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Agricultural Research Service

SCIENTIFIC DISCOVERIES

The Impact of Agricultural Research Service (ARS)

Research - Fiscal Year 2018

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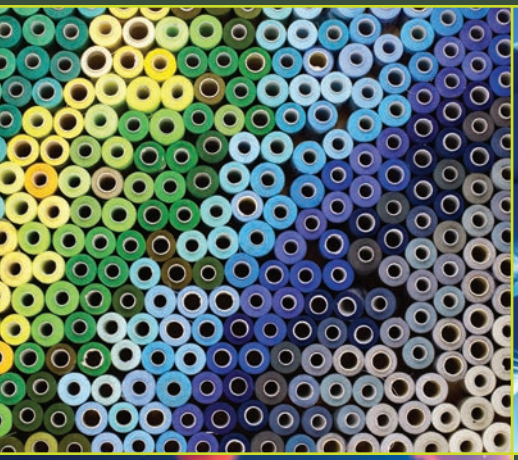

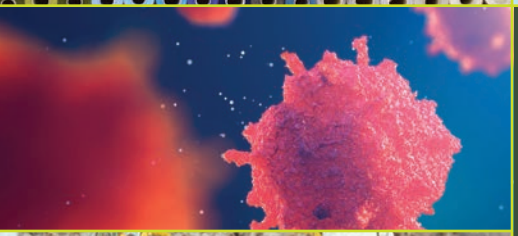

Mission

ARS delivers scientific solutions to national and global agricultural challenges.

Vision

Global leadership in agricultural discoveries through scientific excellence.

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Chavonda Jacobs-Young, Ph.D.
Administrator
Agricultural Research Service

INTRODUCTION

The Agricultural Research Service (ARS) is the chief, in-house scientific research agency of the U.S. Department of Agriculture. As ARS Administrator, I feel very fortunate to be part of a dynamic organization whose scientific and technological achievements have far-reaching impact—both here at home on the daily lives of Americans and globally as well.

I'm also *proud* of ARS—and not just because our research generates $20 of economic impact for every dollar invested in it. I'm proud because of ARS's long tradition of scientific excellence, integrity, and timely information sharing.

In this latest edition of *ARS Scientific Discoveries*, you'll read about select ARS accomplishments in crop and animal production, animal welfare, food safety, human nutrition, natural resources, and other areas of high national importance. You'll also read about some of the unique facilities and assets that ARS brings to bear in tackling these priorities—from the Electron and Confocal Microscopy Research Unit in Beltsville, MD, to the National Plant Germplasm System, a living collection of plant genetic diversity that's critical to world food security.

ARS is much more than just its buildings and scientific research program; it's about the people, too. Some of them are world renowned for their achievements, and we proudly highlight two of these individuals on page 48. Just as often, though, great things take place out of the limelight and on a smaller scale in our labs, greenhouses, and experimental plots across the country.

My travels to meet the staff at a few of our 90-plus field locations each year really underscore this point. The ongoing demonstration of innovative approaches and creative problem-solving exemplifies the folks who make ARS a premier research organization. I greatly appreciate their dedication and hope you enjoy reading about their many accomplishments in this year's *ARS Scientific Discoveries*.

