THE SCIENCE BEHIND GMOS

GMOs 101:
What are they and why should you care?

WALKING THE TIGHTROPE:
Tips on talking about GM crops

TO LABEL OR NOT:
Exploring regulatory processes
This issue of Futures is just the start of our focus on GMOs. Food@MSU, an initiative led by the College of Agriculture and Natural Resources that aims to spark meaningful conversations on food and where it comes from, plans to host an Our Table discussion on GMOs this fall. As usual, the public will be invited to attend, listen and ask questions. Details of the gathering will be announced on the food.msu.edu website later this summer.

The photo to the left reflects the reality that over the years there has been a sustained barrage of conflicting comments and enough information and misinformation to confuse even the most savvy consumer about GMOs.
GMOs 101: A primer to help understand the basics about GMOs.

Are GMOs safe?: Exploring the safety of genetically modified foods.

Walking the GMO tightrope: Communicating effectively on a divisive subject.

The GMO debate: Are GMOs the surrogate for the debate about agriculture?

To label or not?: Navigating current laws and initiatives on GMO labeling.

Researcher Q&A: Get to know director of agriculture & agribusiness programming, Ron Bates.

Superweeds: Examining the concerns about superweeds, secondary pests and biodiversity.

Resistance: The past, the present and possible future of resistance to pesticides.

On the Horizon: Short articles about gene editing, and GMO fed livestock.

Growing new soybeans for Uganda: GMOS could help smallholder farmers.

Kurt Stepnitz retires: Long-time Futures & MSU photographer Kurt Stepnitz retires.

Opinion: High time for scientists to look in the mirror.
“I believe the scientific community can help bridge the disconnect between consumers and farming.”
Covering GMOs is long overdue

As editor of *Futures* magazine for the past six years, I hate to admit that this is the first time we’ve delved deeply into the issues related to genetically modified organisms (commonly called GMOs). It’s long overdue. Sure, we’ve written stories about GMOs in the past, but we’ve never dedicated an entire issue to this highly charged topic. “So,” you may be asking yourself at this point, “Why now?”

A 2017 study from the Center for Food Integrity revealed that the vast majority (80 percent) of consumers want to know more about their food and where it comes from, but lack a direct connection to agriculture. Increased population growth is physically moving more people in our society away from farms and into more urban, more populous places. The result has been fewer connections between consumers and the farms where their food is produced.

I believe the scientific community can help bridge the disconnect between consumers and farming. But there’s a problem: the public doesn’t particularly trust scientists. In the first MSU Food Literacy and Engagement Poll, conducted in 2017, only 59 percent of respondents indicated that they trusted academic scientists when it comes to the health and safety of food. That’s higher than their counterparts in government (49 percent) and industry (33 percent) received, but still discouragingly low.

Science-related publications such as *Futures* can and should help share scientific data in ways consumers can easily grasp and understand – especially on such important issues as GMOs. At the same time, I won’t pretend that covering this topic doesn’t make me uncomfortable, because it does. The scientific community must do a better job of listening and engaging in productive, nonconfrontational discussions about GMOs. I hope this issue of *Futures* will be the start of that effort.

Ironically, as our team was in the throes of researching and writing the issue, the news broke that “Bill Gates calls GMOs ‘perfectly healthy’ – and scientists say he’s right.” The story sparked a flurry of conflicting comments and enough information and misinformation to confuse even the brightest consumers. It also made me wonder “Is this really the right time for us to discuss GMOs in these pages?” Eventually I was convinced anew that this is the right time. We’ve put this off long enough.

This issue of *Futures* is just the start of our focus on GMOs. Food@MSU, an initiative led by the College of Agriculture and Natural Resources that aims to spark meaningful conversations on food and where it comes from, plans to host an Our Table discussion on GMOs this fall. As usual, the public will be invited to attend, listen and ask questions. Details of the gathering will be announced on the food.msu.edu website later this summer.

Until then, I welcome your feedback on this issue – I think.

Holly M. Whetstone
Start talking about food and where it comes from and there’s a good chance that the conversation will eventually get around to genetically modified organisms, or GMOs. Questions also arise (“What is a GMO?” “Are GMOs safe for my family and the environment?” “Are GMOs necessary?”), with little consensus as to the answers.

Getting down to basics:

By Cameron Rudolph, Writer
AN ONLINE SEARCH FOR “GMO” RETURNS MORE THAN 88 MILLION RESULTS — A TANGLED MESS OF FRIGHTENING IMAGES, DENSE DATA, SKEPTICISM, INSULTING COMMENTS, AND CONFLICTING CLAIMS AND COUNTERCLAIMS. FOR THE AVERAGE CONSUMER, SEPARATING REPUTABLE SOURCES FROM PROPAGANDA IS TOUGH, IF NOT IMPOSSIBLE.

In 2017, researchers with Michigan State University’s Food@MSU initiative conducted the first nationwide Food Literacy and Engagement Poll. They asked more than 1,000 consumers about their knowledge of and opinions related to our food system, and of the science behind it.

When asked whether they thought the statement “Genetically modified foods have genes and non-genetically modified foods do not,” was true or false, 37 percent of respondents said they believed it was true. In fact, all food contains genes. The average plant, for example, has 20,000 to 45,000 genes, while humans have about 20,000 genes (according to a 2014 article in The Scientist magazine).

Respondents were also asked to rate how much they trust scientists when it comes to the health and safety of food. Academic scientists fared best, earning the trust of 39 percent of respondents, with governmental scientists in the middle at 49 percent and industry scientists trusted by only 33 percent.

In a 2016 Pew Research Center survey of more than 1,400 U.S. adults, 39 percent of respondents reported that they believe genetically modified foods are worse for health than non-GM foods, 10 percent indicated that GM foods are better for health than non-GM foods; and 48 percent responded that GM foods were neither better nor worse for health than non-GM foods. This indicates that a significant portion of the public is either neutral on the issue of GM foods or doesn’t know what to think. This result is somewhat surprising, given that media reports often indicate that no one is undecided about the GMO controversy.

WHAT IS A GMO?

Even the answer to the question “What is a GMO?” can be controversial. At its most basic, genetic modification is the process by which changes occur in an organism’s genome. Nature is perpetually modifying the genetics of every organism in an effort to help the organism adapt to its changing environment.

The most debated topic related to GMOs is whether they threaten the health of humans or the environment.

“It’s important to understand that all organisms — not just those that are the basis of foods — are genetically modified in some way, shape or form,” said Brad Day, a professor and associate department chair for research in the MSU Department of Plant, Soil and Microbial Sciences. “They are genetically modified by persisting in the environment. Radiation from the sun can induce changes in the genome, for example.”

More than 30,000 years ago, humans realized they could have a hand in the process of modifying genes when they domesticated and began selectively breeding wolves to ensure the animals passed along specific characteristics (such as docility, fur color, tracking ability, size or protectiveness). This practice set the stage for contemporary dog breeding. Humans have bred plants for thousands of years, too, in an effort to ensure the survival of desirable traits.

While conventional selective breeding methods are still the most common, the newer biotechnology techniques used to create GMOs are actually rooted in genetic engineering. Scientists use biotechnology to insert one or more genes from one organism into another to give the second organism the specific trait controlled by the transferred gene or genes.

Adding a gene that promotes drought resistance, for instance, may permit farmers to grow a crop in a nontraditional region of the world or in an area with dwindling water resources.

In 1973, Herbert Boyer and Stanley Cohen created the first genetically engineered organism — E. coli bacteria that had the gene for resistance to the antibiotic tetracycline transferred into it. Once the pair demonstrated that the organisms could pass the added trait to subsequent generations, interest in genetic engineering ballooned.

Farmers who became early adopters of GM crops did so primarily to save money. Insect-resistant crops needed fewer pesticide applications, and herbicide-resistant crops made weed control easier and more effective.

“Genetic engineering is a technology used in several disciplines, but food has been by far the most controversial [use],” Day said. “Changes in the genome may include input traits — something that helps the grower manage the crop better in response to insects, diseases or weeds. There are also output traits — things that might improve yield, delay flowering times or enhance a plant’s ability to produce a nutritional element such as a vitamin.”

Today, GM varieties of 10 crops have been approved for sale by the federal government and are commercially available in the U.S. Corn, soybeans and cotton represent the vast majority, and roughly 90 percent of those crops produced in the U.S. are GM varieties. The
other approved GMO crops are varieties of squash, papaya, alfalfa, sugar beets, canola, the Innate potato and the Arctic apple.

Three federal agencies are responsible for approving GMOs, depending on the organisms’ intended purpose: the U.S. Department of Agriculture, the U.S. Environmental Protection Agency, and the U.S. Food and Drug Administration.

ARE GMOS SAFE?

The most debated topic related to GMOs is whether they threaten the health of humans or the environment. Critics often call GMOs “unnatural” and “dangerous.” Researchers such as Rebecca Grumet, a professor in the MSU Department of Horticulture, point out that safety questions can also arise with conventional breeding, since plants make toxic substances on their own.

“Modification through genetic engineering is not unsafe simply because it’s genetic engineering,” Grumet said.

“In terms of alterations to a plant’s genome, what’s important is not the method that was used. It’s what genes or traits have been introduced. The idea behind genetic engineering is that it’s more precise, and it lets scientists take advantage of traits present in a given species to better another.”

Internationally renowned organizations (such as the American Medical Association, the National Academy of Sciences and the World Health Organization) have deemed GMOs safe. Rigorous testing throughout the process of trait development, and ensuing research, have led scientists to reach the same conclusion.

“Hundreds of independent research studies have shown that there are not greater risks associated with GM crops,” Grumet said. “There is scientific consensus on this topic, despite the controversy.”

According to the Genetic Literacy Project, it takes an average of eight years and more than $135 million to develop a new GM trait and shepherd it through the federal regulatory process. The GLP is a part of the Science Literacy Project, a nonprofit organization funded by grants from foundations and charities that accepts no corporate money.

The best-known GMOs are probably the Roundup Ready crops that are resistant to glyphosate, the active ingredient in the herbicide Roundup. Introducing a resistance gene into a crop’s genome allows farmers to better control weeds without causing unintentional harm to crops.

A common criticism of glyphosate-resistant crops is that their existence has encouraged the skyrocketing use of Roundup over the past two decades, which could harm human and environmental health. Grumet, who co-teaches an MSU class called “Biotechnology in Agriculture: Applications and Ethical Issues,” sees that criticism as misleading.

“It’s certainly true that there has been a drastic increase in the use of Roundup, but there has been a parallel decrease in the use of other herbicides,” Grumet said. “Much of the time, the herbicides farmers used historically were far more toxic than Roundup, which is one of the least toxic.”

Given the pervasiveness of Roundup Ready crops, glyphosate-resistant weeds are becoming a problem in the environment, and in some cases, leading to a return to the use of the older herbicides Grumet mentioned.

