cows — and in humans — is to figure out the factors and mechanisms that make it difficult for them to conceive. His work is focused on studying the egg at the cellular level. Understanding the root of the problem, Smith believes, paves the way for developing approaches to addressing infertility problems.

"A growing body of evidence in literature supports the idea that problems with egg quality contribute to poor reproductive performance in dairy cattle," explained Smith, a professor in the MSU Department of Animal Science. "What we're interested in learning is what makes a good egg a good egg and a bad egg a bad egg, how to tell the difference, and what factors have to be optimal to produce healthy, viable offspring at term and beyond.

"This is where the application to human health comes into play," Smith added. "A major cause of infertility in women, especially those of advanced age, is poor quality ooctyes."

In human reproductive clinics, clinicians collect as many eggs as possible from patients, though only a small number are transferred or implanted in the woman's uterus. This can lead to couples having a surplus of fertilized embryos left frozen in storage after pregnancy is achieved.

"Better quality eggs produce better quality embryos to transfer," Smith said. "If there were ways that we could select for the best quality eggs before fertilization takes place, it may

PHOTO: MICHIGAN DAIRY NEWS BUREAU

Advances in reproductive technologies will help dairy producers increase conception rates, taking them one step closer to minimizing infertility and maximizing milk production in their herds.

result in greater pregnancy success and alleviate some of the moral and ethical challenges associated with having to store extra fertilized embryos indefinitely."

Numerous procedures used today in assisted reproduction clinics for humans were developed using farm animals, and experimental models where egg quality is compromised already exist using cows. Cows serve as a good model for studying reproduction in humans. Both humans and cows, for example, release one egg during each reproductive cycle; mice release several. The hormonal composition of the egg and the reproductive timeline (gestation length) in both cows and humans are also similar.

Tremendous opportunities exist for the practical application of enhanced reproductive technologies in humans, as well as in the dairy and beef cattle industries.

In the context of human infertility, the advancing age of people seeking to get pregnant is an issue, Smith said.

"The sociological trend to wait until later in life to have children is growing, so the magnitude of the problem is increasing," he said. "Fundamental research is needed to come up with ways to make it more effective for older people to have children, and the challenge is not going away."

In the dairy and livestock industries, not only will advances in reproductive technologies help producers achieve higher conception rates in traditional commercial herds, but the findings may also enhance success rates in the bovine embryo transfer and in vitro fertilization fields.

Smith asserts that there is utility in pursuing combinations of approaches when dealing with complicated biological problems such as infertility in dairy cattle. One is taking the tools and information that's already available and trying to develop new approaches and strategies to solve problems. The other is stepping back and understanding the problem at a fundamental level that allows you to more effectively solve that issue.

> **"What we're interested in learning is what makes a good egg a good egg and a bad egg a bad egg . . ."** ● GEORGE SMITH