Chavonda Jacobs-Young

97 PROJECTS
$198 MILLION

Animal Production and Protection

114 PROJECTS
$236 MILLION

Natural Resources and Sustainable Agricultural Systems

8,000
ARS Employees

90+
ARS Locations

Students participating in ARS outreach events

>33,500
School and community presentations

>15,000
Science fairs

>11,000
ARS location visits

>14,000
Courses and demos

FUNDING

Crop Production and Protection

Nutrition, Food Safety and Quality

ARS NUMBERS AT A GLANCE

61
Number of new patents issued

40
Number of new licenses

4,138
Peer-reviewed publications

ARS STUDENT REACH

ARS trainees

>2,100
Students and interns

>450
Postdocs

76,050
Total number of students reached

SECTIONS

ANIMAL PRODUCTION AND PROTECTION

PROTECTING ANIMAL HEALTH AND CONSUMERS FROM DISEASE

Public health concerns over the first U.S.-confirmed case of bovine spongiform encephalopathy (BSE) in Washington State in 2003 prompted trade restrictions that cost the Nation's cattle and associated industries an estimated $11 billion in losses from 2004 to 2007. BSE is a progressive neurological disease that damages the brains and spinal cords of afflicted cattle, causing poor coordination, erratic behavior, and other symptoms. Abnormally structured proteins called "prions" cause BSE and related disease in sheep and goats, known as "scrapie" (at $20 million annually in losses), chronic wasting disease (CWD) in deer and elk, and, in humans, Variant Creutzfeldt-Jakob disease (vCJD). Two ARS locations—one in Ames, IA, the other in Pullman, WA—have been on the forefront of studies to diagnose prion diseases and distinguish between them in vulnerable livestock. Together with their Federal, State, and international partners, ARS researchers at the two locations have also developed preventive measures and tools that producers can use to safeguard their herds and flocks. This includes strategies for breeding scrapie resistance in sheep and goats—an approach adapted in the United States, Canada, and parts of Europe to eradicate the disease. In the United States, this program has reduced incidents of scrapie in sheep and goats by 90 percent annually since 2003. In another example, ARS-led research showed that cattle do not acquire "atypical" forms of BSE from eating prion-contaminated feed, unlike "classical" BSE, which has been linked to vCJD. Rather, atypical BSE is thought to occur spontaneously due to a rare genetic mutation, similarly to vCJD in humans. In 2012, 2017, and 2018, U.S. cattle producers dodged another costly round of trade restrictions after test results showed that the new cases of BSE reported in cows were atypical rather than classical. This confirmed that no breach in the safety and security of the feed given to cattle had occurred, and that the USDA surveillance system was effective in detecting rare cases of atypical BSE.

In the United States, this program has reduced incidents of scrapie in sheep and goats by 90 percent annually since 2003.

ANTIBIOTIC ALTERNATIVE BOOSTS PIGLET HEALTH

If you've ever been stressed out about something, then you know it can take a toll on you, not only mentally and emotionally but also physically. The same applies to livestock animals. In piglets, for example, stress from events like weaning or transport can hinder their immune function and leave them more susceptible to disease. Feeding the piglets dietary antibiotics was one solution to help them cope. In West Lafayette, IN, a team specializing in novel approaches to ensuring animal welfare and post-harvest food safety tried a different approach that began with amino acids, the basic building blocks of proteins important to many bodily functions. One of these amino acids, L-glutamine, shows potential to serve as a natural antibiotic alternative to promote growth and well-being in piglets. ARS researchers discovered this after conducting trials in which feeding supplemental L-glutamine as an antibiotic replacement to piglets improved their growth and intestinal health, especially during stress events. The discovery is especially timely given the 2017 Veterinary Feed Directive issued by the U.S. Food and Drug Administration banning the use of antibiotics in swine diets to promote growth. In the trials, newly weaned and transported piglets given L-glutamine in their diets to replace antibiotics ate 60 percent more food than those in other groups given either antibiotics or no antibiotics. In addition, piglets fed L-glutamine to replace antibiotics had less intestinal damage and showed fewer behaviors associated with illness than those not provided antibiotics. Encouraged by the results, ARS has filed a patent on the amino acid-based approach.

In the trials, newly weaned and transported piglets given L-glutamine in their diets to replace antibiotics ate 60 percent more food than those in other groups given either antibiotics or no antibiotics.

