The New Color of Corn

Orange Corn Combats Vitamin A Deficiency
There is a reason this magazine is called *Agricultures*. “Culture” in many senses of that word is an important component of our efforts.

A Purdue University team of agronomy researchers has identified a genetic blueprint to convert white corn to orange corn, which is unusually high in vitamin A carotenoids. Vitamin A deficiency is a major health concern in the developing world. Previous attempts to introduce GMO crops high in vitamin A, such as yellow rice, have encountered resistance. Produced using traditional plant-breeding methods, orange corn is a promising alternative. Scientific innovation alone doesn’t ensure food security; crops must also be accepted by consumers and fit within their culture.

The link between science and culture is also evident in our story about the Sloan Indigenous Graduate Partnership, a joint program between the Alfred P. Sloan Foundation and a consortium of universities led by Purdue. The scholarships that make it possible for American Indian and indigenous students to pursue graduate degrees in STEM fields is just the start. Mentors and support networks are just as crucial to help them adapt to a different environment, one often without role models. A program goal is to create a new generation of Native American scholars who will serve as role models for future students.

Biochemistry major Emily Erickson’s selection as one of 14 students nationwide to receive the Churchill Scholarship illustrates how students’ academic strengths are complemented by challenging programs and a mentoring faculty and staff. Erickson credits her achievements in large part to Purdue Ag’s culture of encouraging students to realize their potential.

Along with our other stories about Purdue’s partnership with Indiana zoos to help improve hellbender salamanders’ chances for survival, and the many ways big data can help farmers around the world be more productive, this issue illustrates how agriculture is more than the business and science of cultivating crops and raising livestock.

*Jay Akridge*  
Glenn W. Sample Dean of Agriculture

For more about the topics in this issue, see expanded coverage on the *Agricultures* website, agriculture.purdue.edu.
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Vitamin A deficiency is a major health concern in the developing world, but GMO crops high in vitamin A, such as yellow rice, have encountered cultural resistance. Agronomist Torbert Rocheford has used natural selection and breeding methods to develop orange corn—a crop unusually high in vitamin A carotenoids.

**18 From Goats to Cambridge**
Emily Erickson became interested in mammary biology research when raising dairy goats on her family’s farm. The biochemistry major is one of 14 students in the U.S. awarded the prestigious Churchill Scholarship. Erickson will continue breast cancer research this fall at Churchill College at the University of Cambridge in Great Britain.

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Agriculture becomes more high-tech every year, and researchers at Purdue University are zeroing in on how the gazillion bits of digital information being created every day—“big data” as they are often called—can help farmers become more efficient and even more productive.

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SPOTLIGHTS

➤ Code Red for farm families

Purdue Extension’s Women in Agriculture team has developed a resource to help farm families and owners of other small businesses keep important information handy in the event they need it in an emergency.

Called Code Red, the spreadsheet has two main sections—one for personal information and the other for business information.

In the event of an emergency, the business would be able to continue in a timely fashion and with minimal disruption because of the resource of Code Red, said Kelly Heckaman, Women in Agriculture committee co-chair and an Extension educator in Kosciusko County.

“The crisis may be only for a short time, or it may be a long-term change in the operation, but the need for timely information about the people in the operation and their contacts is very important,” Heckaman said. “We hope this resource will help farm families turn a code red situation into a code green, and the business can continue to operate.”

The spreadsheet keeps important information such as passwords, bank account information, rental agreements, insurance papers and power-of-attorney documents in one location.

➤ Ag placement rates continue upward trend

Ninety-six percent of May 2014 Purdue University College of Agriculture graduates responding to a survey reported finding jobs or were continuing their education. It was the fifth consecutive year of increase in the placement rate.

The survey reflects an improving job market as well as continued strong value of a Purdue Agriculture education, said Marcos Fernandez, associate dean and director of the college’s academic programs.

“Purdue Agriculture has a proven reputation of educating and preparing our students well—to be job-ready,” Fernandez said. “And our successful Ag Career Fairs—the second-largest in the country—and strong placement rates are a testament to how others feel about our students and graduates. It is a great time to be part of Purdue Agriculture.”

The college awarded bachelor’s degrees to 501 students in May 2014. That is up from 426 the previous year and 399 in 2010, when the nation was struggling to recover from the Great Recession and the placement rate was 77 percent.

The college’s summary of post-graduation activities tracked students with bachelor’s degrees until February of this year. Ninety-three percent of graduates responded.

The average starting salary for College of Agriculture graduates was $43,200 a year. Agricultural and biological engineering graduates received the most, an average of $55,405.

➤ USDA grant to help beginning farmers

A team of Purdue University faculty, staff and Extension educators will lead a U.S. Department of Agriculture effort in Indiana aimed at supporting new and beginning farmers and ranchers.

The National Institute of Food and Agriculture initiative—called Infrastructure, Access, Community: A Plan to Support Beginning Farmers in Indiana—is designed to increase the number of farm start-ups in the state and provide direct, practical assistance to anyone who is new to farming.

“We are particularly interested in supporting small farms and military veterans,” said Kevin Gibson, associate professor of botany and pathology, who is one of the team leaders.

Plans call for annual training sessions for Extension educators, workshops, and farm tours focusing on effective farming practices, networking events, and a “one-stop shop” website with a variety of resources for beginning farmers.
Purdue, Vincennes renew transfer program

The Purdue University College of Agriculture and the Vincennes University College of Science, Engineering and Mathematics have signed a transfer agreement to both continue and expand a cooperative agricultural education program that has been in place for nearly six decades.

Students in the VU-Purdue Cooperative Agriculture Transfer Program who complete an Associate of Science degree in agriculture or a related science at VU can move to Purdue for the final two years to complete a bachelor’s degree.

Agreement provisions allow VU students to be treated the same as resident Purdue students entering their junior year.