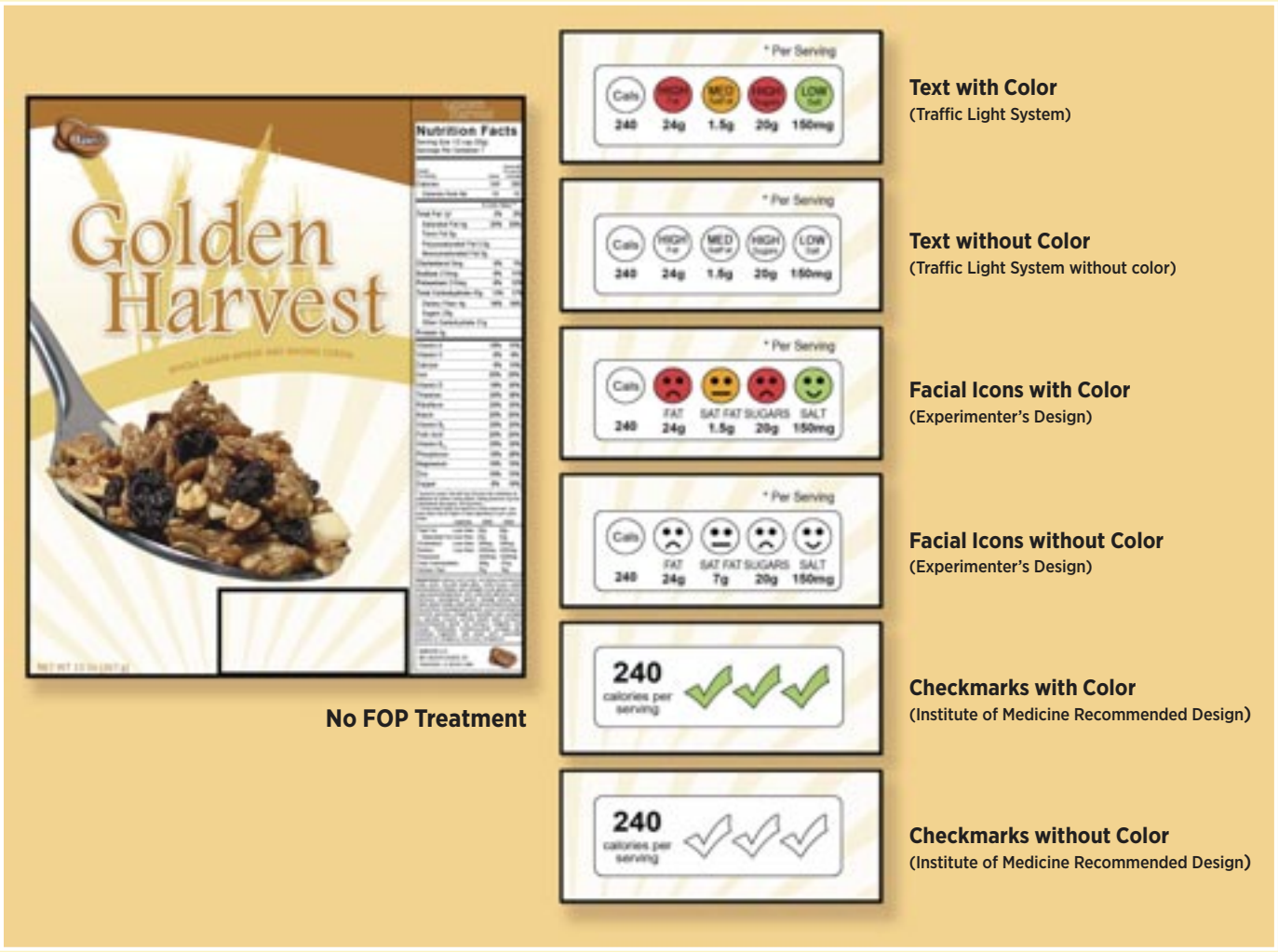
"This is the power of basic research: to understand and solve complex problems," Smith said. "It also validates the need for using farm animals to conduct this basic research that can, in turn, be translated long-term into new technologies and practices to achieve reproductive efficiency and productivity in agriculture and a better understanding of infertility problems in humans." ●

families and community vitality

Healthy, vital communities with an active citizenry are well-equipped to address the challenges facing many of today's families.

Whether it's research that seeks to improve medical packaging and nutritional labeling, develop better strategies to raise emotionally competent children, address the more global issues of effectively communicating health and environmental risks or protect populations from diseases such as dengue fever, Michigan State University AgBioResearch scientists are helping people learn and make healthy, well-informed choices. The projects highlighted in this section are just a sample of the work being done in this priority area to benefit both Michigan residents and people worldwide.

[Packaging up a **new approach** to **healthcare improvement**]



Various types of front-of-package (FOP) labeling systems, such as the ones shown here, are being studied at MSU. Some of the systems utilize smiling and frowning faces; others are based on a traffic-light color scheme and a check-off program. Researchers are examining how people respond and react to the different types of labels in an effort to improve healthcare in particular.

Medical errors cause the death of as many as 98,000 Americans each year at an estimated cost of $20 billion, according to the Institute of Medicine. Michigan State University (MSU) AgBioResearch scientist Laura Bix is spearheading research on medical packaging with the overall goal of improving healthcare.

"If packaging is difficult to manipulate or comprehend in the first place, any problems will certainly be intensified during an emergency situation," said Bix, an associate professor in the MSU School of Packaging. "To alleviate error potential, we look at aspects of design that are traditionally driven by branding and/or production needs, and examine them scientifically to determine how they influence behavior."

Bix said her advancements are the result of collaboration taking place across MSU.

"We partner with Mark Becker from cognitive psychology to understand perceptual issues and with Tamara Reid-Bush from mechanical engineering to look at biomechanics and how design influences the ability to aseptically present in a sterile field," she said. "We also partner with the Learning Assessment Center — a joint venture between the MSU colleges of Human Medicine, Nursing, Osteopathic Medicine and Veterinary Medicine — where they can simulate an emergency medical situation in a state-of-the-art facility. This enables us to look, in a very realistic context, at perceptive and physical behaviors and how they may have fallout for patient health."