PROVIDING PIGS WITH BROAD-SPECTRUM *SALMONELLA* PROTECTION

Some types of *Salmonella* cause disease in food animals, like pigs, while others cause foodborne illness in humans. Although *Salmonella* vaccines are sold in the United States, most of them are specific to individual types of the bacterium. This can leave food animals and consumers alike vulnerable to other types of *Salmonella* that cause disease or foodborne illness, respectively. ARS researchers in Ames, IA, tackled the problem by using a laboratory-weakened strain of *Salmonella* to make a vaccine that offers cross-protection against multiple types of the bacterium that can infect animals or people. In experiments, the new vaccine protected pigs from infection by *S. Typhimurium* and *S. Choleraesuis* and, in turkeys, from a multi-drug–resistant type known as "*S.* Heidelberg." The latter is responsible for an outbreak in ground turkey in 2011 that led to one of the largest meat recalls in U.S. history. Another bonus: using the new ARS vaccine won't interfere with standard tests that producers use to check their pigs for natural *Salmonella* infections.

A FARMING BOOT CAMP FOR VETERANS

In Fayetteville, AR, scientists at the ARS Poultry Production and Produce Safety Research Unit have teamed with staff from the University of Arkansas (U of A) Division of Agriculture and the National Center for Appropriate Technology (NCAT) to introduce veterans to the farming profession and teach them basic agricultural practices. The program, now in its 10th year, includes workshops, more than 35 online courses, internships, and "Armed to Farm" boot camps at the U of A campus in Fayetteville. ARS scientists and staff have been instrumental in designing and overseeing the implementation of many of these training programs. Learning is focused in areas of expertise shared by ARS, U of A, and NCAT staff: poultry and livestock production, small ruminant (sheep and goats) production, marketing, and food production safety. Approximately 600 veterans have attended the summer boot camps and other programs to date. The boot camps last for several days, and attendees stay for free on the U of A campus, where they can learn as well as develop friendships and the kind of informal networks that can help them adjust to civilian life. The online courses are also free, enabling veterans to explore what farming may hold for them and learn at their own pace.

PROTECTING A TASTY FISH

Farm-raised tilapia is big business for fish producers, netting an estimated $8 billion annually worldwide. However, tilapia farmers lose about $1 billion annually due to two devastating bacteria: *Streptococcus agalactiae* and *Streptococcus iniae*. But relief is now in sight—for both the fish and the farmers who raise them. ARS researchers in Auburn, AL, helped evaluate new strains of tilapia that can resist the bacteria that cause the deadly fish disease streptococcosis. Management strategies, antibiotics, and vaccines typically used to combat streptococcosis can be effective but have drawbacks. Both approaches can be expensive, and the use of antibiotics raises concerns about antimicrobial resistance.
In cooperation with a Nile tilapia breeding company, ARS researchers developed experimental models for evaluating the effectiveness of selective breeding methods used to fortify the fish's defenses against streptococcosis. The work represents a milestone in breeding disease resistance in tilapia (the fourth-most consumed fish in the United States) and in reducing the dependency on costly antibiotics and their potential impact on the environment.

CROP PRODUCTION AND PROTECTION

PLANT DETECTIVES CORNER A CITRUS KILLER

Citrus greening (or Huanglongbing) disease has cost Florida's citrus industry $1.3 billion in losses since its discovery in the State in 2005. Today, citrus greening can be found in every citrus-growing county in Florida and throughout other citrus-growing States, including California. An insect called the "Asian citrus psyllid" spreads the bacterium (*Candidatus* Liberibacter asiaticus) that causes the disease. This happens when psyllids feed on citrus trees. Affected fruit are green, misshapen, and bitter. Although harmless to humans, the fruit is unsuitable for fresh market or juice. A team of ARS and Boyce Thompson Institute researchers in Ithaca, NY, may have found a weak link in the citrus-greening disease cycle, however. Before it can be transmitted to citrus trees, the bacterium must first breach the psyllid's gut cells to multiply. The researchers found that the insect's adult stage resists such cellular breaches by an act of cell suicide, undercutting the bacterium's chances of being transmitted. The team is now hunting for the details of that mechanism of resistance in hopes of unlocking ways to make nymph psyllids just as inhospitable—and less harmful to citrus trees.