**10 Approved GE Crops and Year Commercially Launched**

- Soybean - (1995)
- Squash - (1995)
- Corn - (1996)
- Cotton - (1996)
- Papaya - (1997)
- Canola - (1999)
- Alfalfa - (2006)
- Sugar beet - (2006)
- Potato - (2016) (Innate varieties)
- Apple - (2017) (Arctic varieties)

(70 to 90 percent are used in animal feed)

*List from GMOanswers.com*
There are many common arguments against the use of GMOs. This list comes from GM Watch, an independent organization that seeks to “counter the enormous corporate political power and propaganda of the GMO industry and its supporters.” It covers many of the common concerns about GMOs.

10 Reasons We Don’t Need GM Foods*

1. GM crops do not increase yield potential
2. GM crops increase pesticide use
3. GM crops have created “superweeds”
4. GM crops have toxic or allergenic effects on laboratory animals
5. GM and non-GM crops cannot “coexist”
6. GM is not needed for good nutrition
7. There are better ways to feed the world
8. Conventional breeding is better than GM at producing crops with useful traits
9. GM is an imprecise technology that will continue to deliver unpleasant surprises
10. GM crops are not about feeding the world but about patented ownership of the food supply

* gmwatch.org/files/10-reasons-we-don’t-need-GM-foods.pdf
She said that this is not surprising. When used frequently (as is the case with antibiotics) any product will lead to the natural survival – and therefore selection – of individuals that are resistant to the product. (One example is the development of antibiotic-resistant bacteria.) This is why agricultural scientists must continually search for new ways to manage emerging threats to crops. Keeping consumers informed of disease and pest problems in food crops and about the science behind potential solutions to these problems helps increase public understanding and acceptance.

“We, as scientists, must do a better job of interacting with the public about this topic,” Day said. “Roundup Ready crops are a really good example. I don’t have a vested interest in touting GMO technology as a catchall answer to solving the problem of world hunger. It’s one tool among many that society has to understand in order for the technology to be deployed in the most efficient, safe and useful way possible.”

**ARE GMOS NECESSARY?**

Conservative estimates suggest that the human population will surpass 9 billion by 2050. The actual figure could be closer to 10 billion. Either way, we’ll need a massive boost in food production to feed that many people. Crops that are more adaptable to varying climate conditions and less vulnerable to pathogens and other pests will be significant pieces of the puzzle.

“We can’t control the fact that the population is increasing or that there is a finite amount of agricultural land – land that is decreasing in quality overall,” Day said. “When you’re talking about feeding 9 or 10 billion people by 2050 with crops that won’t get wiped out by pests and diseases, we don’t have the luxury of feeding everyone from a backyard garden. Some people have fears about large-scale industrial agriculture and GMOs, and that’s why we should also be looking at things from the viewpoint of sustainability.”

Wealthier families currently have greater ability to decide on whether to consume GM foods or not. Additionally, regulatory systems in the U.S. make introducing GM foods an expensive and onerous process designed to protect consumers. In other communities, especially those around the globe facing matters of basic nutrition and sustenance, choices are much more limited.

Cholani Weebadde, an assistant professor in the MSU Department of Plant, Soil and Microbial Sciences and associate director of the World Technology Access Program, spends much of her time assisting developing countries with capacity building. A plant breeder and international agriculture expert, Weebadde is uniquely suited to speak about GMOs with political and agency leaders.

**26 countries are growing GE crops today.**

- Genetic Literacy Project

“In my opinion, it’s important that countries have functional regulatory systems in place so they can make science-based, informed decisions on commercializing GM crops and products so farmers have access to the best technologies,” Weebadde said. “Having transparent systems in place with evaluations conducted using a risk-based approach – is important for countries and their ability to say yes or no to the technologies.”

In Uganda, for example, bananas are a staple crop that is highly susceptible to a pathogen that causes bacterial wilt. Plant breeders have tried to use conventional selective breeding techniques on elite banana selections to bolster resistance to the disease, but the trait doesn’t seem to exist in the banana genome.

Scientists observed, however, that another food crop, sweet pepper, has two genes that could do the trick. By inserting the appropriate genes from sweet peppers into bananas, they were able to develop bananas that are resistant to bacterial wilt. But because Uganda doesn’t have an efficient process for approving genetically modified crops, these bananas can’t be grown commercially in the country.

Pests and diseases aren’t the only concerns driving the development and use of genetically modified crops. Climate change is also making farming more challenging worldwide. According to Weebadde, some food crops are naturally ill-equipped to handle the added environmental stresses, ranging from not enough rain to unyielding cold spells.

“Since we are dealing with narrow genetic and germplasm bases for most of our staple food crops, we may have to reach out to genetic engineering technologies and genes from other sources to improve them further,” she said. “Otherwise, we may run out of options.”

Golden rice is a well-known case in which GMO development has stalled due to lack of regulation. Pioneered throughout the 1990s, golden rice was developed to combat vitamin A deficiency in countries that rely on rice as a staple crop. Lack of vitamin A can lead to blindness and even death.

Three genes help golden rice produce beta carotene, which the human body synthesizes into vitamin A. Critics said the initial product didn’t generate enough beta carotene to make an appreciable difference. A second version unveiled in 2005, however, contained 23-times more of the substance than the original.

Some organizations in the U.S. and Europe have rallied against golden rice commercialization. Weebadde believes that policy makers at the country level should be empowered, through the establishment of regulatory bodies, to make decisions on behalf of their citizens.

“We don’t need to think as much about issues such as vitamin A deficiency in the U.S. because it’s well under control,” Weebadde said. “But we wield a lot of power in terms of developing regulatory processes for GMOs. It’s our responsibility to provide all of the facts as they are.

“Although some issues may not be a concern in the U.S., oftentimes our actions can have deleterious effects internationally, so we have to be responsible for those actions. Providing unbiased, science-based information regarding GMOs is crucial for this reason.”
Questions of safety are often answered by way of a comparison – “Travelling in an airplane is safer than driving in a car.” Understanding is gained through familiarity with the object of comparison. When it comes to genetically modified, or GM, foods, the comparison to non-GM foods is not only illustrative of safety but a key part of determining it.

BY TOM CUMMINS, WRITER
In the United States, the Food and Drug Administration determines the safety of GM foods through a rigorous series of tests based on the concept of “substantial equivalence” – a process designed to demonstrate that the GM or novel food version of a food (or crop) is as safe as the traditionally bred non-GM version. If there is no significant difference, the GM food is considered safe for consumption.

However, if something is “as safe as” something else, is it accurate to say – it is just as unsafe?

“No food, GM or non-GM, is absolutely safe,” explained Robert Hollingworth, professor emeritus of the Michigan State University Department of Entomology and Institute for Integrative Toxicology. “However, it is very close to the universal conclusion of every expert who has evaluated it, that the GM crops we have at the moment are as safe to consume as the standard crops that we have been consuming for years.”

It might come as a surprise to many that conventional (non-GM) whole foods are not tested for safety. The absence of testing is partly due to the assumption that the foods we have been eating for generations are inherently safe. Another reason is that safety-testing whole foods is substantially different and more challenging than testing single chemicals such as drugs and pesticides.

THE DIFFICULTY OF TESTING WHOLE FOODS

“You really cannot adequately test whole foods, the way that you can test single chemicals,” said Hollingworth. “One of the main criteria when chemical testing is that you give the test animals (typically mice or rats) at least one dose that is much higher than you’d expect any one human being to ever get. Test animals can be less sensitive than humans so low levels that could be safe for the mouse would not be safe for you or me. So, a high dose is a key part of the process and you can’t do that with whole foods – you can’t feed 10 times the normal amount of apples to a mouse.

“Also, crop plants contain a large variety of chemicals that can vary considerably between different varieties of the crop, the conditions under which it is grown and stored, and how it is cooked. This makes interpreting safety tests by feeding any food to animals very challenging.”

There are many non-GM crops in the food supply that contain naturally occurring, potentially toxic chemicals. These typically serve to defend the plant against insects and predators. The low levels of chemicals present in these crops today are the result of traditional selective breeding practices over thousands of years.

“You can use conventional breeding methods which may change the genetics of a crop far more than it would be changed by a GM technique,” said Hollingworth. “There are examples of people breeding varieties of potatoes with high levels of glycoalkaloids that were actually dangerous to consume – glycoalkaloids are about as toxic as strychnine. People found out about it and stopped growing them. But it is perfectly possible to do that kind of thing and you do not have to answer to anybody before putting it on the market.”

Conventional breeding practices have resulted in the wide range of fruit varieties available in supermarkets and grocery stores today, such as Fuji, Honeycrisp and Red Delicious apples. The difference in taste, texture, size and color between different varieties are the result of significant changes to the original genetics of the fruit.

Selectively breeding food crops to be more appealing in appearance and in taste has also involved mutation.

“More crops than you would imagine, in the supermarket today, were actually bred by mutagenesis. That is either treating the seeds with mutation-causing chemicals or blasting them with radiation,” said Hollingworth. “Ruby Red Grapefruit is an example and some of the barley strains that are used, even to produce organic beer, were produced in this way. It is quite common.”

Despite the extent of change caused by the mutation, mutagenesis is not classified as genetic engineering, and consequently, not subject to the same laws and regulations as GM foods. Even though the mutation can cause bigger changes to the genetics of the plant than the intentional changes achieved through genetic engineering.

“With mutagenesis, often the majority of things that happened were bad and so they would get thrown away, but once in a while something that was positive, like having no seeds or being shorter and therefore easier to harvest resulted and those were eventually released on the market, and without anybody asking a question,” Hollingworth said. “Technically, at least, today you can still do that.

“Now that doesn’t necessarily mean that we shouldn’t be interested in what’s going on with the GM. It’s just that we have a very remarkably double standard in some of these things.”

CLASSIFICATION OF GM FOODS

A food is classified as GM when its genetic makeup or genome has been modified in some way using biotechnology. Both traditional selective breeding practices and mutagenesis cause changes in the genome. However, while foods produced from all these approaches are similar in that the genome was altered, there is one branch of GMOs that are uniquely different
“No food, GM or non-GM, is absolutely safe. However, it is very close to the universal conclusion of every expert who has evaluated it, that the GM crops we have at the moment are as safe to consume as the standard crops that we have been consuming for years.”

– Robert Hollingworth
from the mutant grapefruit and fruit varieties consumers are familiar with—transgenic GMOs.

A GMO is transgenic when it contains a gene from a different species. This allows for certain traits from one species of plant, for example, to be selectively transferred to another species. Golden rice is one example of a transgenic GM crop. Genes from corn and harmless bacteria were added to rice to greatly increase the amount of beta carotene in it.

Beta carotene (which turns the rice yellow, hence the name) is an ingredient the human body needs to make vitamin A. Vitamin A deficiency causes 500,000 cases of blindness in children every year, according to the World Health Organization, and many of these children will die. Golden rice can help prevent this.

Felicia Wu, John A. Hannah distinguished professor in MSU’s Department of Food Science and Human Nutrition and Department of Agricultural, Food, and Resource Economics, said food allergies are one concern people have about transgenic GM foods in particular.

“Anytime you introduce a novel gene into an organism, you allow it to encode for a new protein,” she said. “Proteins are rarely toxic and they are rarely carcinogenic, but they can be allergenic. Everything to which we’re allergic in our food or our environment is a protein. So a real concern when these GMOs first came out was that we were introducing new potential allergens into the food supply.”