"If packaging is difficult to manipulate or comprehend in the first place, any problems will certainly be intensified during an emergency situation." • LAURA BIX

Another area of emphasis has been on front-of-package (FOP) nutrition labeling. Bix and a host of collaborators are gauging the consumer responsiveness to a traffic light system used primarily in Europe to convey nutritional content. FOP systems are a truncated version of the standard nutrition facts panel. They display information about certain components of a product such as sugar, fat and salt often associated with health conditions such as diabetes, heart disease and hypertension. Green lights suggest foods low in these components, while amber denotes moderate levels and red indicates high amounts. State-of-the-art technology is used to observe how people respond to the labeling.

"We use tools from cognitive psychology such as eye tracking and change detection to examine, from a fundamental platform, how people are behaving," she said. "Are they attending to the information — whether the design or color influences their attention, and how profoundly might it influence attention, if at all."

In addition to color, the study is also gauging the effectiveness of a system utilizing icons with different facial expressions. A smiling face designates low levels of salt, sugar and fats; a straight mouth signifies moderate levels; and a frown denotes high levels.

"There's literature from psychology that suggests that faces are immune to something called inattentional blindness or attentional blink, which means that, because the world is so vast, there are tons of things we're filtering out," Bix explained. "There is research that suggests that we have neural pathways in our heads devoted to attending faces. If that's true, then we are asking, 'Can people ignore these face icons in terms of the aspects of their food and nutrient content?'"

Incorporating tools from cognitive psychology, such as eye tracking, can provide insight into why people are behaving a certain way, Bix said. Some of the key label features measured are design and color.

But ease of use isn't just about eye-catching and understandable labels. It's about the opening of packages as well.

"Manufacturers tend to be good at minimizing materials and maximizing their ability to produce; they don't always put the same level of thought into how to enable the user," she said.

Bix believes that packaging has the potential to generate significant payoffs for the healthcare field.

"There are huge problems in healthcare that are costly not only in terms of death and illnesses but also finance," she said. "Many people are doing a lot of very good work, but there hasn't been much of a focus on packaging. If we can help enable the healthcare provider to present items to the sterile field in a way that they remain sterile, that is one less avenue for infection to occur."

Medication errors are an area receiving more attention than packaging, Bix said.

"Look-alike, sound-alike names have been studied to a great degree, and a lot of people have dabbled in ways to mitigate medication error," she said. "But I think packaging is an area very rich for improvement because of its contribution to this problem. There aren't many — if any — people in the world specifically focusing on packaging as an avenue to reduce medication errors."

Bix said that being involved at the ground level in research that helps to improve healthcare is rewarding.

She dreams of a day when a new facility focused entirely on healthcare is established.

"In an ideal world, I'd like to see us form some sort of center around issues involving healthcare and healthcare engineering," she said. "We have a really unique situation on the MSU campus. The resources we already have should be brought to bear on problems that have not yet been widely studied. I'd really like to see some of the seeds that we have planted, grow and bloom." •

[Developing **strategies** to **raise emotionally competent kids**]

Sam stands in line for a drink of water. His cheeks are flushed and his mouth is so dry that it's difficult to swallow. Finally, it's his turn. As he approaches the fountain, the teacher calls the students back to their seats. How will Sam react?

Keeping emotions in check can be difficult at any age, but especially for young children. Michigan State University (MSU) AgBioResearch scientist Holly Brophy-Herb is working to identify strategies to help parents teach young children to express and manage their emotions in effective ways. One key finding is that children learn important emotional cues early in life.

PHOTO: ISTOCKPHOTO/CEFUTCHER

Studies show that toddlers learn to manage their emotions and behaviors early in life, in large part from their parents. Those unable to keep their emotions in check are more likely to struggle in school.

"Our research is the first of its kind to examine multiple emotion socialization strategies that parents use with infants and toddlers," said Brophy-Herb, an associate professor in the MSU Department of Human Development and Family Studies. "That's especially important because children start to discern messages about how to handle emotions in infancy. There are many ways that parents — both indirectly and directly — teach their young children about how and when to express their emotions."

Brophy-Herb and her colleagues are interested in the types of emotional socialization strategies that parents use during everyday situations such as mealtimes and parent-child play.

Brophy-Herb said a child's inability to manage emotions is likely to have negative effects socially and academically. Studies show that children who lack self-regulation skills — the ability to manage emotions and behaviors — have a more difficult time in peer interactions and are more likely to have school adjustment problems and less than optimal academic outcomes.

Parents who label an emotion and reference the cues of that emotion — such as "Oh, he's sad. Do you see his tears? He's crying." — equip their children to manage their feelings and to develop self-regulation skills over time, Brophy-Herb said.