BEEFING UP BROCCOLI'S HEAT TOLERANCE

Broccoli ranks among the top six most popular vegetables, with Americans eating 8 to 9 pounds per person annually. California grows the lion's share of the vegetable, but so do other States, particularly on the eastern seaboard. Eaten steamed, raw, or added to a favorite casserole, broccoli is packed with vitamins, minerals, and fiber. However, getting broccoli from farm to fork can be difficult. A cool-weather crop, broccoli's yield and quality can take a nose dive when summer temperatures soar. Aware this has hampered expansion of the $800-million crop into new production areas, ARS researchers in Charleston, SC, decided to examine the genetics that underpin broccoli's ability to cope with heat stress. That search led them to a particularly sturdy bunch of plants that could stand the heat of summer. The researchers also identified marker regions in the plants' DNA that broccoli breeders can use to pass the trait into commercial cultivars. Field trials are underway along the eastern seaboard, setting the stage for a longer growing season and new production areas to meet increasing demand for this nutritious powerhouse.

A "GUT CHECK" FOR IMPROVED HONEY BEE HEALTH

Let's face it, honey bees are the rock stars of the pollinator world. Their busy, fastidious collection of nectar and pollen from nearly 100 different kinds of flowering crops—including apples, cherries, and almonds—contributes $22 billion to the yield and quality of our Nation's agriculture. But life isn't always easy for our honey bee buddies. They face sundry threats, including from *varroa* mites, pesticide exposure, and poor nutrition. Among research pursuits to give them a helping hand, ARS researchers in Tucson, AZ, have focused attention on the honey bee "microbiome"—the bacteria and other microbes that inhabit the insect's gut. The researchers found a close connection between the microbiome's make up and the physiology of honey bee aging and stress. For example, as queens age, the levels of certain kinds of bacteria increase, while others diminish. This can exert a profound effect on the queen's and her colony's overall health. Besides a useful roadmap to improved methods of queen rearing, hive nutrition, and management, the researchers' microbiome findings may offer an excellent model for similar studies in other species, including humans.

COUNTERING AN ASH TREE THREAT

White ash has been a go-to wood for making Major League Baseball bats for quite some time because of its light weight and resistance to splintering, among other properties. But the sturdy wood species is no match for a half-inch, metallic green beetle known as the "Emerald Ash Borer" (EAB). The invasive pest was first detected near Detroit, MI, in 2002 and is found today in 33 States and two Canadian provinces. The EAB's larvae are mainly to blame for the deaths of hundreds of millions of ash trees. The larvae feed on the tree's inner bark, disrupting the movement of water and nutrients. ARS researchers in Newark, DE, are working to counter such attacks with releases of the parasitic wasp *Tetrastichus planipennisi* and gene-based control. In a 3-year study, the wasps killed 36 to 85 percent of EAB larvae in ash saplings and caused the pest's population to crash. The other approach deactivates specific EAB genes with material called "double-stranded RNA." In the lab, larvae that fed on sugar water containing the RNA died after 10 days, raising the prospect for a new, nontoxic pesticide to fight them with. Used in concert with other measures, these approaches could help put an end to the pest's appetite for destruction, saving a beloved tree of ecological, cultural, and economic importance to the Nation.

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BEER BREWING BEGINS WITH ARS HOPS AND BARLEY BREEDING

Beer is among the world's oldest and most widely consumed beverages, generating $111 billion in annual sales in the United States alone; in fact, humankind's thirst for the alcoholic beverage dates back an estimated 13,000 years. ARS has been on the forefront of recent efforts to breed new varieties of hops and barley used by the brewing and malting industry. ARS researchers in Corvallis, OR, have bred more than 20 varieties of hops since the 1950s; in fact, about one-third of the hops used in U.S. beers have ARS origins. A 1972 release, 'Cascade' is one of the most widely used hops varieties in the world and is so popular as a flavoring ingredient that it is sometimes identified on craft brew labels. ARS's continued development of new hops—including 'Triumph', the latest release—and barley varieties is critical to helping the brewing industry keep pace with increasing consumer demand for new brands offering diverse flavors and aromas. No less important to growers are varieties that can hold their own against pests and diseases.