Marcos Fernandez, director of academic programs in agriculture at Purdue, said providing a seamless experience for students is among the many benefits. “We have an on-site coordinator at Vincennes who also advises students and a staff member at Purdue who oversees transfer students when they get here," he said. "We continue to focus on improving our transfer process in the state with colleagues like Vincennes and increasing our number of transfer students.”

Charles Mansfield, Purdue's coordinator on the VU campus, said the curriculum is designed so that courses are equivalent to those at Purdue. “Students get high-quality agriculture, science and math classes at Vincennes," he said. “It's a great option for students to get through the basics.”

VU also draws upon area Purdue Extension resources and the Southwest Purdue Agricultural Center, which is near the Vincennes campus.

The cooperative arrangement could expand to include use of VU teaching, laboratory and residential facilities for Purdue undergraduate and graduate students in summer educational or research experiences at SWPAC.

By Olivia Maddox

Great Lakes smelt population declining

The reasons for the dwindling smelt population in the Great Lakes to near historic lows are more complicated than previously believed, new research suggests.

Although results of the 2014 study show that the number of smelt surviving their first few months actually has been rising since 2000, the increase in hatchlings isn’t producing more adults. Whatever the cause, the loss of adult rainbow smelt is keeping the population on a downward trend even as offspring survival improves.

Researchers from the U.S. Geological Survey, Illinois-Indiana Sea Grant and the U.S. Environmental Protection Agency’s Great Lakes National Program Office discovered the unexpected increase in offspring after analyzing about 40 years of fisheries data using a novel modeling technique.

The researchers speculate that the drop in the number of adult smelt may be allowing hatchlings to thrive. Adult rainbow smelt frequently eat their offspring. Fewer adults means fewer predators for juvenile smelt.

The need to find food in a lake infested with millions of quagga and zebra mussels that filter out plankton may be driving adults further out into the lake and away from spawning grounds, the researchers said.

By Anjanette Riley
Protecting soybeans from disease

Researchers from around the Midwest and Canada are studying soybean sudden death syndrome to help farmers better protect their crop from the recurring disease.

Most Indiana soybean fields had some level of the disease last year, the most severe incidence of the disease since 2010, noted Kiersten Wise, an associate professor of plant pathology.

Wise and other researchers have been looking for answers beyond typical production practices, which include crop rotation and planting disease-resistant varieties.

“We wanted to look at how a combination of various production practices affected SDS to determine a better management strategy,” she said. Those practices include early to late planting, use of varieties resistant to both SDS and soybean cyst nematode, and fungicide seed treatments. They also examined how weed killer glyphosate and pre-emergence herbicides affected SDS severity.

Last year, Wise conducted field trials at the Pinney Purdue Agricultural Center in northwest Indiana. The study included the additional option of seeds treated with a new chemical, fluopyram, designed to protect the root system against the SDS fungus in the seed zone.

“We’re still learning about new ways to manage SDS,” Wise said. “There will be more questions to answer this year and beyond.”

Drug combo a promising treatment

Low doses of metformin, a widely used diabetes medication, and a gene inhibitor known as BI2536 can successfully halt the growth of late-stage prostate cancer tumors, a Purdue University study finds.

Prostate cancer causes the second-highest number of cancer-related deaths in men in the U.S., and methods of treating advanced prostate cancer are limited.

Xiaoqi Liu, associate professor of biochemistry and cancer research, and fellow researchers made the discovery.

“Combining low levels of two well-tolerated drugs could significantly delay the progression of this disease,” Liu said. “Completely curing the cancer at the advanced stage is pretty much impossible, but this treatment might manage it for a while—that’s exciting.”

Liu and fellow researchers from Purdue collaborated with the University of Wisconsin-Madison and the Indiana University School of Medicine. The next step in the research is to test the combination of drugs in clinical trials.

By Natalie van Hoose
Taking the bait

Water-storing crystals known as hydrogels can effectively deliver pesticide bait to invasive Argentine ants, quickly decimating a colony.

Pesticide sprays and baits are common tactics for managing pest ants. But sprays can have little long-term impact and carry environmental costs such as chemical contamination of soil and water sources. Baits also present challenges: Ants prefer liquid food to solids, rendering granular baits less appetizing. But liquid baits can be difficult and costly to dispense, maintain and clean up.

Entomologist Grzegorz Buczkowski and fellow researchers tested the ability of hydrogels—crystals that can absorb 300 times their dry weight in water—to deliver liquid bait to invasive ants. They found that hydrogels saturated with a small amount of the chemical thiamethoxam dissolved in sugar water reduced the Argentine ant population in an orchard by about 94 percent in two weeks.

“When you drop hydrogels on the ground next to a colony, the ants really go crazy. It’s like a big party,” Buczkowski said. “This has great potential for managing invasive ants in other agricultural systems and natural environments. You could treat a whole vineyard using hydrogels.”

Vegetable trials yield data

Purdue Extension has released the Midwest Vegetable Trial Report for 2014, which contains 30 reports from seven land-grant universities on the performance of vegetable varieties and production practices.

The variety of crops covered in the report includes Asian vegetables, cantaloupe, pepper, pumpkin, sweet corn, watermelon, broccoli, cucumber, potato, radish and tomato.

Purdue vegetable specialist Liz Maynard said vegetable growers often tell her the trial reports help them identify varieties and practices that may do well on their farm.

“While even one year’s worth of data from an independent trial is valuable, the fact that reports from past years are also online means that consistency of performance from year to year can be assessed,” Maynard said. “Growers also find the reports useful to get an idea of expected yield for various crops.”

The publication is available free for download at Purdue Extension’s The Education Store at www.edustore.purdue.edu. Search for it by product code, 16-18-14-W.