"When that type of language is used with toddlers and preschoolers, children have an easier time recognizing emotions – their own and those of others," she said. "Not only do they begin to gain the language to label those emotions, they are also learning about the context in which emotions occur and cues associated with certain emotions. Over time and with parental support, this knowledge grows to include multiple strategies for expressing emotions and responding effectively to the emotional expressions of others."

Parents serve as role models. Their actions and reactions, especially during emotionally charged situations, are particularly influential.

"These all contribute to the child's ability to self-regulate, especially in situations when emotions run high," said Brophy-Herb. "In general, parents do a pretty good job of dealing with

children's happy emotions, but it's more difficult to know how to handle more extreme emotions such as sadness, anger or jealousy. The way parents react to their child's emotions — whether we want it to or not — teaches them about how to express emotions."

> **"There are many ways that parents — both directly and indirectly — teach their young children about how and when to express their emotions."** • HOLLY BROPHY-HERB

Brophy-Herb is investigating how emotional socialization differs from one racial and cultural group to the next. She is examining Hispanic/Latino, African American and Euro-American families to find out how language about emotion and conceptualizations about emotion socialization may differ across groups.

Income is another factor that Brophy-Herb is gauging in her studies.

"Our data clearly shows very sophisticated forms of parenting in families struggling with multiple risks due to a lack of economic resources," Brophy-Herb said. "There is a stereotype that low-income parents are not sophisticated in their parenting, but we have videotape after videotape of lovely emotion socialization strategies used by parents of infants and toddlers despite challenging economic circumstances. We value the strengths-based approach in our work and want to contribute to a focus on resilience in at-risk families in the field."

The ultimate goal is setting children on a positive path, Brophy-Herb said. In the near future, she plans to focus further research on the emotional impact of fathers.

"There are more dads who are primary caregivers than ever before, and fathers — whether primary caregivers or not — play a vital role in their children's development," she said. "There's also more freedom, I think, for men to talk about emotions than ever before. So that's certainly something we're really interested in learning more about — how do dads think about emotions and how do they socialize emotions in their sons and daughters?" •

[Diving deep to understand health and environmental risk communications]

If you think diving with sharks sounds like an adventure, you most likely are part of a group that is the focus of Michigan State University (MSU) AgBioResearch communication scientist Maria Lapinski's work. Her research involves projects designed to better understand how people communicate about health and environmental risks. One of her latest projects is trying to understand how risks are promoted on shark diving websites and what kinds of people are most likely to be motivated to take the risk of diving with sharks. This is important because it helps researchers understand why people take risks.

"The people who do shark diving are likely to be high sensation seekers," said Lapinski, an associate dean for research in the MSU College of Communication Arts and Sciences. "We wanted to understand how risks are being promoted with shark diving because that helps us understand why people actually take risks and how you design messages for high sensation seekers."

She and colleague Meredith Gore, who has a joint appointment in the MSU Department of Fisheries and Wildlife and the School of Criminal Justice, and a team of student researchers did content analysis of shark diving websites to look at the extent to which the sites explicitly explained the risks of sharks to humans and the ways in which emotion was addressed on the sites.

"The websites do not do much explicit promotion of sharks as scary animals or explaining the risk of diving with sharks," Lapinski said. "They focused on the positive emotions or potential positive emotional outcomes of shark diving, such as bonding with sharks. People already have the perception of danger, so the websites don't have to talk about it."

Lapinski believes that, for people who do high-risk activities that take planning and preparation, there is a level at which they want to believe that it is dangerous and that not everyone can do it.

"We wanted to understand how risks are being promoted with shark diving because that helps us understand why people actually take risks and how you design messages for high sensation seekers." • MARIA LAPINSKI

PHOTO: ISTOCKPHOTO/QLDIAN

For many adventure travelers, diving with sharks is the ultimate trip. Risk communications researchers are studying messages used to promote shark diving to better understand why people take risks.

"They don't believe they are going to die, however," she added. "We are calling it a susceptibility threshold. How probable is it that some negative event will happen to you?"

Another example of Lapinski's work under the umbrella of health and risk communication involved food safety risks at a group of childcare centers that identified where contamination could happen and then developed training materials to help childcare providers avoid it.

"Our study found that hand-washing practices at these facilities could be improved, both when people wash as well as the quality of their washing," Lapinski said. "In addition, we discovered — somewhat to our surprise — that childcare providers are influenced by the children they care for as well as other daycare workers. It is important for them to do their best because of the kids. That was an important consideration as we designed an intervention to help improve hand washing."

The three-phase project mainly focused on bacterial and viral contamination because those pathogens are believed to be the most common in childcare centers. In phase one, the researchers took microbial swabs at the centers — no dangerous levels were found — and interviewed center workers and directors. They also observed workers, watching how often they washed their hands and the quality of their hand washing. In phase two, an agent-based risk assessment model was developed to examine points of intervention.