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HUMAN NUTRITION AND FOOD SAFETY

PROFILING OUR NUTRIENT NEEDS FOR BETTER HEALTH

Having the right set of tools can make all the difference when trying to get something done. Such was the case when ARS nutrition researchers in Beltsville, MD, combined seven different analytical methods to resolve conflicting information about vitamin D levels needed for a healthy diet. About a decade ago, the National Academy of Sciences (NAS) became concerned about conflicting information regarding vitamin D and decided to update the standard reference values, known as the "Dietary Reference Intakes" (DRIs), which spell out how much vitamin D we need to stay healthy. Vitamin D is often added to milk, breakfast cereals, orange juice, cheeses, and other foods. Researchers soon discovered that different studies were coming up with different vitamin D levels in the same foods. ARS researchers identified shortcomings in analytical methods used and resolved them by developing an approach that uses several scientific instruments to come up with a more definitive profile of a nutrient—one that includes the nutrient's molecular structure and shows how readily our bodies will absorb it. Based on the approach, NAS updated the DRIs for vitamin D, and to this day, the methods developed by ARS are the reason why scientists can say with certainty that the amount of vitamin D in a fortified serving of milk, cheese, or other food product is at a level where it should be.

"NUT" THOSE CALORIES—THESE ONES!

Here's some nutrition news to go nuts about: Some of our favorite tree nuts, like almonds and walnuts, have fewer calories than previously thought—at least in terms of what the human body can use. For example, an ounce of almonds has about 168 calories. However, ARS physiologists in Beltsville, MD, found that not all those calories may be available for uptake and use by the body. Many factors beyond a food's basic composition can influence the so-called "bioavailability" of its calories. With nuts, this includes whether they're raw, roasted, or ground—and even how well they're chewed! In their studies, the researchers found that the bioavailability of calories for almonds was 4.6 calories per gram. That's 23 percent less than the currently accepted 6.0 calories per gram. Although this may not seem like much, a calorie reduction of 23 percent daily can be quite significant. Providing accurate information on what the body can use (or metabolize) calorie-wise is important for reliable food labeling and can have important health ramifications.

In laboratory trials with obese mice and hamsters, a diet of grapeseed flour reduced the rodents' blood cholesterol by 37 percent and abdominal fat by 35 percent.

SQUEEZING MORE VALUE FROM WINE GRAPES

California is known as "wine country," but for every two bottles of wine made, one bottle of waste is produced in the form of grape stems, seeds, and skins. These byproducts of wine-making aren't worthless, however. Take, for example, grape seeds. Not only do the seeds contain many healthful compounds, such as protein, lipids, carbohydrates, and antioxidants, but they also can be made into a health-promoting flour, ARS chemists in Albany, CA, found. In laboratory trials with obese mice and hamsters, a diet of grapeseed flour reduced the rodents' blood cholesterol by 37 percent and abdominal fat by 35 percent. A grape skin study showed similar cholesterol-lowering benefits. Encouraged by the findings, the researchers and their collaborators conducted human clinical trials to find out if the same thing happens to people, potentially benefiting human health and creating a new, value-added market for grape growers and the U.S. winery industry, which generates about $40 billion annually in domestic sales and is driven in large part by California, Washington State, and Oregon.

TAKING A CRACK AT KEEPING EGGS FRESH

Eggs are enjoyed in too many forms and foods to list here—they are that prominent in our diet. But there's been some lingering questions about how best to store them. In the early 1970s, U.S. egg producers and processors began washing and refrigerating their eggs following concerns about spoilage and foodborne illness. But the approach never caught on in Europe, where eggs are kept at room temperature, even on store shelves. The rationale was that chicken eggs are coated with a thin, protective cuticle or membrane that prevents *Salmonella* and other harmful bacteria from penetrating the shell. Hence, the shells shouldn't be washed. ARS researchers in Athens, GA, decided to settle the matter with a study that compared the two storage methods, plus two others, using 5,400 eggs. In short, the U.S. approach worked best, ensuring the highest quality eggs after 15 weeks of storage. Furthermore, the egg's cuticle is meant to control respiration and naturally degrades after laying, diminishing any protective effect. Besides helping keep overseas markets open to U.S. eggs with science-based evidence, the ARS team's published findings reaffirmed the benefits of egg washing and refrigerated storage.