A record year for popcorn

Indiana farmers last year planted more acres in popcorn than ever before and produced a record crop, according to a new report from the U.S. Department of Agriculture.

Farmers planted 91,000 acres of corn used to make popcorn, up 10,000 acres from 2013, according to a National Agricultural Statistics Service report produced for Purdue University.

Although the amount of Indiana acres harvested in popcorn was small compared with the 5.77 million acres in corn grown for grain, Indiana is regarded as the second-largest popcorn producer in the nation behind Nebraska.

The NASS said total Indiana production was a record 4.32 million hundredweight, or cwt, equal to 432 million pounds. That was up 16 percent from the 3.72 million cwt in 2013. The average yield of 48 cwt per acre, up 2 cwt from 2013, also was a record.
This one-year-old hellbender will be raised in captivity for the next few years before being returned to the wild.
When 50 young hellbenders moved from Purdue University’s Aquaculture Research Lab to one of three Indiana zoos to be reared for the next few years, it may mark about the farthest distance they will travel in their lives. Adult salamanders only range about 300 meters. But spending the first years of their lives in captivity will greatly improve their odds for survival.

Purdue is partnering with Columbian Park Zoo in Lafayette, Fort Wayne Children’s Zoo and Mesker Park Zoo in Evansville in a conservation program that will involve raising year-old hellbender salamanders and then returning them to their southern Indiana habitat.

Zoos Crucial to Survival

Rod Williams, associate professor of wildlife science and leader of the university’s hellbender effort, approached zoo officials about joining the program, which also includes the Indiana Department of Natural Resources.

North America’s largest salamander is in decline nationally and is most vulnerable to predators when young.

Wildlife scientist Rod Williams is partnering with three Indiana zoos and the state to raise juvenile hellbenders in captivity and increase the species’ odds for survival.
Purdue’s Rod Williams (from left) and Erin Kenison and Fort Wayne Children’s Zoo David Messmann and Joe Smith celebrate the first transfer of hellbenders to an Indiana zoo.

**Saving a Species — continued**

“Mortality can be as high as 99 percent in the wild,” Williams says. “By rearing them in captivity for three to four years they will have a much better survival rate.”

In 2013, Williams and his team collected 300 eggs from the Blue River in southern Indiana, currently the only location in the state where the salamander is found.

“You don’t want to have all your eggs in one basket—literally,” Williams says, referring to the 1-year-old hellbenders that were hatched at the aquaculture facility. “Parceling some of them out to different locations reduces the risk that an equipment malfunction or other problem could jeopardize the entire clutch of eggs.”

This spring, the research team transported the hellbenders to the zoos in a pickup outfitted with water tanks that maintain the same conditions as in the lab. The zoos have been preparing since last summer, setting up chillers, water pumps and tanks, replicating lab conditions.

Last fall, a representative from each zoo and Williams’ team attended a hellbender husbandry conference at the St. Louis Zoo, a world leader in captive rearing of the amphibian.

Joe Smith, director of animal health for the Fort Wayne zoo, says the zoo’s mission is to inspire people to care about wildlife.

“We’re always looking for local opportunities, and it’s especially important that our guests can take steps to protect hellbenders and their environment,” he says.

“Knowing that they will be returned to the wild is a big motivator for me,” says Smith, a veterinarian. “We don’t often get to contribute to conservation so directly. Most of our impact is through education.”

For Williams, education is an important part of the partnership. The zoos will expand on Purdue Extension programming and the Help the Hellbender website.

Studies conducted by Linda Prokopy, associate professor of natural resources planning, showed that awareness of the hellbender is pretty low, especially among the general public. Saving the species will take buy-in from people who live in the areas surrounding the rivers and streams where the animals live. And anglers need to know what they should do if they catch a hellbender.

“Collectively, the zoos can reach about a million patrons a year,” Williams says. “The combination of research, conservation messaging and increased awareness is a win-win for everyone.”

While Columbian Park Zoo has worked with Purdue on other projects, this is its first wildlife conservation collaboration with the university, says Dana Rhodes, interim zoo director. “It’s a great conservation program and local-state partnership.”

While the hellbenders will not be incorporated into public exhibits at the zoos, they may be included on special tours, such as those for school groups.

**Expanding Hellbenders’ Habitat**

This summer Williams’ team will evaluate the habitat quality of Indiana’s historic waterways—tributaries of the Ohio River—for water quality, prey abundance and habitat stability, as well as checking for the presence of hellbenders. Previous surveys have not located hellbenders outside the Blue River, but scientists now have a much more accurate method at their disposal.

Williams and Zach Olson, a former post-doc at Purdue, showed that they could detect hellbender DNA from samples of moving water. This process—termed eDNA sampling—is especially valuable because traditional detection methods required people to literally turn over stones in rivers and visually spot the amphibians. “We don’t think we will find any (outside the Blue River), but we want to check to be sure,” Williams says.

The Purdue team will work with the Indiana Department of Environmental Management to evaluate water quality in the streams. Hellbenders prefer fast-moving currents and rocky stream bottoms. Like many other amphibians, they breathe through their porous skin, which makes them vulnerable to water pollution.

In September, researchers will return to the Blue River to again collect eggs. After hatching, the young will be kept at Purdue until they are approximately six months old—a critical period in their development.

As the Purdue program expands, Williams anticipates that Fort Wayne and Mesker Park, the two larger zoos, will be able to take an increasing number of hellbenders.

“We wanted to start small while everybody is learning,” he says.

**Survival Rate Increasing**

Two years ago, Williams and his team released 18 hellbenders—collected in West Virginia and reared
A new Purdue University exhibit explains the important role that salamanders play in the environment. A Salamander Tale, a traveling exhibit of the Department of Agricultural Communication's Exhibit Design Center, explores the world of salamanders with the help of a guide, Herbie the Hellbender. Visitors to the exhibit will learn what makes a salamander a salamander, discover how amphibians differ from reptiles and read about how people can help protect salamanders. They also can play a video game and guide a hellbender through a river environment.