GM foods are tested in a variety of ways for their potential to cause allergies, including a gastric acid simulation to see how easily the novel food would be digested by humans. According to Wu, if something is digested quickly in the human gut (within 90 seconds), it is very unlikely that it is going to cause an allergic response. If it lasts longer than that, Wu said it could be an allergen.

In 1992, the U.S. Food and Drug Administration made a policy decision that a GM food was not required to be labeled as “GMO” if the novel food was not materially different from its conventional counterpart. For consumers with food allergies, this was a serious concern, given the potential for new allergens in transgenic crops.

“When the news came out that there was this type of genetically modified corn (StarLink) that wasn’t labeled, as is currently the case in the United States, then nobody knows if they are eating a protein to which they could be allergic. That was a concern of mine when I first started doing research on GMOs.”

**SKEPTICISM ABOUNDS**

When first studying genetically modified crops in the early 2000s, Wu said she was skeptical.

“At the time, I didn’t understand why we needed genetically modified crops,” she said. “I thought we had done perfectly fine for thousands of years with traditional agriculture using conventional and even relatively newer hybrid breeding techniques.”

Wu cites one example in particular, StarLink, a GM corn variety approved by the EPA in 1998 for animal feed. It was not approved for human consumption because of its poor gastric acid test results, which could indicate allergic risk. In 2000, StarLink was identified in taco shells and corn dogs. The products were recalled, and production of Starlink ceased. Now any food crop, even if only intended to be used as animal feed, must also pass tests for human consumption.

“When the news came out that there was this type of genetically modified corn (StarLink) that wasn’t
supposed to be in food but had turned up in taco shells and corn dogs, the public was scared about it,” Wu said. “I remember as part of my dissertation, I did a survey in Pittsburgh about what people thought about the health effects of GMOs. You could tell that they were a little bit afraid even when they were joking, they said things like ‘Am I going to grow a third arm?’ and ‘Will my hair turn green?’”

Two decades later, despite an international scientific consensus, concerns about the safety of GM foods persist. Hollingworth thinks this concern can be explained in part by the combination of consumers’ lack of understanding of biotechnology and little incentive for the majority of consumers to choose GM foods over conventional ones.

“I think the typical U.S. consumer can’t see any real immediate benefit to them [GM foods]. The benefit is almost all going to the producer in terms of ease of production and cost savings,” he said. “And if you have no understanding of the technology – and most people have none – you have no way to work out if what you’re hearing about GM foods being dangerous or being safe makes sense because you have no context to put it into.”

For Wu, the benefits of certain GMOs to the consumer became clear when, in her own research, she came across findings from Iowa State University revealing that transgenic Bt corn had lower levels of mycotoxins than conventional corn. (Bt corn gets its name from the genetic modification it undergoes to introduce Bt toxin, a naturally occurring insecticide made by the bacterium Bacillus thuringiensis, into it.) Mycotoxins are chemicals produced by fungi when they colonize crops such as corn, wheat, and peanuts, and can be very toxic to humans. For example, aflatoxin is a specific mycotoxin that can cause liver cancer.

“Mycotoxins are in food supplies worldwide. We can’t completely eliminate them from our food, so the FDA regulates them in the U.S.,” explained Wu. “For aflatoxins, 20 parts per billion are allowed in corn, peanuts and peanut products, as well as almonds and pistachios. That means 20 micrograms of aflatoxin for every kilogram of food, which isn’t much. However, there is a cumulative effect because the more you are exposed to any carcinogen, the greater the risk. Aflatoxin directly damages our DNA.

“In studies done all over the world, Bt corn has lower levels of mycotoxins than conventional corn. In the U.S., that means that corn growers have economic benefits from planting Bt corn. In other parts of the world, where mycotoxins are not as strictly regulated, planting Bt corn could mean improved human and animal health. Aside from cancer, mycotoxins have also been associated with growth impairment in children.”

While the beta carotene in golden rice might not strike the average U.S. consumer as a strong enough incentive to explore GM foods and learn more about biotechnology, a lower risk of cancer and increasing the likelihood that children grow up healthy and strong just might.

‘GENE SILENCING’

The potential for biotechnology to take GM foods beyond “as safe as” to “safer” doesn’t stop with transgenic methods. The cellular mechanism of RNA interference (RNAi) is one biotechnology that doesn’t involve the insertion of a gene to produce a new protein, and as a result, eliminates any risk of introducing a new allergen into the food supply.

“I am part of a USDA project right now in which my colleagues are trying to develop a type of corn that uses RNAi to confer host-induced gene silencing (HIGS),” said Wu. “This allows the corn to sense when a fungus has infected it, and the corn will be able to turn off certain genes in the fungus that produce aflatoxin, such that it could still be infected by the fungus but now there is no aflatoxin.”

RNAi is often referred to as gene silencing, since the process turns off specific gene expressions. The approach has been used to create the non-browning Arctic apple varieties that are sold in the U.S. As her ongoing research attests, Wu said the benefits of gene silencing to consumers can go well beyond cosmetic.

“When you think about the possibilities there is so much potential. And there is no novel protein, like there is in traditional GMOs; you are just tweaking with genes and making the genes do things that they had not done previously,” said Wu.

“You could now apply biotechnologies to crops so that they produce particular vitamins, particular nutrients. They could have benefits to farmers and consumers. They could withstand drought. They could do all kinds of things. As long as they’re proven safe, they could be amazing.”

“I think the typical U.S. consumer can’t see any real immediate benefit to them [GM foods]. The benefit is almost all going to the producer in terms of ease of production and cost savings, and if you have no understanding of the technology – and most people have none – you have no way to work out if what you’re hearing about GM foods being dangerous or being safe makes sense because you have no context to put it into.”

- ROBERT HOLLINGWORTH
When talking about genetically engineered, or GE, foods, it is good to realize two essential points: 1) The scientific consensus is that GE foods are not inherently any more dangerous than conventional plant breeding technologies; and 2) The science doesn't always matter.

In 2016 the National Academies of Sciences, Engineering and Medicine released the results of a study stating there was no substantiated evidence of a difference in risks to human health between current commercially available GE crops and conventionally bred crops. Similarly, a 2014 Pew Research Center survey found that 88 percent of American Association for the Advancement of Science members said it was safe to eat genetically modified, or GM, foods.

Despite these findings, there remains much skepticism among consumers. And leaves the scientific community pondering how to to have productive conversations around food? The science behind the answer to that question is nearly as complex as the science of GE foods themselves. For most scientists, the answer is – give people the most accurate scientific information possible, as often as possible. But as many scientists have discovered, providing more information generally does little to change opinions. In fact, being bombarded with data can actually cause some people to hold even tighter existing beliefs - even if they lack scientific evidence to back them.

John Besley, an associate professor at MSU who studies public perceptions of science and technology, likens the GMO conversation to another complicated subject – dating.

“I can't go on a date and give you a fact sheet about why I'm an awesome partner,” he said. “It doesn't work with dating and it doesn't work with science.”

And if you provide that fact sheet on the first date, you're probably not going to get a second.

BY SEAN CORP, WRITER
Despite the number of news stories that have been published on GMOs, most people report not having heard much about the topic. According to the Pew Research Center study mentioned earlier, 46 percent of people say they either care “not too much” or “not at all” about GMOs. The same study reports 71 percent of people have heard “a little” or “nothing at all” about food with genetically modified ingredients.

Providing more information about GMOs to consumers who lack knowledge about the issue – an approach known as the information deficit model – is no guarantee that they’ll gain a better understanding of the science. In fact, studies show people are prone to become even more skeptical and hostile to information if it doesn’t fit their current beliefs.

Besley said people are hardwired to engage in motivated reasoning and confirmation bias, two reasons why the information deficit model is ineffective. Motivated reasoning is the concept that information that fits already-held beliefs is weighted more heavily than opposing information. Confirmation bias is the idea that people are more willing to seek out and remember things that support their beliefs.

“Scientists can do a lot of harm if we go into communities and treat people like students waiting to be educated,” he said.

Instead, Besley said the key is building a long-term relationship, through honesty, authenticity and politeness, that helps establish trust.

“If you’re not talking to somebody in a language they can understand, you’re not paying attention to them,” he said. “You’re not really thinking about them. If you’re not thinking about the person you’re talking to, I think that’s the classic definition of a jerk.”

Ultimately, the best piece of advice I can give to scientists is, ‘Don’t be a jerk.’

Several MSU initiatives aim to bridge the gap between the public and the scientific community on the subject of GMOs. MSU Extension, the outreach and educational arm of MSU with offices in nearly every county in the state, is training educators throughout the organization about how to talk about difficult topics, including GMOs.

MSU Extension crop educator Ron Goldy, who has been with the organization for decades, said he has little difficulty in speaking with growers about GMOs. However, the public is a different story. He often fields questions from people who have a wide range of beliefs around GMOs and different reasons to support or oppose them. His goal, he said, is to listen first.

“When I get questions, I often ask people, ‘What do you know already?’ You have to feel where they are coming from so you can talk to them from the frame of mind they are most interested in,” he said.

Goldy recently organized a conference dedicated to talking about GMOs that attracted nearly 100 MSU Extension educators and instructors whose work covers a wide range of
disciplines dealing with agriculture, health, youth education and food systems.

“I know emotions aren't usually changed with facts, but as a scientist that is the world I live in,” he said. “We are unbiased representatives – I am giving them the information I have based on the research around GMOs.”

Another project is Food@MSU’s Our Table, roundtable discussions held throughout the state that bring together the public and a variety of experts to have freeform conversations on various food issues. Sheril Kirshenbaum, a scientist and author of books about scientific communication, moderates the Our Table discussions.

She said the problem is that too often people are talking past each other and not listening to each other. She places the onus on scientists to help bridge that divide.

“I think we have to give people a good reason to trust us,” Kirshenbaum said. “The scientific community needs to spend more time listening to people and less time talking at people.”

Our Table aims to create that space for listening and the exchange of ideas by bringing together scientists and experts in other fields – farmers, medical professionals, community leaders – to talk with the public about important food issues. A discussion on GMOs is scheduled for fall 2018.

“Our Table was built around the idea that we need to have conversations with people we don’t usually speak to,” Kirshenbaum said. “We don’t tell anyone what they should believe when they leave the room, but we hope everyone leaves Our Table a little more thoughtful about the topic from all perspectives.”

That two-way dialogue is important.

“You can foster beliefs not just about GMOs, but about yourself to the person you’re talking to,” Besley said. “If I am a scientist talking about GMOs, I can foster beliefs that I’m a person a lot like you. I can foster beliefs that I am competent, I can foster beliefs that I am working to make the world a better place.”

Her recommendations for educators and scientists are the same as the recommendations for everyone else – the most important thing is to develop active listening skills so everyone involved feels heard. She teaches people concepts such as paraphrasing – restating a person’s position back to them to ensure understanding; reframing – presenting an issue from an alternative viewpoint that might better generate consensus or understanding; and summarizing – concisely encapsulating a person’s point of view to reinforce that you are listening to them.