PRODUCT QUALITY AND INNOVATION

MAKING SNACK FOODS MORE HEALTHY AND SUSTAINABLE

Dried fruit and vegetable snacks are becoming more popular among U.S. consumers. But these healthy alternatives to traditional snack foods eat up a lot of energy. In fact, in California, the dried fruit and vegetable snack industry is the State's third-largest energy user. Fortunately, California also is home to an ARS team in Albany that specializes in researching ways to reduce food-processing wastes and create new, value-added products from agricultural commodities. With support from the California Energy Commission, the team devised a two-step system that dries fruits and vegetables using 75 percent less energy than traditional methods. Commercial-scale tests of the system, which combines an infrared blanching step with hot-air drying, show that it produces crisp, flavorful snacks from carrot, kale, bell pepper, squash, pear, and apple within an hour. A private company, Treasure8 (treasure8.com), is now producing and test-marketing these healthy snack alternatives (beet, apple, sweet potato) under the Ground Rules brands (http://groundrulesfoods.com/) and in private label.

The team devised a two-step system that dries fruits and vegetables using 75 percent less energy than traditional methods.

MAKING WALNUT DRYING MORE ENERGY EFFICIENT

Packed with protein, antioxidants, essential vitamins, and minerals, walnuts are a powerhouse component of a heathy diet. However, before these nuts even reach the grocery store, they must be harvested, washed, dried, and dehulled—all of which uses lots of energy. One of the most energy-hungry steps involves hot-air drying. In Albany, CA, ARS researchers teamed with University of California-Davis scientists to devise a thriftier approach using infrared heat. Drying walnuts with hot air takes more than 24 hours and uses significant amounts of natural gas and electricity. In commercial-scale trials, pre-drying the walnuts with infrared heat before regular hot-air drying shortened the total time by 35 percent and saved up to 25 percent of the energy normally used. That's no small feat considering California produces 99 percent of U.S. walnuts—or about 570,000 tons annually. Infrared drying may also work with other types of nuts like pistachios.

Pre-drying the walnuts with infrared heat before regular hot-air drying shortened the total time by 35 percent and saved up to 25 percent of the energy normally used.

ONE MAN'S TRASH...

Sometimes, you've got to dig deep for fresh new ideas—even if it's a smelly landfill! As part of a pilot project with the Crazy Horse Sanitary Landfill in Salinas, CA, ARS scientists are exploring ways to convert household waste (a.k.a., "municipal solid waste") into methane and ethanol that can be used to power trucks or generators instead of diesel fuel, which is derived from petroleum. Other partners in the effort include the Salinas Valley Solid Waste Authority and the Joint BioEnergy Institute. In addition to easing U.S. reliance on foreign petroleum, the effort aims to extend the active life of our Nation's landfills by keeping trash out of them. To achieve this, ARS researchers are helping increase the efficiency of an autoclave system that processes solid waste and food products into a cellulose-rich slurry that can be converted into 70 gallons of ethanol per ton of landfill material. Cellulose is a type of complex carbohydrate that gives structure to plant cells—including fiber used in paper and sundry other products that get tossed. If all cellulose available from U.S. household waste were diverted into ethanol, this reuse could provide more than 10 percent of the Nation's transportation fuel!