Content for the exhibit was provided Rod Williams and Linda Prokopy of the Purdue Department of Forestry and Natural Resources. The exhibit debuted in January at the Culture and Heritage Museum in Rock Hill, South Carolina. The hellbender, a declining amphibian species, is endangered in at least five states and protected or of special concern in many others. Surveys in Indiana starting in 1998 have shown that populations had not only declined but that remaining hellbenders were in particular danger. Also known as "old lasagna sides" because of noticeable wrinkles on their sides, hellbenders typically grow to as long as 24 inches. They spend up to 30 years under flat rocks in rivers and streams across Appalachia, parts of the Midwest and the northern tips of several southern states.

The study provided valuable baseline data. "What we learned will help improve how we rear them in captivity and ultimately increase survivorship," Williams says. "While 22.5 percent may not seem that high, going from 1 to 22.5 percent is a huge jump. Our goal is to reach 40-50 percent. That would be remarkable and go a long way to restoring the hellbender population in Indiana."

The next hellbender release will be 80 in summer 2016, followed by an additional 130 in summer 2017. These hellbenders, too, will be fitted with transmitters. Williams expects to release some of them in at least one other waterway.

Williams grew up near Corydon, Indiana, close to many of the streams the hellbenders would have inhabited. He never encountered one in the wild until he was approached by Indiana Department of Natural Resources officials in 2007 to help spearhead the conservation project.

"When my wife and I were dating in high school, we took a canoe trip on the Blue River, the same waters where they live," he says. "To think that we could see them in more of these streams where I grew up will be like coming full circle."

Contact Olivia Maddox at maddoxol@purdue.edu
It’s not unusual for college students to feel homesick. But for Melinda Crow, the pain of separation from her native San Carlos Apache community in New Mexico was so severe it nearly cost her a dream handed down by her parents—the chance to earn a graduate degree in the plant sciences.

Dream Endangered

Crow’s mother and father both served in the Air Force, but they encouraged Melinda to follow her own path. After completing a bachelor’s degree in environmental science at Haskell Indian Nations University in Lawrence, Kansas, Crow enrolled in the College of Agriculture at Purdue to pursue her master’s.

It wasn’t long before she felt a profound culture shock. “The campus was so big,” she recalls. “It was very different from where I had grown up and gone to school.”

In the summer of her second semester Crow decided to pack up and go home to Albuquerque.

She might have stayed there, probably giving up on her education and pursuing a career in business, she says, if it had not been for the support she received from her mentors and peers in the Sloan Indigenous Graduate Partnership program.

“My professor, Kevin Gibson, called me and told me he wanted me back,” Crow says. “He did everything possible to make sure I succeeded.”

Purdue a Leader

The Sloan program, funded by the Alfred P. Sloan Foundation, was established at Purdue in 2007 to provide academic, financial and moral support to American Indian and indigenous students pursuing graduate degrees in science, technology, engineering and math—the so-called STEM fields.

Purdue is the lead institution in the Sloan consortium. The other partners are the University of Alaska Anchorage, University of Alaska Fairbanks, University of Arizona, University of Montana, Montana State University and Montana Tech.

Purdue might seem to be an unlikely hub for one of the nation’s premiere Native American scholarship programs. As Felica Ahasteen-Bryant, director of Purdue’s Native American Educational and Cultural Center, points out with a wry smile, “There aren’t a lot of Indians in Indiana.”
The state has no federally recognized tribes, and before Ahasteen-Bryant’s appointment in 2007, Purdue had no Native American student organization.

There was, however, a small group of faculty and staff who saw a pressing need and set out to meet it. “We had native students come here and struggle because they were in a strange environment with no role models or support system,” says Ken Ridgway, a professor of earth and atmospheric sciences and member of the Lenape (Delaware) Nation, who has mentored many of the Sloan students.

Native Americans have historically been among the most underrepresented minority groups in STEM fields.

According to statistics from the Sloan Foundation, only 48 research doctorates were awarded to American Indian and native peoples in 2012. Indigenous people account for 1.2 percent of the U.S. population yet received just 0.3 percent of all doctorates awarded that year, down from 0.5 percent 20 years earlier.

New Generation of Scholars

One of the main goals of the Sloan program is to create a new generation of Native American scholars who can be role models for future scholars in the STEM fields.

“That’s really critical,” says Raymond RedCorn, a Ph.D. candidate in agricultural and biological engineering and member of the Osage Nation of Oklahoma. “When you don’t see other people who look like you, you question if it’s doable.”

So far, 16 Sloan students have earned master’s or doctoral degrees at Purdue. Many of them have returned to their communities to work with young people.

Crow completed her master’s thesis in botany and graduated from Purdue in 2012. She is now a faculty member at Haskell, where she mentors low-income native students who are the first in their families to attend college.

“It’s an honor to be working here and helping to foster relationships between Haskell and Purdue,” she says. “Now I have an opportunity to help make those transitions easier.”

Contact Darrin Pack at dpack@purdue.edu
The Power of Orange

Naturally Nutritious Orange Corn Counters
Africa’s “Hidden Hunger”

By Natalie van Hoose

Purdue plant geneticist Torbert Rocheford owes a lot to cow manure. Unsure of what to do with his life after college, he took on grunt work at a dairy farm in Maine, contemplating a graduate degree in animal breeding. But the more manure he spread over the fields around the farm, the keener his interest in plants became.

Plus, he reasoned, plants don’t kick.

His interest was piqued by plant breeding courses offered by the University of Maryland, and he enrolled in the school's agronomy program, a subject he had never heard of before. The legacy of Norman Borlaug, the iconic plant breeder whose semi-dwarf cereal crops helped spark the Green Revolution, inspired him.