Making people feel like they have a voice and that they are heard goes a long way, Besley said.

“The literature focuses on, ‘Do people feel like they have a voice?’ Do people feel like they’re treated with respect?’ ‘Do people feel like you’re open?’”

“People need to feel like if they want to say something they could say something. That they have been listened to. That the decisions are being made in a reasonable way by competent people who care about communities.”

While scientists often feel like they are under attack and there is a general culture of mistrust in this “fake news” era, Besley said trust in scientists has remained high and remarkably steady compared to other professionals since the 1980s.

He said it’s about reinforcing that trust and building on it by being an active participant in a long-term conversation, and going into communities to nurture the dialog.

“Scientists are so excited about what we do we can’t wait to tell that story and detail our methods and our conclusions that we forget to stop and have a back and forth,” Kirshenbaum said. “It’s when those questions are asked, when you can have a real exchange, that learning happens.”

And the scientists can learn just as much from the public as the public can learn from the scientists. ✤
Public concern over genetically modified organisms, or GMOs, is often associated with questions over their possible effects on human health and their environmental implications. However, perceptions of the agricultural and food industries, trends in higher education, questions around how research is funded, political leanings and socioeconomic factors can also play a part.

Paul Thompson, holder of the W. K. Kellogg Chair in Agricultural Food and Community Ethics at Michigan State University, conducts research on the ethical and philosophical questions associated with agriculture and food.

“The debate over GMOs sits in a kind of strange space,” said Thompson, a professor in both the colleges of Agriculture and Natural Resources (CANR), and of Arts and Letters (CAL). “There’s a kind of disconnect in terms of the way people think about agriculture, in the way they think about their food and their environment,” said Thompson, who has dual appointments in the departments of Community Sustainability; Agricultural, Food and Resource Economics in CANR; and Philosophy in CAL. “I think there are issues ahead in terms of how we negotiate some of these things.”

MSU alumna Elizabeth P. Ransom agrees with Thompson about the complexity of public concern.

“One such example is plant breeding. For thousands of years, Thompson pointed out, people have been selectively breeding plants and manipulating seeds to produce traits we find most desirable. That’s genetic modification, but many don’t view it as such.

“There’s a sense in which people learn about some pretty standard practices in agriculture through the GMO debate.”

BY BETH A. BONSALL, WRITER
Paul Thompson, W. K. Kellogg Chair in Agricultural, Food and Community Ethics at Michigan State University
surrounding GMOs. Ransom is an associate professor in the Department of Sociology and Anthropology at the University of Richmond and has research interests in the sociology of agriculture and food.

Ransom believes there needs to be more transparency in regards to GMOs—which universities and researchers could help provide to those who want to learn more about the benefits as well as the issues. The intersection of food and social issues creates an opportunity for discourse on these complex topics.

“There are going to be some unintended consequences [with GMOs]. How do we review and monitor those?” she asked. “There’s a real opportunity for universities, but it does require scientists in academia to be a little more reflective [in helping the public learn about the benefits and issues related to GMOs].”

PUBLIC PERCEPTIONS

Public perceptions and opinions about GMOs aren’t based solely on facts, and can be informed by their assumptions and emotions. Political beliefs, gender, education levels, and socioeconomic factors also influence beliefs and behavior.

While the correlation between education levels and GMO perceptions seems to be weakening, political leanings are starting to have some influence, said Thompson.

“Liberals tend to be more worried about GMOs, and don’t trust the science on GMOs,” he said. “Conservatives don’t trust the science on climate change.”

The way different groups approach and interpret risk can also factor into what they think about GMOs.

“There are socioeconomic and gender factors in how people think about risk in general. People who are traditionally marginalized tend to be more concerned. If there’s an indication something might be risky, they assume it is,” he explained. “Men are less likely [than women] to infer risk on the basis of some sort of initial indication.”

There is also public concern around GMOs and other issues, in part, because there isn’t a regulatory mechanism in the United States for blocking something—such as a GM plant—four years after it started.

“People loved the Glow Plant, but I think that’s because they weren’t eating it.”

— Paul Thompson, MSU professor & W. K. Kellogg Chair in Agricultural, Food and Community Ethics at MSU Extension GMO Workshop in early 2018

Glenna is a professor of rural sociology and science, technology, and society in the PSU College of Agricultural Sciences. For the past 15 years, he has studied agricultural biotechnology, genetically engineered, or GE, crops and their social impact, including the ethical implications of democratizing science and technology research.

Many people are concerned about concentration and consolidation within the agriculture and food industries and view GMOs as facilitating that trend. Funding from industry for university research is another concern.

“People are losing trust in this science because there’s too much industry involvement,” Glenna said.

Additionally, the growing inequity and economic issues in the United States have caused ripple effects on what people say and what they actually do, said Ransom.

“I think we have to actively start reducing some inequalities,” she said. “We have to rethink our education system. If you don’t have a public that can better understand nuances, then they will not be able to discuss and debate the issues surrounding the introduction of new technologies.”

Food safety is an integral part of the GMO conversation, especially for the public. Thompson said people tend to make broad generalizations about food that lead to specific actions. Some of those actions may also be attributed to a lack of trust in food industries and industrial agriculture.

“For a person who’s not involved in the food system professionally, that starts to mean: ‘Well, I’m going to start eating more salads,’ or ‘I’m going to start buying organic,’” said Thompson. “I think there is a widespread perception that these food industry firms are not ethically responsible firms.”

Marketing plays a role, too.

“The food companies themselves have sort of encouraged the idea that all of the products we’re buying were produced in pristine little family operations where it’s a perennial springtime,” said Thompson. “I don’t
think anyone believes all of the marketing, but it does have an effect.”

AGRICULTURE & FOOD SYSTEMS

Since starting his career in 1980, Thompson has seen a significant amount of industrialization, resulting in the loss of family farms, as overall agriculture and equipment has grown larger. It was the ‘90s when he first started hearing the term “industrial agriculture.”

“Every aspect of the food system has become more and more concentrated,” he said. “I would actually love to see a food system where we would have more people who are actually farmers. There are things that would be healthy in so many ways about that.”

Agriculture has moved more into genomics and biotechnology, where a lot of the knowledge is proprietary and not published.

“We do see a whole host of changes that are at least ethically controversial,” he added.

Proponents say GMOs increase the efficiency of agriculture and provide new ways to feed the world. But some argue, as Glenna does, that the science hasn’t lived up to all its promises.

“We were going to have all kinds of nutritional outcomes, and it just hasn’t happened,” he said.

The global conversation expands to the overall effects of GMOs and agriculture on the environment, biodiversity and sustainability.

“In some respects it’s the extent of agriculture that is a difficult issue, especially as you start to think on a global basis,” said Thompson. “One of the things we have to think about is: How much of the earth’s surface do we really want to dedicate to agriculture, and should we be setting aside areas?”

With her background in sociology and anthropology at the University of Richmond, Ransom expressed concern about the effect of genetically engineered crops on smallholder farms globally and how that ties into a larger debate about sustainability.

“Our global food system is pretty diverse still,” she said. “From a sustainability point of view, smallholders have been overlooked.”

When smallholder farms do well, they could produce more food on smaller parcels of land than industrial farms that often focus on one type of crop, said Ransom.

Her ongoing research focuses on global trade and international agriculture assistance in developing countries. Specifically, she studies the ways agricultural assistance targets women, including within the dairy chain in Africa.

GE crops can help and harm smallholder agriculture, she said. “That’s the challenge for GE scientists. They really need to be nimble about how they work in diverse spaces.

“One of the things we have to think about is: How much of the earth’s surface do we really want to dedicate to agriculture, and should we be setting aside areas?”

– PAUL THOMPSON

“Our world has increasingly become more urban. As we grow as a population, are there ways we can grow and retain rural livelihoods?”

THE ROLE OF UNIVERSITIES

While land-grant universities were enthusiastic about GMOs early on, they failed to understand the broader implications for large public institutions, such as funding shifts to increased reliance on grants and industry.

“As a result, the land grants really did lose a fair amount of their credibility and have really struggled to recover it,” Thompson explained. “It’s actually created some divisions within the ag programs that are really unfortunate.”

Historically, agricultural schools developed seed varieties for commercial use. Increasing regulations and expenses, especially related to developing GE seeds using biotechnology, have made it much harder for universities to compete in this area.

“It’s really reduced the role that nonprofit actors can play in the food industry,” Thompson added. “It’s weakened the commitment of public institutions to developing technology in the food system.”

Thompson said that communications, reflection and outreach are becoming a more structured part of the research process, and scientists should take some cues from the Extension outreach programs at land-grant universities like MSU.

“It’s becoming a responsibility for people who want to work in these fields to actually design and support research, education and outreach programs,” he said. “These programs can really start to repair this loss of trust and confidence.”
TO LABEL OR NOT...

Navigating current laws & initiatives on GMO labeling

THE QUESTION: WHAT’S IN A PRODUCT LABEL?

THE ANSWER: A LOT.

Product labels may include “just” images, “just” words or some combination of images and words. But whatever their content, labels have power. They’re designed to catch the attention of consumers and to serve as a visual symbol of their brand. This is done both explicitly, through stated corporate and regulatory guidelines, and implicitly, through consumer perceptions and expectations. Often times, the line between useful, accurate scientific information and marketing is blurred when it comes to labels, making them confusing for consumers. GMOs, or genetically modified organisms, are no exception to this.

BY ALEX TEKIP, WRITER
“We have a lot of labels on our food, and how many of us actually read them, or understand them? Whereas you see a little figure stamped on it, you know that means something, right?” said Jennifer Carter-Johnson, an associate professor of law at Michigan State University. “We’re brand-aware in the U.S. There are so many warnings on everything and so many pieces of nutritional labeling and all of this. We read the things that are important to us, but we’re very brand aware.”

Branding includes trademarks. One trademarked image becoming more prevalent is the orange and black butterfly of the Non-GMO Project. The butterfly’s presence on a product label indicates that the product has been verified to meet the nonprofit’s standards for what it means to be “non-GMO.”

According to its website (nongmoproject.org), The Non-GMO Project is a “mission-driven, nonprofit organization dedicated to building and protecting a non-GMO food supply.” They work to build this supply by requiring standards for third-party verification that must be met in order for a product to earn their seal. The organization’s verification process takes three to six months, on average. Verification requirements include that product ingredients be tested by one of several third-party testing companies, which charge for their services.

“[Their seal is] a certification mark. It’s a type of trademark, a very specialized type of trademark,” said Jeff Carter-Johnson, adjunct professor in the MSU College of Law (and Jennifer Carter-Johnson’s husband). “They are basically a third-party group that certifies that some product meets their standards in order to put that mark on the label. In a lot of ways, it does exactly what we want out of this. It provides a lot of information from a very small footprint on a label. A consumer can look at that and they know that this product has met those standards.”

In order for a product to display the Non-GMO Project verification label, a participating manufacturer, company or organization must have the product ingredients tested by a third-party testing company and must demonstrate “continuous improvement” with the “goal of completely eliminating any GMO-risk inputs from the production chain.” Participants must “meet or continually be below” the project’s established Action Thresholds for High-Risk Inputs.