SAVING ENERGY, STOPPING MOLDS IN STORED PEANUTS

Americans eat more than 6 pounds of peanut products per person each year, making the legume a prized cash crop with a farm value of more than $1 billion. Consumers may not realize how much hard work—and science—goes into every bite. After harvest and processing, for example, loads of shelled peanuts are placed in cold storage at 38 degrees Fahrenheit (° F). However, ARS researchers in Dawson, GA, determined that 38° F isn't the best temperature to use—contrary to long-standing industry practice and a recent trend towards shelling peanuts 12 months a year. Based on a year-long study they conducted, the researchers observed that at 38° F, the relative humidity levels in the top portion of shelled peanuts in bulk-storage containers increased enough to cause mold growth. In commercial situations, such mold growth can prompt buyers to reject an entire lot (20-metric ton shipment) of bagged peanuts upon arrival—at a significant cost to the sheller. The researchers found that raising the temperature to 55° F with relative humidity levels of 65 percent solved the mold problem without affecting peanut quality. Another benefit: energy savings of up to 50 percent. Based on these findings, the U.S. peanut industry is revising its best management practices for keeping shelled peanuts in cold-storage facilities. Two commercial shelling companies have begun making the temperature switch in their cold-storage facilities.

The researchers found that raising the temperature to 55° F with relative humidity levels of 65 percent solved the mold problem without affecting peanut quality. Another benefit: energy savings of up to 50 percent.

PROTECTING THE FABRIC OF OUR LIVES WITH SILVER

Currency, jewelry, and high-quality cutlery are some of the better known uses for silver. Now, an older use as a germ-fighting agent that dates back more than 100 years is getting a new technological spin. ARS researchers in New Orleans, LA, have created silver nanoparticles whose antimicrobial properties can be passed directly into the cotton fibers that make up fabrics and textiles. The standard approach has been to grow the nanoparticles—about 1 to 100 nanometers in diameter—in a bulk chemical solution. These were then coated onto the surface of the fibers. The problem was that the silver nanoparticles eventually washed off with repeated laundering cycles, losing their value as germ fighters. The new ARS method gets around this problem by growing the nanoparticles directly inside the fibers. There, they slowly release silver ions that kill more than 600 kinds of bacteria. In trials, the nanoparticle-fortified fibers kept socking it to germs even after 50 home-laundering cycles. The advance has breathed new life into a wide range of potential applications—from wound and burn dressings, to undergarments, shoe liners, upholstery, and bedding.

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NATURAL RESOURCES

NO NEED TO WATCH GRASS GROW

Ranchers in the Northern Great Plains have a new forecasting tool, called "Grass-Cast," to take some of the guesswork out of figuring how much grass will be available for livestock grazing during the upcoming summer. Ranchers currently use their experience and "boots-on-the-ground" observations of rangeland conditions to decide how many cattle to release for grazing and when. Now, using Grass-Cast, they can hone those decisions using 34 years of historical data on weather and grass growth, plus seasonal precipitation outlooks. Grass-Cast crunches this data to predict if rangeland grasses in a rancher's county will produce above-, below-, or near-normal amounts. Grass-Cast is released in early May each year as three color-coded maps and is updated every 2 weeks. Like a fine wine, Grass-Cast gets better with age, improving in accuracy as the growing season unfolds. However, ranchers are encouraged to "leaven" this new forecast with their local knowledge about plant communities, topography, soil types, and other conditions before making final grazing decisions. Debuted in May 2018, Grass-Cast is the result of a collaboration between ARS scientists in Fort Collins, CO, Colorado State University, the USDA Natural Resources Conservation Service, the National Drought Mitigation Center, and University of Arizona. Updates are available on the USDA Northern Plains Climate Hub website (https://www.climatehubs.oce.usda.gov/hubs/northern-plains).

Now, using Grass-Cast, they can hone those decisions using 34 years of historical data on weather and grass growth, plus seasonal precipitation outlooks.