“I wanted to feed the world,” he says.

Rocheford worked with several crops before settling on corn. Decades of work have not dulled his admiration for its rich genetic diversity—DNA sequences differ wildly between corn varieties—or the bounty of kernels studding each ear.

Amping Corn’s Nutritional Clout

Now the Patterson Endowed Chair at Purdue, Rocheford focuses on boosting the nutritional quality of corn, a process known as biofortification. His open-pollinated variety of maize growing at the edge of the Purdue Agronomy Center for Research and Education (ACRE) boasts a unique quality: Its kernels are a deep orange hue. This corn, the product of 10 years of natural plant breeding, is packed with carotenoids, organic pigments that range from pale yellow to dark red.

Carotenoids offer more than color. They are also antioxidants and sources of key nutrients. Humans and animals—with the exception of the pea aphid—cannot make their own carotenoids and rely on their diet to supply them.

The orange corn bred by Rocheford’s lab and his collaborators have unusually high levels of provitamin A carotenoids, substances such as beta-carotene and beta-cryptoxanthin, which can be converted by the human body into vitamin A. Stored in the liver, vitamin A is essential to the immune system, reproduction, communication between cells and the synthesis of certain hormones. It also becomes retinal, the primary light-absorbing pigment in the eye.

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Global Partners in Research Combat Malnutrition

By Jennifer Stewart

On a breezy day just outside of Texcoco, Mexico, passersby can hear the rustle of food crops growing in the research plots surrounding the International Maize and Wheat Improvement Center, or CIMMYT.

Pulling back the husks on some of the corn plants reveals bright orange kernels—evidence of a long-standing collaboration between CIMMYT and Purdue Agriculture. Orange corn, rich in provitamin A, is part of a HarvestPlus-funded project led by Purdue plant geneticist Torbert Rocheford. The goal: To get provitamin A into the diets of severely deficient populations, starting in Zambia.

Rocheford says the task would be impossible without his international partners. Indiana weather patterns, disease pressures and soil types don’t lend themselves to testing plants adapted to very different climates. “For example, corn adapted to Indiana is generally not going to have the kind of disease resistance needed for Zambia.”

Enter CIMMYT. Rocheford and collaborators at Cornell and Michigan State universities working on a complementary National Science Foundation-sponsored project identify natural forms of the target genes that will efficiently increase orange color, provitamin A and total carotenoids. They share the results with CIMMYT, where researchers take the genetic information and put it into corn ideally suited for growth in Zambia.

Relationships like this one have a variety of benefits, says Purdue’s Jess Lowenberg-DeBoer, associate dean and director of International Programs in Agriculture. “International collaborations enhance Purdue’s research in several ways, including partnerships with cutting-edge researchers located outside the U.S. Our research benefits from their skills and insights,” Lowenberg-DeBoer says. “Sometimes these partnerships also give us access to scientific equipment and infrastructure that we do not have at Purdue and field research opportunities to test theories or hypotheses in a very different environment from what we have in the U.S.”

Corn to Conquer Climate Change

Orange corn isn’t Purdue Agriculture’s only work with CIMMYT. The two have partnered on a handful of other studies, including a project called Heat Tolerant Maize for Asia (HTMA), led by Mitch Tuinstra, a Purdue professor of plant breeding.

Like Rocheford, Tuinstra needs access to the right maize varieties and growing conditions. His lab is working to identify the genes and traits for heat-stress tolerance. The research team partners with CIMMYT on access to germplasm and testing environments. HTMA is tested in field plots at CIMMYT’s sister institution, the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), in Andhra Pradesh, India.

HTMA is a Global Development Alliance project funded by the U.S. Agency for International Development with matching funds from Purdue and public- and private-sector maize breeding programs in India, Pakistan, Bangladesh and Nepal.

The project is vital as researchers race to understand how crops react to climate change. “We know almost nothing about crop adaptation to high-temperature stress, and climate change is a big concern in Southeast Asia,” Tuinstra says. “This presents serious challenges for the ability to produce enough food.”

Boundless Benefits

Purdue Agriculture works with public and private institutions, foundations and companies worldwide, including the Gates Foundation, the Tropical Agricultural Research and Higher Education Center in Costa Rica, and Kabul University in Afghanistan.

The results of those partnerships not only improve lives elsewhere, but in the U.S., too, Lowenberg-DeBoer says.
The diets of Western countries generally supply enough vitamin A, but vitamin A deficiency plagues parts of the world such as sub-Saharan Africa, leading to blindness and an increased susceptibility to infections, which can prove fatal. Children, who need the vitamin for development, and pregnant or nursing women, who require it for sustenance, are especially vulnerable. The World Health Organization estimates that every year 250,000-500,000 children go blind as a result of a lack of vitamin A. Half of them die within a year of losing their eyesight.

To help combat the deficiency, Rocheford and his fellow researchers teamed up to develop nutritionally richer varieties of corn with HarvestPlus and the International Maize and Wheat Improvement Center (CIMMYT), institutes that are part of the CGIAR global partnership of organizations working to improve food security. Corn is a staple crop and a dietary mainstay in countries that suffer most from vitamin A deficiency. Many people in sub-Saharan Africa eat nshima, a grits-like dish made from corn, three times a day.

“The point of biofortification is to look at what people are eating, what their staples are, and make those more nutritious,” Rocheford says.

Orange Corn Lends an Ear to America

If Rocheford has his way, people all over Africa, the U.S. and beyond will one day hear the rustle of orange corn dancing in the breeze. HarvestPlus already has taken the crop to Zambia and Zimbabwe and is beginning a program in Ethiopia. The development of orange corn hybrids for the U.S. has started.

While Americans don’t typically lack provitamin A, Rocheford says orange corn has high total carotenoids, a type of antioxidant, which could be good for the eyes.