- Seed and other propagation materials: 0.25 percent
- Inputs to human food, ingredients, supplements, personal care products and other products that are either ingested or applied directly to skin, and pet food: 0.9 percent
- Livestock feed and supplements, including those used for animal-derived inputs to human food products: 5 percent
- Inputs to packaging, cleaning products, textiles and other products that are not ingested or applied directly to skin: 1.5 percent

“Your average consumer probably looks at that and goes ‘non-GMO means nothing genetically modified is in there.’ Whereas in actuality, it doesn’t, but that information is out there for them if they wanted to see it, and the certification mark does supply that information,” said Jeff Carter-Johnson.

The labeling section of The Non-GMO Project Standard notes that “labeling claims must be accurate and truthful, and must not mislead the consumer about the GMO content of the product.” That can get a little murky, though, given that products that wouldn’t be genetically modified in the first place can be verified through The Non-GMO Project.

“As to whether this is working [to provide consumer information,] it’s a little unclear when they are marking things like water and salt,” said Jeff Carter-Johnson. “These are products that simply can’t be genetically modified as there are no genetics to them.”

Jennifer Carter-Johnson raised similar concerns.

“Companies are now going so far as to use this GMO food product label as essentially being just a marketing buzzword,” she said. “It’s not really telling the consumers anything. If anything, it’s making the consumers fear everything that doesn’t have this label on it, and it’s forcing people to pay in order to get certified to get this label, even if you’re selling bottled water, which doesn’t even have DNA in it. To my mind, that’s a bit of an ethical issue.”

“[They’re putting these labels on things that are GMO-free, but they also would never be GMO.]”

— Jennifer Carter-Johnson

Bonnie Knutson, professor in MSU’s School of Hospitality Business, said, “We buy with our heart and justify it with our head.” Justifying a purchase with your head, however, becomes more difficult when the information you’re using to purchase an item could be viewed as deceptive or confusing.

Neal Fortin, director of the Institute for Food Laws and Regulations at MSU, said GMO labeling as a whole is misleading because it implies a difference to most people that’s not there.

“To label one as a GMO does make a lot of people think that there’s a safety concern that’s not there,” he said. “On the other hand, I’m also in favor of people being able to find out the information, but it’s very tricky to do it in a nonmisleading way.”

Knutson pointed out that information is power for consumers.
“The more information you have, the more you make a decision, and what you see as the right decision for you,” she said.

Labels are in theory designed to provide a service to the consumer, but can often be a form of advertising, and may not be entirely factual – or fulfill consumers' desire for transparency.

“They're putting these labels on things that are GMO-free, but they also would never be GMO,” said Jennifer Carter-Johnson. “It’s not like there’s a competing product out there that has GMO in it. The only reason to put a GMO-free label on it is in order to convince somebody that your product is better than another one. In those situations, it's a marketing issue.”

SEEKING CLARITY

The desire for open, transparent and honest labeling for genetically modified foods is reflected in the National Bioengineered Food Disclosure Standard.

According to the U.S. Department of Agriculture, the 2016 law charges the USDA Agricultural Marketing Service with “developing a national mandatory system for disclosing the presence of bioengineered material.” The goal of the new program is to “increase consumer confidence and understanding of the foods they buy, and avoid uncertainty for food companies and farmers” by establishing a standard for GMO labeling. The law is an amendment to the Agriculture Marketing Act of 1946.

“If you have genetically modified foods or ingredients in your product, you're going to have to label,” said Jennifer Carter-Johnson of the 2016 law. She notes that statute exempts very small food manufacturers — whether that be a business or a farm that manufactures food — from the labelling requirements. Right now, the National Bioengineered Food Disclosure Standard proposed rules, released by the USDA in May 2018, define a very small food manufacturer is as “any domestic and foreign food manufacturer with annual receipts of less than $2.5 million,” but the proposed rules asked for input from industry and the public on whether $2.5 million is the correct number to use.

Among the changes in the proposed rules for the National Bioengineered Food Disclosure Standard is a suggestion to label products with GMO ingredients as a “bioengineered food” or containing a “bioengineered food ingredient,” instead of “genetically modified” or “genetically engineered.”

Jennifer Carter-Johnson noted that the reason for the change is because that's the language used in the National Bioengineered Food Disclosure Standard:

“The National Bioengineered Food Disclosure Standard gave the Secretary of Agriculture the authority to determine other terms that are similar to ‘bioengineering’ – implying that other terms such as ‘genetically modified’ or ‘genetically engineered’ could have been considered equivalent or interchangeable to ‘bioengineered’ in these regulations,” she said. “However, the Secretary declined to include these additional terms in the draft regulations.”

Jeff Carter-Johnson said the term “bioengineered” could complicate the consumer experience when reading labels.

“My concern with the use of the term ‘bioengineered’ without defining its relationship to more commonly used terms such as ‘genetically modified’ is that consumers will face numerous, confusing and seemingly overlapping information on product labels,” he said.

Vermont was the first state to require most products containing genetically engineered ingredients or produced via genetic engineering to be labeled as such, through a 2014 law that took effect in 2016. Cheese — important to Vermont's economy — was excluded, as was meat from animals that have eaten feed with GMO grains. Vermont's law was overridden in 2016 when the National Bioengineered Food Disclosure Standard was signed into law.

“That was the state law that spurred the federal government to actually take action and pass the bioengineered food disclosure act, because they had to do this in order to preempt the Vermont law,” said Jeff Carter-Johnson.

Although labeling laws aim to improve transparency for the consumer, “transparent doesn't always mean that it's not misleading,” said Fortin.

“People are not computers and they don't perceive things the way we want them to perceive them,” he said. “We have to take into account human perceptions and how we communicate things, too. It's not always an easy matter.”

BE label prototypes

In May 2018, the U.S. Department of Agriculture released a set of proposed food labeling rules and several prototypes for a logo to use on packaging to indicate a food's bioengineered status. All of the prototypes use the abbreviation “BE” for “bioengineered.” The agency's goal is to create a mandatory, uniform national standard for disclosing information to consumers.
Michigan produces more than 300 agricultural commodities, which ranks the state as the second most agriculturally diverse in the nation (behind California). Ron Bates leads a team of 70 county-based and 79 campus-based staff members in ensuring that MSU Extension provides relevant services to the people involved in the state’s diverse agriculture and agribusiness sector.

“We have a really good group of people working across the state directly with agribusinesses and farmers,” Bates said. “It’s just been really fun and a great learning opportunity for me to interact with such a broad base of stakeholders and our staff working in those different segments of Michigan agriculture.”

MSU Extension helps people improve their lives by bringing the vast knowledge resources of MSU directly to individuals, communities and businesses. Addressing emerging issues and concerns such as biotechnology and genetically modified organisms, or GMOs, is always a high priority for the organization, and Bates believes MSU Extension can help reduce consumers’ confusion about these topics.

“I think our role is to be able to be fully engaged in that conversation [about GMOs] in a nonthreatening way,” Bates said. “There is so much information and science that we know – information about safety, environmental compliance, environmental sustainability, as well as impact on the diet. People can take that information and use it how they want to, but it’s important for us to serve as the voice they can trust to help them understand the science.”

As new issues related to food, agriculture, health and well-being gain public attention, Bates said he constantly reevaluates MSU Extension’s programs and resources to help the organization stay relevant and meet people’s needs.

“I’m continually asking the questions, ‘Is the work that we’re doing impactful?’ ‘Is it helping people be able to take that information and put it back into their lives and businesses in a way that will be helpful for them?’ It is very exciting when we’re doing things right and seeing the impact that our staff are having across the state.”
Name: Ron Bates

Title: Director, Agriculture and Agribusiness Institute, MSU Extension, and Professor, Department of Animal Science

Joined MSU: August 1996

Education: B.S. in animal husbandry from Delaware Valley University, which was then Delaware Valley College of Science and Agriculture, 1981; M.S. in animal science from Oklahoma State University, 1983; Ph.D. in animal breeding from Oklahoma State University, 1986

Hometown: Ligonier, Pennsylvania

Muse (person who has most influenced and/or inspired me): I’ve tried to learn from people throughout my career, so I have many. My mother, my father and my aunt; faculty and farm managers that I interacted with during college; certainly, my graduate advisors as well as the members on my graduate committee. I was very fortunate and they were all very influential in my life.

On my bucket list: I’d like to spend a couple weeks in Ireland and travel across Europe.

Favorite vacation: I always like to be where you can do fun things but yet relax. We like to canoe, swim, and see things that are both from history, as well as geography. But, also where you can take some time and enjoy just being.

On a Saturday afternoon, you’ll likely find me: In spring, summer and fall I’ll probably be out in the yard. One of those things that is never-ending.

Something many people don’t know about me is: I was in the choir in junior high school.

Best part of my job is: Working with the great people we have here. I just have had a great opportunity to collaborate with people who are genuine, good people who are very smart and are really passionate about the job at hand, moving the college, moving Extension forward – that just makes for a really fun opportunity.

If I wasn’t the Agriculture and Agribusiness Institute director, I’d be: I have had the opportunity to do my dream job all of my life, more or less, so I would just be right back doing what I’ve been doing – being on the faculty and doing Extension work.

I went into this field of study because: Growing up, until I was 12 or 13, we didn’t live on a farm. I had friends at the time with a barn who lived about six or seven miles away, so it was bikeable. They were in 4-H, so I was able to join 4-H and raise a pig there at their place. Twice a day, I would get on my bike and ride up there. I kind of got hooked. It was something I really enjoyed doing, and I never let it go.
Superweeds, secondary pests & lack of biodiversity are frequent GMO concerns.

Doug Landis and students work on a campus research plot.
These GMO crops, and those that followed, gave farmers new tools to deploy against two of their oldest foes: insects and weeds. The benefits were many. According to a 2016 study by PG Economics, an agriculture advisory and consultancy firm based in the United Kingdom, they reduced the volume of pesticide sprays by over 8 percent and reduced greenhouse gas emissions from agricultural equipment by over 500 kilograms in the United States alone. The use of GMO crops also improved soil health by making no-till farming practical.

Today, about 94 percent of soybeans and 89 percent of corn grown in the United States are herbicide-resistant, according to the U.S. Department of Agriculture (USDA) Economic Research Service. These statistics also show that Bt corn and Bt cotton comprise 81 and 85 percent of their crops, respectively. And many modern cultivars now contain both Bt and herbicide-resistant traits.

GMO technology has not come without controversy. Since the introduction of GMO crops, consumers, policymakers and scientists alike have raised concerns over their potential negative effects on the environment. Critics claim that GMO crops have caused the emergence of herbicide-resistant superweeds, the rise of secondary pest insects to fill the void left by those decimated by Bt toxin, and a reduction in biodiversity in areas surrounding agricultural fields.

**THE RISE OF SUPERWEEDS**

Since the introduction of glyphosate-resistant crops, about 38 weed species worldwide have been identified that have developed resistance to glyphosate. As a result, these so-called superweeds can continue to infest fields and siphon nutrients from the valuable crops planted there, leading farmers to use other costlier – and potentially harsher – herbicides to control them.