With the knowledge that providers cared so much about the children under their care, and the other findings from the research, the team came up with "a really innovative" intervention where the childcare providers teach the kids how to wash hands using a five-day curriculum that includes songs, games and activities.

"The best way to learn is by teaching someone else," Lapinski said. "The reality is that childcare providers do an amazing amount of work to keep kids safe. We don't want to add a burden, but if there are opportunities to make things

safer, it makes sense to do that."

A final area in Lapinski's overarching interest in risk communication is how cultural and social norms fit into this process. Lapinski was part of an interdisciplinary MSU team, led by Folu Ogundimu from the MSU School of Journalism, that investigated the cultural and social factors influencing whether people living in northern Nigeria did or did not get a polio vaccine for their children.

"This project was interesting because when and why people do or don't get the vaccine is a complicated social dynamic fed by a series of events that have influenced people's perceptions of the safety of the vaccine," Lapinski said.

She also teaches courses on risk communication and health communication for diverse populations. Her enthusiasm is infectious, and students like the real-world examples that her research provides.

"I am fortunate that I can teach and research on the same topic," she said.

Lapinski sees risk communication on health and environmental issues becoming increasingly important as the globe "shrinks" and countries and cultures become more integrated.

"Both health and environmental risks are increasingly becoming global, making understanding the social and cultural dynamics of these issues critical for effective communication about them," she said. ●

[Halting an **infectious disease**]

PHOTO: JAMES GATHANY, CENTERS FOR DISEASE CONTROL

The *Aedes aegypti* mosquito *(above)* can spread dengue fever and other tropical diseases. Only the female bites for blood, which she needs to mature her eggs.

Dengue fever is among the most important reemerging infectious diseases, with an estimated 50 million to 100 million cases around the globe annually that lead to more than 20,000 deaths, according to National Institutes of Health (NIH) data. It's caused by a virus transmitted by mosquitoes, and there is no vaccine or treatment. Research by Michigan State University (MSU) AgBioResearch entomologist Zhiyong Xi has found that a bacterium can stop dengue viruses from replicating in mosquitoes and could have ramifications with other mosquito-borne diseases.

"Breaking the link between the mosquito vector [carrier] and the dengue virus is the best option for protecting people," said Xi, an assistant professor in the MSU Department of Entomology, who specializes in medical entomology. "In nature, about 28 percent of mosquito species harbor *Wolbachia* bacteria, but the mosquitoes that are the primary transmitters of dengue fever, *Aedes aegypti*, have no *Wolbachia* in them. We found that *Wolbachia* is able to stop the dengue virus from replicating. If there is no virus in the mosquito, it can't spread to people, so disease transmission can be blocked."

Dengue fever is rare in the continental United States, but in

"Breaking the **link between the mosquito vector** [carrier] and **the dengue virus** is the **best option for protecting people.** If there is **no virus in the mosquito, it can't be spread to people,** so disease transmission can be blocked." • ZHIYONG XI

2010 there was a dengue outbreak in Florida — the first time dengue had shown up in the continental United States since 1934. Overall, about two-fifths of the world's population is at risk of contracting dengue fever, and up to 100 million people are infected each year (NIH). Most people recover in about two weeks, but the infection can turn into dengue hemorrhagic fever, which causes bleeding from the nose and gums and can be fatal.

Aedes aegypti is often called the yellow fever mosquito and can spread not only dengue fever but also Chikungunya (a viral disease that causes severe joint pain and fever), yellow fever viruses and other diseases. The mosquito can be recognized by white markings on its legs and a lyre-shaped marking on the thorax. It originated in Africa and is now found in tropical and subtropical regions throughout the world.

Xi's lab uses a number of functional genomics tools to dissect interactions among dengue viruses, *Wolbachia* and mosquito hosts to understand the mechanism of *Wolbachia*-mediated resistance to dengue virus and develop novel genetic strategies for blocking disease transmission in mosquitoes.

"Only when we know the mechanisms underlying the *Wolbachia*-mediated viral interference will we be able to determine why it's happening and further improve the efficiency of the viral interference," he said.

Xi and his colleagues introduced the *Wolbachia* bacterium into *Aedes aegypti* mosquitoes by injecting mosquito embryos with the parasite. They have been able to maintain the bacterium in the mosquitoes in the lab for nearly 7 years because it is passed from mothers to offspring.

When a *Wolbachia*-infected male mates with an uninfected female, the bacterium causes a reproductive abnormality that triggers early embryo mosquito death, called cytoplasmic incompatibility (CI).