“The U.S. population doesn’t really need any more vitamin A,” Rocheford says. “But we may be deficient in the carotenoids lutein and zeaxanthin, which are good for eye health. It’s still unclear whether the increasing rates of macular degeneration are due to lower levels of lutein and zeaxanthin in the diet, but the macular is full of them. It would be good to have more carotenoids in our diet.”

Cont.
The Power of Orange
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the developing world to skyrocket—bring affordable food to hungry populations—the productivity of non-staple foods did not make a similar leap. This pushed up prices of foods such as pulses, produce, fish and animal products. As a result, many people in poverty could put more calories on their plate, but at the expense of getting the diversity of the nutrients they needed.

“Agriculture must play a major role in the solution to vitamin and mineral deficiencies that the food system may have inadvertently caused,” Bouis says.

Biofortification could be a crucial component of that solution. About 75 percent of the world’s poor live in rural areas, too far from urban hubs to be effectively reached with supplementation. But giving rural farmers ways to grow their own more nutritious crops can enrich the diet of many.

“It’s the power of a seed,” Bouis says.

Corn of a Different Color

The research team had to adapt its biofortification efforts to encompass two additional challenges: The corn had to be all-natural to ensure that the people who needed provitamin A the most would eat it—and a new color was in order.

Consumers in sub-Saharan Africa have a strong cultural preference for white corn, which contains almost no carotenoids. Yellow corn is more nutritious than white, but it is fed almost exclusively to animals in most African countries. Rocheford’s team and colleagues at CIMMYT would have to develop a type of corn that did not resemble yellow corn in order for the crop to pass the muster of deeply entrenched traditions.

Examining a set of diverse lines of corn from all over the world provided by Ed Buckler of the U.S. Department of Agriculture’s Agricultural Research Service, Rocheford noticed that ears of orange corn from Thailand had naturally high amounts of carotenoids, providing a genetic base with which breeders could work. The distinct color of the corn was an added benefit.

The team has spent years identifying and characterizing genes in corn’s carotenoid biosynthetic pathway in hopes of pinpointing the factors behind provitamin A production. So far, Rocheford and colleagues at Cornell and Michigan State universities have identified several genes that can be selected to rapidly convert high-yielding white corn varieties into orange corn that contains large amounts of provitamin A. Breeders at CIMMYT and Rocheford’s group are using the genes to strategically select and breed for varieties that have higher levels of these nutrients and are suitable for Africa’s growing conditions.

“The faster we can get favorable forms of these genes into orange corn, the faster we can save human lives,” he says.

Transgenic biotechnology could potentially speed the biofortification process, but the team was concerned that genetically modifying the corn would prevent consumers in Africa from accepting it. To sidestep any potential controversy, the team uses natural selection and breeding methods used for thousands of years.

Their efforts have brought the provitamin A levels in high-yielding, orange corn hybrids up to 12 parts per million, nearly a tenfold increase over levels in most yellow corn varieties. Experimental lines at CIMMYT that trace back to the orange corn grown at ACRE can contain up to 35 parts per million when the most favorable form
of one of the first identified genes is crossed in.

Testing Corn on African Taste Buds

Three varieties were released in Zambia in 2012, and acceptance studies that measure consumer response to orange corn have been positive, Rocheford says. HarvestPlus works with local breeders and growers to spread awareness of the corn, its nutritional benefits, and how to grow it. More than 10,000 farming households in Africa now know about orange corn.

Rocheford’s favorite example of orange corn’s success is a story told to him by Eliab Mupongwe, the HarvestPlus country manager for Zambia. Mupongwe held a field day for orange corn and provided local women with enough ground orange corn to make 100 servings of nshima for lunch. But when the meal was served, there was only one platter of orange nshima, which was offered to dignitaries and politicians—all the other platters had nshima made from white corn.

He asked the kitchen staff what had happened. The head cook replied that when they heard the orange corn contained vitamins, they took it home and fed it to their children.

“That’s no statistical test or formal study, but it sums up nicely that there’s good potential for consumer acceptance,” Rocheford says.

Considering cultural issues in addition to plant genetics and field management practices should be common practice for good plant breeders, he says. Scientists on the team have had to contend not only with plant biology, but also with consumer behavior, cultural preferences, logistics of seed delivery and local politics. Rocheford sees all these factors as part of the job.

The HarvestPlus and CIMMYT teams are preparing to introduce orange corn into Zimbabwe and Ethiopia, where varieties will need to be able to withstand drought and the low nitrogen conditions of the soil.

Rocheford’s ultimate dream is to see orange corn sown all across sub-Saharan Africa. He also aims to bring orange corn to growers in the U.S. The corn contains the carotenoids lutein and zeaxanthin, which may help prevent macular degeneration, a leading cause of impaired vision in the elderly. CIMMYT is now sending him improved versions of the genetic materials he helped discover and develop to cross into Midwestern corn germplasm.

“That’s a total paradigm shift,” he says. “This shows the value of thinking globally—trying to help your neighbors may in turn help you some day.”

Contact Natalie van Hoose at nvanhoos@purdue.edu

A researcher at CIMMYT holds a vial of carotenoids isolated from kernels of orange corn. The institute, founded by Nobel laureate Norman Borlaug, employs about 180 researchers who work on improving wheat and maize yields and nutritional content.
Emily Erickson grew up on a hobby farm—milking dairy goats, raising chickens and growing vegetables. In addition to this hands-on experience, she and her siblings made the management decisions for the family enterprise as well.

Dairy goats were her favorite project. She learned about herd health and management, participated in 4-H and attended shows. Goats also fueled science-minded Erickson's interest in research.

"Milking dairy goats every day sparked my interest in mammary biology research, and with that my research career began to take off," says Erickson, now a senior biochemistry major.