Questions quickly arose regarding the role the expanded use of GMO crops played in the development of superweeds.

Bernard Zandstra, professor in the Michigan State University (MSU) Department of Horticulture, has spent his career studying weed control in fruit and vegetable crops.

“Herbicide resistance in weeds comes from the regular, repeated application of the same herbicide, rather than the presence of genetically modified crops,” Zandstra said. “Glyphosate, for example, gives us a very convenient, clean and safe system. For the first 10 or 15 years [it was available], you could spray it once [and be done]. But its overuse caused resistant weeds to develop.”

Zandstra points to a finding consistent across much of the research, that herbicide resistance in weeds, far from a new phenomenon linked with the advent of GMO crops, has been a long-understood consequence of pesticide overuse. Glyphosate-ready crops merely made it easier to rely on a single herbicide for all weed management.

James Hancock, professor emeritus in the MSU Department of Horticulture, said that cases of GMO traits being transferred to non-GMO plants in the wild are rare. He added that while the overreliance on one herbicide has spurred the development of resistance to it, genetic modification did not have a direct role.

“The idea of herbicide resistance escaping from a GMO crop into the wild is an understandable concern,” Hancock, an MSU AgBioResearch expert in plant breeding and the biosafety of GMO crops, said. “In terms of being able to survive under the stresses of the wild, our domesticated crops are wimps. They’re bred to thrive under specific, human-maintained conditions. So if they hybridize with wild plants, those offspring will almost always be weaker and less capable of surviving [than the parent plants].”

Before glyphosate-based herbicides became available, farmers relied on a suite of chemicals for weed control. Individual herbicides were effective against a narrow range of plants, and farmers used them in rotation to effectively manage...
MSU entomologist Doug Landis and his students work during summer field season in his MSU laboratory at the Center for Integrated Plant Systems.

weeds. Rotation helped control the emergence of resistance by exposing weeds to a wide range of stresses.

According to Zandstra, when used in conjunction with appropriate spraying practices, GMO crops remain invaluable to many farmers.

“GMO crops, like anything else on the farm, are a tool,” he said. “When used in the context of good agronomic practices, such as rotating herbicide sprays, they become a great tool for the farmer and the consumer by making farms more efficient and economical. I recommend using another non-glyphosate herbicide alongside glyphosate, for example, so that if you do have some resistant weeds in the field, you ensure you aren’t leaving them behind to flourish.”

Even if herbicide-resistant weeds were to render some current weed control technologies ineffective, Hancock said farmers and researchers would find ways to adapt to the changes.

“Weed resistance just returns us to where we were before we had access to herbicides like glyphosate,” Hancock said. “That doesn’t create a new problem, it just brings an old one back that was being handled in different ways.”

OUT WITH THE OLD PESTS, IN WITH THE NEW

As major insect pests succumb to Bt crops, other secondary pests that aren’t affected by Bt toxin often take advantage of the lack of competition.

A well-known instance of this occurred in China, where widespread use of Bt cotton allowed farmers to effectively control the destructive cotton bollworm while reducing pesticide use. It dramatically improved yields and cut pest management costs. The bollworm’s decline, however, allowed the population of mirid bug, historically a minor pest of cotton plants that is not affected by Bt toxin, to increase. This again led to increased pest control costs as farmers contended with a new threat that their previous practices couldn’t contain.

“Bt toxin is only effective against particular species, leaving a wide array of insect pests that aren’t impacted by it,” Hancock said. “It makes logical sense that if you kill a major pest, but the chemical you’re using doesn’t kill other pests, those secondary pests will rise to take the first one’s place. But it remains in farmers’ best interests to control that first major pest, and then develop other solutions to confront the new problem.”

GMO crops are a very powerful, safe technology when used alongside good agronomic practices.

They’re tools that have helped us feed our society and helped growers earn a living, and that contribute to the plentiful, inexpensive food we enjoy in this country.

– BERNARD ZANDSTRA
Above:
Doug Landis, University Distinguished Professor in the Department of Entomology at MSU, works with a student at the MSU Clarksville Research Station.

Right:
MSU AgBioResearch scientist James Hancock, a professor of horticulture and developer of four of the world’s most widely planted northern highbush blueberry varieties.

Below:
Bernard Zandstra, professor in the Department of Horticulture at MSU, conducts research on weed control in fruit, ornamental and vegetable crops.
While the use of Bt crops has helped farmers control a number of serious pests, Hancock said it was never intended as a total or permanent solution to all insect pest issues in agriculture. Effective insect control will likely always require a suite of integrated pest management practices, with Bt crops playing a significant, but not all-encompassing role.

**Biodiversity & Landscape Simplification**

As the popularity of GMO crops has risen, so too have concerns that the crops could reduce the biodiversity of both the agricultural landscape and the surrounding wild ecosystems.

“Any time you have a successful crop variety – GMO or not – that everyone wants to plant, you inevitably reduce the biodiversity in farm fields,” Hancock said. “GMOs are no different in this regard than any other effective cultivar, but GMO crops tend to have traits that make them particularly successful for farmers. At the same time, however, there are already hundreds of GMO crop varieties available, so farmers aren’t being limited to just a handful.”

The USDA and EPA employ an extensive four-tier testing process to ensure Bt and other pest-resistant crops don’t directly harm nontarget insect species.

“Our regulatory system guards against the release of harmful crop varieties,” Hancock said. “It’s also unlikely a breeder would be willing to release something that would have an impact on the natural ecosystem.”

While GMO crops undergo years-long, thorough vetting processes, some questions still remain. MSU AgBioResearch entomologist Doug Landis has studied the phenomenon of landscape simplification and its effect on monarch butterflies for several years.

Due to the effectiveness of herbicide-resistant crops, plants like common milkweed have been all but eliminated from most crop fields. While beneficial to crops, the loss of milkweed has been linked to new challenges facing insects like the monarch butterfly, which has experienced a population decline of about 80 percent in the last two decades. Many factors have been connected with the decline, with no single, definitive cause emerging. But Landis believes the simplification of agricultural landscapes may play a role.

“Monarchs overwinter in Mexico, but they breed during the summer in the north central U.S. and parts of Canada,” said Landis, University Distinguished Professor in the Department of Entomology. “They depend on this breeding period to build up their numbers for the migration south, and the best information we have suggests a principle reason for monarch decline is the reduced abundance of milkweed in that north central region.”

**Treatin GMO crops as one among many tools in a management plan will help limit the spread of superweeds and secondary pests, as well as preserve landscape biodiversity.**

The loss of milkweed from crop fields has forced monarchs to seek out milkweeds in more dangerous grassland settings, where predators abound. In grasslands, 60 percent of monarch eggs can be lost in a single day, compared to just 10 to 20 percent in an agricultural setting, said Landis.

He is quick to point out that monarchs survived for thousands of years before agriculture came to North America. He adds that rebuilding natural systems may allow them to survive and thrive again.

“Ecologists talk about the importance of having enemy-free space for the survival of young of any species,” Landis said. “We believe such spaces existed in grasslands thousands of years ago, when fire and larger animals disturbed the landscape and created patches for new milkweed to grow.”

Landis and his research team are exploring ways to recreate this in the modern landscape. One approach under investigation is selectively mowing small patches of milkweed in roadside grasslands to encourage the development of younger milkweed shoots preferred by monarchs.

Reintroducing a diversity of weed and pest management practices, rather than relying on just a few, will benefit the entire ecosystem.

“The problem is relying on one or two practices, like spraying glyphosate or dicamba (another widely used herbicide), across vast areas of land,” Landis said. “It’s a recipe for resistance and landscape simplification, which has knock-on effects for the ecosystem. Reintroducing diversity, both in practices and in the way we structure the landscape, brings resilience to the ecosystem that’s lost when we rely on just one or two things.”

The new difficulties in weeds, pests and biodiversity encountered in modern agriculture don’t stem directly from the use of GMO crops, but rather from treating the crops’ traits as a final solution to weed and pest management issues. Treating GMO crops as one among many tools in a management plan will help limit the spread of superweeds and secondary pests, as well as preserve landscape biodiversity.

“GMO crops are a very powerful, safe technology when used alongside good agronomic practices,” Zandstra said. “They’re tools that have helped us feed our society and helped growers earn a living, and that contribute to the plentiful, inexpensive food we enjoy in this country.”
RESISTANCE: YESTERDAY, TODAY & TOMORROW
Resistance is not a new phenomenon, nor is it a direct result of the introduction of genetically modified organisms (GMO), according to Michigan State University researchers. Rather it’s a natural process that happens over time as pests that are already resistant to a certain type of removal mechanism find ways to survive and reproduce.

“In weeds, what resistance comes down to is just the overuse of a particular herbicide that functions at the same place in the plants,” said Christy Sprague, MSU weed scientist. Sprague is quick to point out that the herbicides themselves don’t make a plant resistant; instead, a small percentage of plants are just naturally resistant to any given herbicide. What’s happening is called selection pressure, caused by applying the same herbicide over and over again, and it has occurred in crops for nearly half a century.

“One of the first weeds identified in Michigan that was resistant was atrazine-resistant common lambsquarters back in the early ‘70s. Since then, we’ve seen multiple weed species that have become resistant to herbicides.”

Even though fungicides used to combat plant diseases are generally applied less often than herbicides used to fight weeds are, selection pressure may still occur.

“In terms of field crop production in Michigan, we typically don’t have to spray frequently,” said Martin Chilvers, MSU field crops pathologist. “Sugarbeets might be an exception to that, where we have to make multiple applications to combat Cercospora leaf spot and that’s where we have seen resistance develop. In terms of fungicides, with overuse you’re just applying selection pressure to the population, and there’s always a small portion of the population that’s going to be resistant.”

Insect resistance to insecticides works in much the same way as disease resistance. Insects can become resistant to a particular insecticide very quickly if it’s used frequently.

“House flies became resistant to DDT within a year or so of the first use because there’s just so many flies and DDT was used so widely,” said Chris DiFonzo, MSU field crops entomologist. “In certain systems, like fruit, vegetables or even home use, insecticide application is often more frequent and there are more cases of insecticide resistance.”

Before GMO crops were developed, farmers generally had to apply a greater variety of herbicides and insecticides more often than they do today to control insect pests and weeds. For more than 20 years now, GMO crops have allowed farmers to reduce insecticide sprays, use fewer types of herbicides and make fewer passes across their fields, allowing them to farm more sustainably both in terms of economics and the environment. While there are some similarities between weed control and insect control in GMO crops, they do differ in how they combat pests.

The GMO technologies used for weed control use seeds into which genes that are naturally resistant to glyphosate
MSU researcher Christy Sprague (left) and Andy Welden, soybean grower and president of the Michigan Soybean Promotion Committee, discuss weeds in his soybean field.

or another broad-spectrum herbicide have been inserted. When that herbicide is applied to a field, the weeds in it will die but the crop will survive. In recent years though, selection pressure has caused some weeds to become resistant to glyphosate, as happened with older herbicides.