"*Wolbachia* doesn't affect embryo development when a female mosquito contains the same *Wolbachia* as a male, so the bacterium can spread quickly, infecting an entire mosquito population," Xi said. "However, the *Wolbachia* bacterium can't be passed from mosquitoes to humans."

The research team, including research associates Guowu Bian and Xiaoling Pan, has deciphered how *Wolbachia* infection affects the *Aedes aegypti* host in inducing resistance to dengue fever. They are working to identify factors that enable *Wolbachia*-based population replacement to succeed in a way that reduces vector capacity to dengue virus.

"The ability of *Wolbachia* to boost immunity and block dengue proliferation in a newly acquired host, *Aedes aegypti*, makes it a potential mosquito vaccine, which could be used efficiently to prevent pathogen transmission," Bian said.

In Pan's recent work, she further discovered how *Wolbachia* activates mosquito immunity and which molecular effectors induced by *Wolbachia* can kill dengue virus.

The team is also doing more investigation of CI. The long-term goal of this research is to understand the links between *Wolbachia* and its host which results in the occurrence of CI. That research could break new ground and lead to solutions for other diseases.

This year, Xi developed the Sun Yat-sen University–Michigan State University Joint Center of Vector Control for Tropical Diseases in China. As a director, Xi will test the *Wolbachia*-based approach for dengue control in field sites.

These projects have huge public health relevance, Xi said.

"The anticipated findings from our research will aid in the development of improved genetic methods to block the transmission of mosquito-borne infectious diseases, including not only dengue fever but also malaria and West Nile virus," he said. •

AgBioResearch Staff

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John C. Baker — Associate Director

Bev Riedinger — Business and Finance Manager

Jackie DeSander — Administrative Assistant

Linda Estill — Executive Staff Assistant

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Val Osowski — Communications Manager

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AgBioResearch Unit Administrators

(UNITS RECEIVING FUNDING)

As of 10-1-2011

Jeffrey Richards, Chairperson
Advertising, Public Relations and Retailing

Steven D. Hanson, Chairperson
Agricultural, Food and Resource Economics

Janice Swanson, Chairperson
Animal Science

Thomas D. Sharkey, Chairperson
Biochemistry and Molecular Biology

Ajit K. Srivastava, Chairperson
Biosystems and Agricultural Engineering

Martin C. Hawley, Chairperson
Chemical Engineering and Material Science

Charles K. Atkin, Chairperson
Communication

David E. Wright, Chairperson
Community, Agriculture, Recreation and Resource Studies

Edmund F. McGarrell, Director
Criminal Justice

James J. Kells, Chairperson
Crop and Soil Sciences

Ernest S. Delfosse, Chairperson
Entomology

Michael L. Jones, Chairperson
Fisheries and Wildlife

Frederik Derksen, Chairperson
Food Science and Human Nutrition

Richard Kobe, Chairperson
Forestry

Richard E. Groop, Chairperson
Geography

W. Vance Baird, Chairperson
Horticulture

Karen S. Wampler, Chairperson
Human Development and Family Studies

Katherine L. Gross, Director
Kellogg Biological Station

Charles J. Reid, Director
Land Management Office

Raymond J. Geor, Chairperson
Large Animal Clinical Sciences

Walter J. Esselman, Chairperson
Microbiology and Molecular Genetics

Joseph H. Hotchkiss, Director
School of Packaging

Jill McCutcheon, Chairperson
Pathobiology and Diagnostic Investigation

David Kreulen, Acting Chairperson
Physiology

Richard E. Triemer, Chairperson
Plant Biology

Raymond Hammerschmidt, Chairperson
Plant Pathology

Michael F. Thomashow, Director
Plant Research Laboratory (MSU-DOE)

Gary R. Anderson, Director
School of Social Work

Raymond Jussaume, Chairperson
Sociology

Charles Steinfield, Chairperson
Telecommunications, Information Studies and Media

Jon F. Bartholic, Director
Institute of Water Research

[AgBioResearch Centers]