National Recognition

Her impressive undergraduate research career culminated in January when she was awarded the prestigious Churchill Scholarship. Only 14 students nationwide receive this competitive award, which funds a one-year master's degree in science, engineering or mathematics at Churchill College at University of Cambridge in Great Britain.

"We are as proud of Emily as her family and friends must certainly be," says Purdue President Mitch Daniels. As our first Churchill winner since 1997, she has brought honor to our entire university. We wish Emily the best of luck and know she will be a tremendous Boilermaker ambassador.”

Erickson's goal is to conduct research in Cambridge's Department of Pathology that will eventually lead to the development of more effective treatments and therapeutic solutions for breast cancer.

She began this line of research in the lab of Karen Plaut, director of agricultural research at Purdue. “Researching aspects of breast cancer in Dr. Plaut's lab led me to spend a summer at the National Institutes of Health," Erickson says. "I studied the regeneration of the mouse mammary gland and how the signaling involved in its regeneration may possess the capacity to redirect cancerous cells." This research also introduced her to mammary stem cells, the part they play in the normal development of the mammary gland and their role in the progression of cancer.

Erickson also spent a summer at the Mayo Clinic, working in drug discovery for pulmonary fibrosis. Her academic accomplishments have led to several national distinctions, including the Goldwater Scholarship and Astronaut Scholarship. She says these experiences helped her through the rigorous application process for the Churchill Scholarship. Purdue's National and International Scholarships Office helped her navigate the scholarship application process.

A Balanced Life

Erickson also continues her childhood connection with goats, co-founding the Purdue Goat Club and currently serving as its president. The goat club hosts outreach activities such as "Pet a Kid" and conducts workshops across Indiana to educate youth about goats and their worldwide role in agriculture and sustainability. "Goats are so efficient," she says. "They can browse on trees and shrubs, and provide milk and meat."

Her passion for goats and music—she's principal violist in the Purdue Philharmonic Orchestra—helps keep life balanced for the busy young researcher. She plans to play her viola as part of Churchill College's Musical Society, which coordinates several ensembles and performing groups of students and staff. "I'm excited to continue my musical experiences at Cambridge, as music is such a big part of my life," she says.

Erickson credits the College of Agriculture's tight-knit community with providing a supportive environment in which to thrive. “The connections, networking and encouragement from professors and mentors have been so helpful.”

From goats to Cambridge by way of Purdue Agriculture—what a journey. And it's only the beginning.

Contact Rosanne Altstatt at altstatt@purdue.edu
As a recipient of the prestigious Churchill Scholarship, Emily Erickson will work on a master’s degree at the University of Cambridge in Great Britain. She’ll continue to focus on breast cancer research.
Big data. Big potential. Big challenges.

Agriculture becomes more high-tech every year, and researchers at Purdue University are zeroing in on how the gazillion bits of digital information being created every day—“big data” as they are often called—can help farmers become more efficient and even more productive. That need will only continue to become greater as a world population grows from 7 billion people today to a projected 9 billion by 2050.

That’s a lot of mouths to feed. There’s also the reality that farmers not only will have to produce much more food than they do now, but they will have to do it on perhaps less land around the world while also protecting the Earth’s natural resources as much as possible to sustain agriculture for future generations.

“Although farmers are more efficient now than they have ever been throughout history, there still are challenges ahead of us, and we are using technology in our work to find solutions,” said Karen Plaut, the College of Agriculture’s senior associate dean for research and faculty affairs.

Maximize Yields, Minimize Impact

The benefits of agronomic data generated in the field are clear to Katy Martin Rainey, an assistant professor of agronomy.

“It’s all about maximizing yields and minimizing environmental impact,” she says.

Rainey sees the potential in using drones to obtain data that can help in the assessment of soybean crops’ health and be another tool to predict yields. The unmanned aerial vehicles, or UAVs, hover above the plants and take digital maps that can be layered with data from other sources for deeper, more defined analysis.

Integrating data from multiple sources can be difficult because of varying data formats and incompatible software and hardware.

“That’s really the big challenge,” Rainey says. “But when you collect a lot of data and integrate it, you can do a lot with it.” The information, for
example, can help researchers develop better seeds and delve deeper into the intricacies of how crops grow. And special cameras record infrared waves that can tell the plant canopy’s temperature; a warm canopy might indicate a pest problem or that a specific part of the field might need irrigating.

Purdue Agriculture’s plant sciences initiative, part of the Purdue Moves program to develop more research and educational opportunities across the university, has a big data element. The university is building an Automated Plant Phenotyping Facility at the Agronomy Center for Research and Education to develop automated systems that aid researchers by collecting billions of field measurements showing differences in plant characteristics, such as canopy development, leaf area and photosynthetic ability. The facility will open in 2016.

**Boosting Production Abroad**

Purdue’s work in collecting and building agronomic data extends abroad to help farmers in other countries produce more food. Phillip Owens, an associate professor of agronomy, is heading a three-year project to map the farm soils of the entire Central American countries of El Salvador, Honduras and Nicaragua—areas comprising 143,400 square miles, about four times the size of Indiana.

The research, conducted in collaboration with Catholic Relief Services and regional and national partners, is funded by a $5 million grant from the Howard G. Buffett Foundation. The objective is to assess soil fertility down to the farm level, indeed even to sections of individual fields, with the goal of reducing application of fertilizers and helping farmers decide which fertilizers would be best for their crops. That, Owens says, would help farmers weigh production costs against possible yields—inputs versus outputs.

Using historical information in the form of soil characteristics records, geology, digitized maps of land elevations and locals’ understanding of soil functions, he and postdoctoral researcher Jenette Ashcroft of Cleveland and research soil scientist Minerva Dorantes of Chicago are developing practical field-scale maps of soil properties. Based on the data they analyze, they will produce a soil suitability index that will help farmers know not only which crops would grow best on their land but also where there is greatest potential for soil erosion, where water on their farm is most and least available and how water is likely to drain.