“[Resistance] really has nothing to do with a GMO crop, it’s just how a management system has happened and it’s just putting that same selection pressure on the weed species,” Sprague said. “When glyphosate-resistant or Roundup Ready crops were first introduced, there was widespread use of glyphosate without a lot of other inputs to help manage weeds. With a focus just on glyphosate, you’re going to have a development of glyphosate resistance.”

According to Sprague, researchers and agriculture companies are now looking into weed control strategies such as using one herbicide that targets specific weeds along with a broad-spectrum herbicide such as glyphosate.

“One of the biggest issues that we have now is we’ve seen more and more weeds develop resistance to different types of herbicides. We also have weed species that have developed resistance to not just one, but multiple types of herbicides,” Sprague said. “Many of our weeds are showing resistance not to just glyphosate but maybe another class of chemistries. We’re running out of options for management without new herbicides being brought onto the market. We’re also trying to look back at some older ones that worked a long time ago.”

Many insect pests, such as the European corn borer and corn rootworm, can be controlled by a protein toxic to pests produced naturally by the bacterium *Bacillus thuringiensis*, or Bt. This toxin (which isn’t harmful to humans) is inserted into the corn genome. Having the ability to combat insects built into Bt corn nearly eliminates the need to apply any other insecticide. Unfortunately, populations of Bt-resistant field crop insects are now surfacing.

“The Bt crop is essentially the insecticide,” DiFonzo said. “It makes the insecticide inside of its tissues and any time an insect is on that plant and feeding, it is exposed [to the insecticide]. So, it’s 100 percent exposure, all of the time, on every acre that crop is being used. This continuous exposure can lead to the development of resistance.”

Unlike weed seeds and spores that can lie dormant in the soil after a crop is removed, insects tend to be more
mobile and mate with others across the landscape, potentially diluting resistance.

“Insects are moving, and in a way, sometimes that can help, because the population moves and mixes more and that can dilute out resistance as it’s starting. But in some ways, it can also make resistance move as well,” DiFonzo said. “So, there are some differences just based on the biology of the critters.”

**CROP ROTATION REDUCES RESISTANCE**

Because Michigan is one of the most agriculturally diverse states in the nation, most Michigan farmers are able to rotate crops on a regular schedule. This practice helps reduce pesticide resistance among diseases, weeds and insects.

“From a disease standpoint, extended rotations really help manage diseases,” Chilvers said. “With foliar and soilborne diseases, if it is possible to get away from just the corn–soybean rotation, extending that with wheat or something can actually help reduce disease pressure in the soil.”

The corn rootworm is one insect farmers are able to combat through crop rotation. Because it survives only on corn, rotating away from corn production on a field eliminates the pest. In some western states, corn rootworm has become resistant to Bt corn due to selection pressure and lack of crop rotation. Michigan’s crop diversity gives farmers a better chance to rotate corn out of fields before potential issues arise. In the eastern Corn Belt, there have been a few cases of isolated Bt rootworm field failures, often on dairy or livestock operations with limited crop rotation potential. Once the issue was identified, most of the affected farms followed crop rotation recommendations from university and crop experts, greatly reducing the prevalence of the resistant insects.

“I think our longer crop rotations delayed the resistance to rootworm traits, as opposed to what’s happened out west. Even if it’s every three to four years, it’s better than the 20-year rotations some of these farms have. Anything is better than nothing,” DiFonzo said. “If you are in Iowa, southern Minnesota or the Dakotas, you may be using a full rate of soil insecticide on top of the Bt trait that you already bought. That resistance issue almost stops once you get to Indiana and Michigan due to crop rotation.”

According to the MSU researchers, Michigan’s diverse agriculture industry that allows for crop rotation, coupled with informed farmers who follow the recommendations of the university’s agriculture scientists, gives the state a slight advantage in the fight against resistance.

**MSU RESEARCHERS “TAKE ACTION”**

Researchers from MSU AgBioResearch and MSU Extension have collaborated with their counterparts at other land grant universities and agriculture industry representatives to combat pesticide resistance. DiFonzo’s Handy Bt Trait Table, helps farmers across the nation select seed with traits that are effective in their location.

Chilvers, Sprague and DiFonzo have worked with other university experts and the National Soybean Board to contribute their expertise to Take Action, a nationwide educational program designed to help farmers manage herbicide, fungicide and insecticide resistance. The goal of the effort is to encourage farmers to adopt management practices that will reduce the effect of resistant pests on crops while preserving current and future crop protection technology.

“It’s great that MSU AgBioResearch and MSU Extension are able to have people who work in these areas when a lot of states don’t,” Sprague said. “I think that’s a big positive because I think it’s helping us be on the forefront of solutions.”
Gene editing makes precise, intentional and beneficial changes in the genetic material of plants and animals used in food production, which can improve their health and sustainability. This often mirrors changes that could occur in nature or through traditional breeding.

How is gene editing currently being used in food and agriculture?
A variety of gene editing applications are being researched and developed as potential solutions to challenges in agriculture. Gene editing can help reduce food waste by producing apples, mushrooms and potatoes that don’t turn brown.

Is gene editing being embraced by other countries?
Countries around the world are discussing gene editing technology, appropriate regulatory measures, and the potential for sustainability. This often mirrors changes that could happen in nature or through traditional breeding.

Does gene editing create GMOs?
What’s the difference between GMOs and gene editing?
In general, genetically modified organisms, or GMOs, are created using transgenic technology, which introduces DNA from one species into another. The transgenic process has been used in several crops and one food animal that are commercially available.

In contrast, gene editing often uses a cisgenic process, which involves precise changes to an organism’s own genetic code without introducing DNA from another organism. This is like the find-and-replace function in a word processor, when a simple, intentional change of a “d” to “e” would change “wind” to “wine.”

—The Center for Food Integrity

No differences in nutritional makeup of the meat, milk or other food products derived from animals that ate genetically engineered feed.

“A new scientific review from the University of California, Davis, reports that the performance and health of food-producing animals consuming genetically engineered feed, first introduced 18 years ago, has been comparable to that of animals consuming non-GE feed. Food-producing animals such as cows, pigs, goats, chickens and other poultry species now consume 70 to 90 percent of all genetically engineered crops. “The review also found that scientific studies have detected no differences in the nutritional makeup of the meat, milk or other food products derived from animals that ate genetically engineered feed. The review, led by UC Davis animal scientist Alison Van Eenennaam, examined nearly 30 years of livestock-feeding studies that represent more than 100 billion animals.”

Journal of Animal Science, 2014
LONG BEFORE PEOPLE STARTED KEEPING AGRICULTURAL RECORDS, THEY WERE GROWING SOYBEANS. ARCHAEOLOGICAL DUGS IN EAST ASIA HAVE REVEALED THAT DOMESTICATION OF THE CROP STRETCHES BACK ALMOST 9,000 YEARS. SINCE THEN, SOYBEAN CULTIVATION HAS EXPANDED TO NEARLY EVERY CORNER OF THE GLOBE.

Though raw soybeans are toxic to most mammals, including humans, cooked soybeans are an excellent source of essential nutrients such as protein, dietary fiber, iron, manganese, phosphorus and vitamin B.

Soybean oil plays an important role in cooking, baking and food processing, as well as in biodiesel production and other industrial applications. Soymeal – the plant matter left over once the oil has been extracted – is a reliable source of livestock feed throughout the world. Like other legumes, soybeans also function as nitrogen-fixers, improving soil health by restoring the nitrogen lost during the cultivation of other major crops such as corn.

Phinehas Tukamuhabwa, director of the Makerere University Agricultural Research Institute in Uganda, has been studying and breeding soybean varieties that meet Ugandan farmers’ needs since 1990.

“When I was in graduate school, I read a great deal about the potential soybeans held for economic development,” said Tukamuhabwa, who is also associate professor in the Department of Agricultural Production at the university. “It was a relatively unexplored crop in Uganda back then, but it has become very important for our farmers.”

Soybeans reached Africa in 1858, when they were first cultivated in Egypt. Today soybeans are grown in 47 of the 54 nations in Africa, including Uganda.

Ugandan farmers first began growing soybeans in 1913. Throughout the 1920s and 1930s, scientists developed soybean varieties tailored to Uganda’s specific climate conditions. Production flourished through World War II, when soybeans were an important source of protein and edible oils for the Allies. Soybean production declined with the war’s end, but ramped up again in the 1970s, driven by renewed interest in staple crops. A push for serious soybean research to develop modern cultivars and crop management systems began then.

Soybean yields in Uganda have more than tripled since the end of World War II according to the United Nations Food and Agriculture Organization. Today the crop contributes about $45 million to the nation’s economy. Processing facilities have been built to turn raw soybeans into soybean oil, soy cake, livestock feed and other products.

Ensuring that Ugandan farmers can successfully grow soybeans is an ongoing challenge for researchers. As diseases like soybean rust threaten the crop, the work of conventional breeding of disease-resistant cultivars becomes more urgent. Diseases, however, are not the only challenge that farmers face in their fields.

Tukamuhabwa estimates that nearly 50 percent of the cost of soybean production in Uganda is incurred in weeding and seedbed preparation. Done primarily by hand, this difficult, expensive and time-consuming labor limits the profitability of Uganda’s farmers, many of whom are smallholders without access to the advanced equipment and extensive fields available in more developed nations.

NEW TECHNOLOGY, NEW POSSIBILITIES

In 2015, Tukamuhabwa attended a workshop in Brazil for African scientists and policymakers. The gathering was coordinated by the African Biosafety Network of Expertise, a network launched in 2008 through a partnership between Michigan State University and the New Partnership for Africa’s Development. The network works to help African nations improve their decision-making capacity on biosafety and biotechnology topics.

While in Brazil, Tukamuhabwa observed genetically modified soybeans growing in the field. During a subsequent visit to MSU, he met Karim Maredia, professor in the MSU Department of Entomology and director of the World Technology Access Program, or WorldTAP.

“Karim and I discussed soybeans and issues farmers in Uganda face while growing them,” Tukamuhabwa
experienced. “He put me in touch with the researchers at MSU, and through them we were able to acquire new soybean varieties with traits that could make a tremendous impact on our soybean industry.”

Through Maredia, Tukamuhabwa met MSU AgBioResearch soybean geneticist Dechun Wang, who used soybeans featuring a genetically modified trait that rendered them resistant to glyphosate herbicides, namely Roundup, in his soybean breeding program. Common in agriculture in the United States, glyphosate-resistant soybeans allow farmers to spray their fields with highly effective glyphosate herbicides, wiping out weeds quickly, efficiently and cost-effectively, without damaging their crops.

“A broad-spectrum herbicide, like glyphosate, makes plant production much lower in cost,” Wang, professor in the MSU Department of Plant, Soil and Microbial Sciences, said. “The glyphosate-resistance trait makes weed control much easier than traditional herbicides; it’s very convenient for farmers and reduces both the cost of weed management and the number of sprays they need to apply.”

Glyphosate is regarded as one of the safest, most effective herbicides available to farmers. It requires few applications to control a wide range of weeds and, once applied, breaks down very quickly in the environment, leaving little in the way of potentially harmful residue.