1 CLARKSVILLE RESEARCH CENTER

9302 Portland Road
Clarksville, MI 48815
Phone: 616-693-2193
Farm Manager: Jerry Skeltis

2 DUNBAR FOREST

12839 S. Scenic Drive
Rt. 1, Box 179
Sault Ste. Marie, MI 49783
Phone: 906-632-3932
Non-resident Forester: Ray Miller

3 FRED RUSS FOREST

20673 Marcellus Highway
Decatur, MI 49045
Phone: 269-731-4597
Non-resident Forester: Greg Kowalewski

4 LAKE CITY RESEARCH CENTER

5401 W. Jennings Road
Lake City, MI 49651
Phone: 231-839-4608
Farm Manager: Doug Carmichael

5 MONTCALM RESEARCH CENTER

4629 W. McBrides Road
Lakeview, MI 48850
Phone: 989-365-3473
Farm Manager: Bruce Sackett

6 MSU FOREST BIOMASS INNOVATION CENTER

6005 J Road
Escanaba, MI 49829
Phone: 906-786-1575
Farm Manager: Ray Miller

7 MUCK SOILS RESEARCH CENTER

9422 Herbison Road
Laingsburg, MI 48848
Phone: 517-819-8828
Farm Manager: Mitch Fabus

8 NORTHWEST MICHIGAN HORTICULTURAL RESEARCH CENTER

6686 S. Center Highway
Traverse City, MI 49684
Phone: 231-946-1510
Farm Manager: Bill Klein

9 SAGINAW VALLEY RESEARCH AND EXTENSION CENTER

3775 S. Reese Road
Frankenmuth, MI 48734
Phone: 989-652-8014
Farm Manager: Paul Horny

10 SOUTHWEST MICHIGAN RESEARCH AND EXTENSION CENTER

1791 Hillandale Road
Benton Harbor, MI 49022
Phone: 269-944-1477
Farm Manager: Dave Francis

11 TREVOR NICHOLS RESEARCH CENTER

6237 124th Avenue
Fennville, MI 49408
Phone: 269-561-5040
Farm Manager: Matt Daly

12 UPPER PENINSULA RESEARCH CENTER

P.O. Box 168
E3774 University Drive
Chatham, MI 49816
Phone: 906-439-5114
Farm Manager: Paul Naasz

13 W. K. KELLOGG BIOLOGICAL STATION

3700 E. Gull Lake Drive
Hickory Corners, MI 49060
Phone: 269-671-5117
Assistant Director for Facilities and Operations: Phil Barry

14 W. K. KELLOGG EXPERIMENTAL FOREST

7060 N. 42nd Street
Augusta, MI 49012
Phone: 269-731-4597
Resident Forester: Greg Kowalewski

★ SOUTH CAMPUS FIELD RESEARCH FACILITIES

246 Spartan Way
Michigan State University
East Lansing, MI 48824-3005
Phone: 517-355-3272
Director: Charles J. Reid

[Publications and Resources]

AgBioResearch encompasses the work of more than 300 scientists in six colleges at MSU: Agriculture and Natural Resources, Communication Arts and Sciences, Engineering, Natural Science, Social Science and Veterinary Medicine.

This **identity brochure**, which provides an introduction to AgBioResearch and the breadth and relevance of its work, is available upon request by sending an email to: **info@agbioresearch.msu.edu.**

The **AgBioResearch centers brochure** highlights each of the 14 outlying research centers and their specific research. These centers focus on the research needs of the agricultural and natural resources industries and rural communities in their part of the state. Projects range from work on forestry and cellulosic ethanol in the Upper Peninsula to cherries in Traverse City, and from wine and juice grapes on the west side of the state to dry beans and sugar beets in the Thumb. One of the facilities, the W.K. Kellogg Biological Station in Hickory Corners, Mich., conducts extensive research on sustainability and other environmental issues.

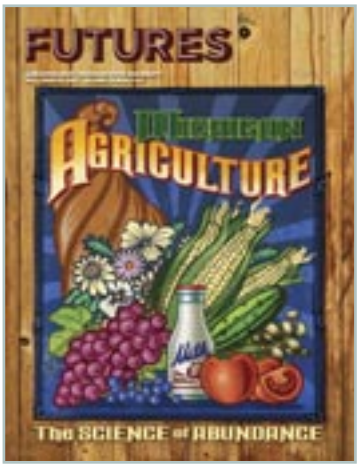
This brochure is available upon request by sending an email to: **info@agbioresearch.msu.edu.**

So what have we done for you lately? This **2011 AgBioResearch Annual Report** delivers brief narratives on some of the year's most innovative research and provides a glimpse of how world-class science is enhancing people's quality of life in Michigan and beyond.

Published twice annually, **Futures** is a free, reader-friendly publication that provides a thematic, in-depth look at research that is applying practical, real-world science in ways that help boost Michigan's economy, sustain the state's natural resources and enhance people's quality of life. Recent issues have focused on AgBioResearch partnerships and Michigan agriculture.

The Art of Partnership: Leading Innovation through Collaboration
Spring/Summer 2011

Partnerships are the lifeblood of many institutions. Whether in marriage, business, sports or academia, teamwork and collaboration are the cornerstones of success, providing mutual benefit and outcomes that wouldn't otherwise be possible. In this issue of *Futures*, you can read about some of the innovative partnerships that undergird the important research being done to generate economic prosperity, sustain natural resources and enhance the quality of life in Michigan, the nation and the world.