Possibly the greatest contribution of this project stems from training local people to use and continually update their countries’ maps.

“We’re putting big data into the hands of small farmers,” Owens says. “We’re setting a platform for better economic growth and to continue to improve their countries.”

But convincing farmers that they should change their ways based on new, high-tech research could be difficult because their livelihoods are engrained through generations of experience.

“People don’t like to experiment with their own livelihoods,” Owens says. “In the end, it will always take an expert to analyze the new information and make recommendations to them.” (See “Purdue Ag Economist: Give ‘Big Insights.’”)

**For the Greater Good**

Information in the form of data from individual research projects already conducted also could be very helpful to the agriculture industry, policymakers and researchers if it were readily available. Agronomy professor Sylvie Brouder was an organizer of a meeting in the Washington, D.C., area in 2013 on the topic of developing a system to provide open access to agricultural research data.
Brouder says data from her research on crop nitrogen responses, coupled with research conducted by others, could help modelers project how nitrogen applications would affect the environment of an entire watershed without conducting a full series of their own field experiments.

“The theory is that my data is more useful in aggregate with your data rather than as stand-alone,” Brouder says. “Traditionally, data in agricultural research have no purpose beyond the current research. But it really does have value beyond that one experiment.”

Tool for Farm Management

Dennis Buckmaster, a professor of agricultural and biological engineering, says farmers also would benefit from data that could help them know how to best market their crops, such as by assessing the demand during and after harvest, and determining what percentage of the crop they might sell at harvest and store on the farm for selling later, and whether to ship it by truck or rail.

Buckmaster, who co-coordinates Purdue’s Agricultural Systems Management program, last year helped to create the Open Ag Data Alliance, an industry organization including Purdue’s Open Ag Technology Group. Part of the alliance’s mission is to develop protocols to make data systems more compatible.

“Data only becomes ‘big’ when you gather it and layer it into something useful,” he says. “Otherwise, it’s just pockets of information.

“To be more useful, data needs to move among systems and be exchanged from one software package to another. But farmers should control how this happens. Controlled systems that aggregate and share information with trusted parties are being developed quickly.”

Associate professor of agricultural economics Scott Downey has a tip for farmers:

“Focus on big insights, not big data.”

Downey wrote a blog item (“What’s all the fuss about big data?”) in which he says Purdue University research shows that farmers overwhelmingly trust local supplier representatives more than they do manufacturers or specific brands.

Downey, an associate director of Purdue’s Center for Food and Agricultural Business, also says some local suppliers have seen that their business is changing from selling tangible products to providing an intangible, information-based service that brings specific insights to the farmers who trust them with the data.

He says local companies will have an advantage if they get good at analyzing data aggregated from hundreds of square miles of farmland—not just from one individual farm.

“Local dealers and retailers should be talking about how they can cooperate with farmers to find the best farming practices for the farmers in their area—using local soil types, water availability and genetics from a wider geography than any one farmer could have on their own.

“The local supplier who brings this type of value will justify the trust their farm customers have placed in them.”

Whether at the manufacturer level or the local level, Downey says “big data will be driving agriculture, and there’s a race to control access to it.”

“The winner in that race will be those organizations that figure out that big insights are way more important than the big data.”
Howling with Wolves

On a late summer evening the sun was setting and the air getting cooler while Rachel Vanausdall ran through wolf facts and information in her head.

The senior wildlife major from Lebanon, Indiana, was preparing for Howl Night at Wolf Park in Battle Ground, Indiana, during an internship last year. Vanausdall and other staff members help Wolf Park visitors learn about wolves and howl at the moon with them.

Four years ago, Vanausdall attended an educational program at Wolf Park and knew she just had to get involved. The nonprofit park is dedicated to research, conservation and public education about wolves. A Howl Night experience solidified her choice to volunteer and kept her coming back.

“Howl Nights are incredible in all seasons,” she explains. “However, despite the frigid cold, winter is probably the best time for a howl night. You can see the wolves more clearly, and they seem to like the cold, so they are pretty active during the program.”

When Vanausdall first started at Wolf Park, she volunteered and assisted in the gift shop. But when she learned about an internship, she was eager for more responsibility—despite some intense competition.

“Wolf Park’s internships are pretty popular,” she says. “They take 10 interns a season from all over the world. Since I was already familiar with the animals and staff as a volunteer, I was accepted for the summer after my freshman year.”

As an intern, her responsibilities expanded. She interacted more with the wolves, observed wolf behavior, helped medicate them and even took care of wolf puppies. She relied on those observations and experiences when she led tours.

“The cool thing people don’t realize about the animals at Wolf Park is that they are not domesticated animals; they are socialized wild animals,” Vanausdall says.

Socialization is a process that begins early in a wolf’s life. Park staff remove wolf pups from their mothers at 10 - 14 days old. Human foster parents live and interact with the pups continuously for the first month of their lives.

Before the pups are placed back with other wolves in their natural habitat, they have interacted with humans for about 1,500 hours. So while they are used to humans, they are still wild animals, which can make them unpredictable.

Vanausdall used the behavioral similarities between dogs and wolves to connect with her audiences.

“For example, if a wolf gets nervous, it starts blinking really fast or flicking its tongue,” Vanausdall says. “We are trained to look for things like that, and we can show visitors what to look for, too.”

For Vanausdall, the most rewarding experiences were the ones she didn’t expect to enjoy.

“Wolf Park taught me how to work with people,” she says. “It was fun to convey the information I learned, and having people share my excitement made everything worthwhile.”

From the Fall 2014 issue of Destination Purdue, a publication for high school students that seeks to broaden the awareness of agriculture and promote interest in the College of Agriculture.
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