While Uganda’s government has authorized the testing of several genetically modified crops, including bananas, cassava, corn and sweet potatoes, introducing new biotechnology requires careful vetting by the country’s biosafety committee. Ruth Mbapazi, research assistant professor with WorldTAP and a Makerere University alumna, helped shepherd Wang’s soybean lines through the Ugandan regulatory process.

Highlighting his partnership with MSU’s scientists became a key element of the information package Tukamuhabwa assembled for the biosafety committee on the work he hoped to accomplish.

“The committee knows that there are limits to scientific knowledge in the developing world,” said Mbapazi, who worked with regulatory agencies in Uganda for 12 years before coming to MSU. “They want to know that experts like the ones here at MSU are willing to help their scientists learn how to use these new technologies.”

**PLANTING THE FUTURE**

In 2017, two years after first meeting Maredia and Wang, Tukamuhabwa was finally able to begin growing the genetically modified soybeans in a greenhouse at the Makerere University Agricultural Research Institute.

Developed for cultivation in Michigan, the crops would mature much too quickly if planted in Uganda’s climate. Consequently, the plants would produce far fewer soybean pods, resulting in a yield too small to be of value. So the first task was crossbreeding the glyphosate-resistance trait from Wang’s varieties into soybeans better suited for Uganda.

“Once I get the plants into the greenhouse and into a confined field trial, I can anticipate moving the plants out of the greenhouse and into a confined field trial,” Tukamuhabwa said. “The major challenge we face right now is getting the glyphosate-resistance trait from the U.S. varieties into the soybeans suited for our own environment,” Tukamuhabwa said. “By backcrossing the MSU varieties with our own, we can ensure we have the best of both worlds.”

The team has already completed two backcrosses, with a third in progress. Once that is completed, he anticipates moving the plants out of the greenhouse and into a confined field trial.

Crops grown in greenhouse trials don’t perform the same as they would under normal agricultural conditions. They don’t reach their natural height, nor do they experience the stresses brought on by pests, diseases and fluctuating weather conditions. Seeing how the new cultivars perform under field conditions is an essential test to ensure their utility to farmers. Tukamuhabwa estimates it will take about four years to complete all of the necessary trials.

Helping educate the public about his research with genetically modified crops is also key to Tukamuhabwa’s work. As in much of the rest of the world, genetically modified organisms, or GMOs, remain a contentious issue, and Tukamuhabwa wants to make sure farmers who use GMOs understand them.

“We need to give people all the information we can, so they can see for themselves that this technology is safe, both for them and for their farms,” Tukamuhabwa said. “That means showing them this has been deemed safe in the other countries that have used it, as well as conducting our own safety studies.”

For Tukamuhabwa, his work is about helping farmers improve their livelihoods and helping consumers gain access to better, healthier food.

“If the plants I develop are resistant to diseases, allow for clean, weed-free fields and produce a good yield for farmers, I feel very good about that,” Tukamuhabwa said. “Having soybeans that perform well in the field and make a difference in farmers’ lives is why I do this, and these glyphosate-resistance varieties may help accomplish that.”

For Maredia, this represents yet another productive relationship between MSU and its partners abroad.

“This is a very good case study that shows what we are working on here in Michigan can also help the world without investing a great deal more money into it,” Maredia said. “We already had this technology developed for our farmers here, but at the same time we were able to use it to help farmers in developing countries. That’s part of MSU’s mission, reaching out to the world.”
Above:
Makerere University researchers examine soybeans in the field. Soybean production has increased in Uganda since the 1970s, and today contributes approximately $45 million to the national economy.

Right:
MSU AgBioResearch soybean geneticist Dechun Wang bred several soybean cultivars for Michigan farmers that include the glyphosate-resistance trait. His cultivars are now being adapted to the Ugandan climate in order for farmers there to enjoy the same benefits.

Below right:
Phinehas Tukamuhabwa (right) and a colleague evaluate a soybean field trial. Since 1990, Tukamuhabwa has worked to develop soybean cultivars that meet the needs of Ugandan farmers.

Below left:
Mbabazi worked with regulatory agencies in Uganda for 12 years before coming to MSU.

Left:
Uganda is in east central Africa.
Long-time Futures & MSU photographer Kurt Stepnitz retires

So long, Kurt. We’re going to miss you!

After 29 consecutive years of snapping photos for Futures magazine, long-time Michigan State University photographer Kurt Stepnitz retired in early May 2018.

Stepnitz began his MSU career in 1981 working for the MSU-U.S. Department of Energy Plant Research Laboratory. Having learned a great deal about plants and agriculture during his first few years on the job, he became a natural fit for Futures when then-editor Christine Erb approached him to shoot the spring/summer 1989 issue.

When asked about his favorite memory of working on the magazine, Stepnitz said there were far too many to single out just one, though a few seconds later, he had a couple to share.

Once when Robin Usborne was editor, Stepnitz remembered, “We went up to the Northwest Horticultural Research Station in Traverse City to cover a field day, along with videographer Scott Allman. Afterwards, we were invited to Bel Lago Winery for a tour with MSU researchers Ron Perry and Stan Howell. We had quite a bit of wine in the cellar that evening. It was so much fun, just hilarious. That’s when Robin decided to go into the viticulture business and changed up her career.”

On another adventurous shoot, Stepnitz asked then-editor Jamie DePolo to pose for the cover.

“She stood on a stepladder in the middle of a south campus corn field to pose for a double exposure with the rising moon behind her,” he said. “She was a champ!”

In 2003, Stepnitz went to work for University Relations (now MSU Communications and Brand Strategy), all the time continuing to work on Futures, as well as covering all sorts of MSU assignments – from commencement events on campus to research around the globe.

A few days after his retirement party at The Hop Cat in East Lansing, Stepnitz and his wife Kharla moved to Minnesota to be near their daughter, son-in-law and adored first grandbaby, Collette Louise (called “Lettie Lou” for short).

He looks forward to spending time with family, restarting his own photography business and enjoying a more urban experience in the Minneapolis-St. Paul area. The couple plan to get their gardening fix at their daughter’s home, where a couple of raised vegetable beds await their attention.

Stepnitz said he appreciates all of the wonderful memories and friendships he’s developed over the years along the banks of the Red Cedar River, and looks forward to settling in his new home near the Mighty Mississippi.

BY HOLLY WHETSTONE, EDITOR
High Time for Scientists – Me Included – To Look in the Mirror

Hardly a day goes by when I don’t talk, or at least think about, genetic modification and its scientific, political and societal implications. Regardless of the setting or occasion, this contentious topic seems to find its way into many of my daily conversations.

A little about me. I’ve spent my career in agricultural research as a scientist, professor and administrator. I work with farmers, scientists and the public. I interact regularly with leaders of major domestic and international agricultural circles and with friends and family. Some of these people are hardcore carnivores, some only eat organic foods and some are vegans or vegetarians. I’ve always tried to look at all issues under discussion – especially this one – with open eyes and through a broad lens.

As we strive to figure out how to feed the world in the face of many challenges, I’ve tried to separate my personal feelings from the best interests of my employer and of the scientists with whom I work. But the more I read, listen and think about genetic modification, the more frustrated and confused I become. Isn’t learning supposed to enlighten and inform us? Well, it’s not working for me on this one.

I’m not confused by or frustrated with the technology or the science. I believe genetic modification can be a sound, powerful and useful modern-day scientific tool. While often depicted as strictly a black-and-white topic – you’re either for or against GMOs, there is no middle ground – genetic modification is inherently, and in my opinion, neither good nor bad. It has both pros and cons.

Instead, I believe that much of the public consternation about GMOs actually stems from a few early products developed with biotechnology – specifically, glyphosate-ready and Bt crops. If we want to debate the merits of these crops, let’s have at it. I think there are sound reasons for carefully examining glyphosate-ready and Bt crop varieties and their impacts on our landscape and food systems. But let’s not damn the technology entirely just because it was used to develop a couple of controversial products. Instead, let’s focus on developing new products that can improve the quality and quantity of our food while protecting the environment and enhancing both human and animal health.

Another part of the confusion surrounding GMOs appears to stem from the close association of the technology with the large multinational companies that control the genetically engineered products. These businesses hold significant, high-profile places in this controversy. Many in the academic world are labeled shills for these businesses when we speak in support of the technology. Again, this confusion isn’t about the technology. It’s about the high-profile end products.

A big part of my frustration is that I share some of these same concerns; however, the products and the technology have been horribly conflated. I strongly believe that advocating for the basic technology, while sharing my concern over it, is just.

The question we – the scientific community – should be focused on is this: Why hasn’t society turned to us for input on this divisive issue? Many people rely instead on information from friends, family and people who share their opinions. By the same token, we scientists tend to stay in our comfort zones while lamenting with our colleagues the emotion-driven, fact-lite arguments against GMOs. I suggest that it is high time for all of us to emerge from our bubbles and to listen to and engage in clear and thoughtful conversations with our critics.

Let’s be honest – we scientists have not been effective listeners. Consequently, society has lost trust in the scientific community. No one wants to be peppered with data and jargon that they don’t understand. And they certainly don’t want to be talked down to. To start shedding the stereotypical perception of scientists as being advocates of progress at any cost, we need to take a long look in the mirror. For real change, we need to start with ourselves, our actions and our words.

I encourage you to talk with consumers and critics, not at them. Work to understand their concerns and allay their fears about biotechnology and GMOs. Remind them that we – and our families – eat, too, and that we’re as concerned as they are about the safety and security of our food supply.

By Doug Buhler, Director of MSU AgBioResearch; Assistant Vice President of Research and Graduate Studies
The Montcalm Research Center (MRC) rests on the light, sandy soils that are home to Michigan’s major potato production region. The location makes sense, because Michigan leads the nation in production of chipping potatoes and is seventh in overall potato production. MRC provides the research the industry needs to produce nearly 2 billion pounds of potatoes, provide over 3,000 jobs and contribute more than $1.24 billion to Michigan’s economy each year.

Research priorities at the center include potato variety evaluation and pest and disease management.

MSU enjoys a partnership with the potato industry at the Burt Cargill Potato Demonstration Storage facility, located next to MRC. It allows researchers to study potato variety performance in a simulated commercial storage environment.

Dave Douches is director of the MSU Potato Breeding and Genetics Program and faculty research coordinator at MRC. The mission of his research team is to develop potato varieties that have higher nutritional values and require less pesticide use than current varieties, and that contribute to sustainable farming practices.

“All of the varieties released by MSU run through variety trials at the Montcalm Research Center,” Douches said. “Genetically modified potatoes bring good opportunities for the growers and the industry, including reduced bruising, less browning, longer storage and less disease in the field compared to conventionally bred varieties. GM is not the only solution, but it’s a valuable agricultural tool.”

MSU researchers also conduct dry bean, soybean, and corn research trials at the facility.

For more information about MRC, visit https://www.canr.msu.edu/montcalm/.

Facility Focus: Montcalm Research Center

Established: 1966
Size: 57 acres

4629 West McBrides Road
Lakeview, MI 48850
Phone: 989-365-3473