Michigan Agriculture: The Science of Abundance
Fall/Winter 2011

Michigan ranks No. 2 in the nation in agricultural diversity, second only to California. The challenges faced in maintaining this world-class diversity underscore the importance of providing the state's agricultural producers with the research and information they need. In this issue of *Futures*, you can read about Michigan's five major commodity groups and how AgBioResearch scientists are rolling up their sleeves and working hand-in-glove with farmers to ensure that the state's commercial agriculture remains profitable and sustainable.

[Publications and Resources CONTINUED]

A complement to our magazine and annual report, the **AgBioResearch quarterly e-Newsletter** brings timely news on leading-edge research, events and other information to keep you in the know.

You can subscribe to this free publication by sending an email to: **info@agbioresearch.msu.edu.**

Ever wonder what AgBioResearch is doing in your area? Sign on to our research center page — **http://www.agbioresearch.msu.edu/research_centers.html** — select the research center you are interested in, and then click on "InfoVideos" to learn about topics including tart cherry research, bean and beet research, planting and harvesting techniques, and the latest in biofuels development.

Check out our recently redesigned website at **www.agbioresearch.msu.edu.**

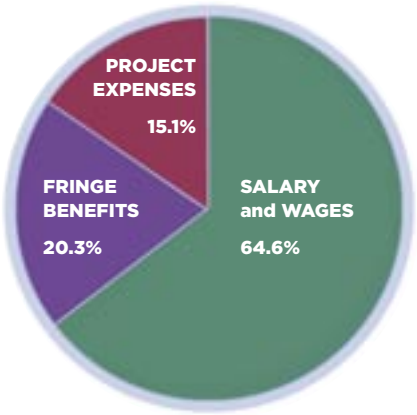
Features on the site include:

- An AgBioResearch overview
- Research center information
- News and events
- AgBioResearch publications and reports
- An AgBioResearch searchable projects database
- Resource links to MSU, government, commodity groups, Michigan agriculture and natural resources organizations, and more!

[Financial Report]

7-1-2010 to 6-30-2011

DISTRIBUTION OF APPROPRIATED FUNDS



INCOME:

Federal Appropriation		
Hatch	$	4,701,208
McIntire-Stennis	$	475,122
Hatch RRF	$	1,137,735
Hatch Animal and Disease, Section 1433	$	62,260
Total Federal Appropriations	$	6,376,325
State Appropriations	$	33,243,100
Total Appropriations	$	39,619,425
Grant — Federal, State and Private*	$	70,762,424
TOTAL INCOME	**$**	**110,381,849**

EXPENSES:

Salaries	$	25,605,729
Fringe Benefits	$	8,032,886
Project Expenses	$	5,980,810
Grants — Federal, State and Private*	$	70,762,424
TOTAL EXPENSES	**$**	**110,381,849**

PERSONNEL:

(Full-time Equivalents Funded From Appropriated Funds)

Research Staff	
Professors	68.33
Associate Professors	31.75
Assistant Professors	24.60
Research Associates and Specialists	7.94
TOTAL RESEARCH STAFF**	**132.62**
Support Staff	
Administrative Professionals	65.11
Supervisors	25.61
Clerical	20.08
Technicians	3.01
TOTAL SUPPORT STAFF	**113.81**

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

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

[Production Credits]

Managing Editor
Val Osowski, Communications Manager, AgBioResearch

Writers
Val Osowski, Holly Whetstone, Communications Managers, AgBioResearch
Jane L. DePriest, DePriest Enterprises, East Lansing, Michigan
Sara Long, Write Way Creative, LLC, Elsie, Michigan

Copy Editor
Leslie Johnson, MSU ANR Communications

Cover Illustration
Andrew Ward, New Media Graphics
Burton, Michigan

Photography
Randy Beaudry
Anthia Cumming via iStockphoto
Jane L. DePriest
Kirk Dolan lab
Fall Creek Farm and Nursery, Inc.
Jenifer Fenton
CEFutcher via iStockphoto
Mike Gangwer
James Gathany
Dan Grooms
Jay Hao
Shannon Henderson
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Carolyn Malmstrom
Michigan Dairy News Bureau
C.S. Mott Group at MSU
Qldian via iStockphoto
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Raghav Sundar
Erin Taylor

Graphic Design and Production
Christine Altese, Altese Graphic Design
Lansing, Michigan

Printing
Lawson Printers
Battle Creek, Michigan