LETTING THE SOIL "SPEAK"

Nitrogen is the chief nutrient added to cereal crops like corn that makes them grow faster and stronger. But adding too much nitrogen can be detrimental. Excess nitrogen can run off the field with rainwater or leach through the soil and contaminate groundwater. Now, a fast, simple, and reliable test is on hand to help farmers determine how much organic nitrogen is available in the soil—and avoid overapplying nitrogen fertilizer. ARS researchers in Raleigh, NC, calibrated the test with lab, greenhouse, and field studies. It works on the premise that soil isn't an inert, dead plot of dirt but, rather, alive with insects, bacteria, fungi, and other organisms that help make nutrients available to plants. Using this "Soil-Test Biological Activity" approach, farmers can better determine how much or how little nitrogen to apply for optimal crop yields, cutting production costs and risks to surface and groundwater supplies.

SUPPORTING ATHLETICS WHILE PROTECTING THE ENVIRONMENT

Tifton, GA, located about 181 miles south of Atlanta, has a long and storied history of breeding some of the world's finest turfgrass varieties. TifEagle, TifGrand, Tifway, and TifSport are just a few success stories whose roots can be traced to a decades-old turfgrass breeding program run jointly in Tifton by ARS and University of Georgia (UGA) researchers. These tough, top-performing Bermuda-type grasses are highly sought after and can be found underfoot (or under*cleat*) on everything from home lawns and recreational fields to golf greens and professional sports stadiums, including Super Bowl 50 at Levi's Stadium in Santa Clara, CA, and on soccer pitches at 6 of 12 sites at the 2014 FIFA World Cup in Brazil. But ARS's turfgrass contributions don't stop with breeding new varieties. Findings by an ARS–university team in St. Paul, MN, provided the U.S. Golf Association (USGA) with key insight into turf management practices that can minimize pesticide runoff into nearby ponds, streams, and lakes. In another USGA-supported project, ARS researchers in Peoria, IL, evaluated the potential of beneficial fungi to biologically control turf pests like white grubs—reducing our dependency on pesticides and keeping our courses and fields primed for peak athletic performance.

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MAKING COTTON CLEANING MORE ECO-FRIENDLY

Cleaning cotton after harvest is a dirty job that requires hot, caustic chemicals and large amounts of rinse water. The chemicals strip away waxes, pectins, and other fiber components that can interfere with subsequent dyeing steps and diminish the quality of finished cotton products. However, the cleaning process generates considerable waste. So, ARS researchers in New Orleans, LA, looked for a more environmentally friendly, biobased alternative. They decided to replace the chemical cleaning agents now used with natural plant enzymes, like cellulase and pectinase used in making fruit jam. They agitated the enzymes in solution with mechanical energy generated by ultrasound equipment similar to a jewelry cleaner. In scale-up trials, the biobased system cut operating costs from water, energy, and chemicals by 20 percent and alleviated worker safety concerns associated with using harsh chemicals. The researchers also designed and tested custom-built rollers that continuously feed cotton fabric into the biobased cleaning system, which is now being evaluated for commercialization.

...the biobased system cut operating costs from water, energy, and chemicals by 20 percent and alleviated worker safety concerns associated with using harsh chemicals.

PROBING THE DEPTHS OF SOIL WATER LEVELS

Ever try using a divining (or dowsing) rod to locate water beneath the soil? The practice has been around for millennia, but farmers today need something more reliable and precise in helping them decide how much and when to irrigate their crops. ARS researchers recently borrowed from advances in smartphone chip technology to develop state-of-the-art sensors that estimate soil water levels using readings from electromagnetic pulses. Using the chip technology, the researchers shrank the size, cost, and power needs of the sensors—features important to field use and making crop irrigation decisions. The latest refinements include hardware for transmitting the sensor's soil-water data to the Cloud—a collection of remote computer servers—where famers can view it. Irrigation control systems can also tap this Cloud data to automate the delivery of prescribed amounts of irrigation water to crops—specifically to where and when they need it. This is especially critical to "deficit irrigation," a practice that gives crops just enough water for a profitable yield—but leaves little room for error. ARS researchers in Bushland, TX, continue to refine the technology in collaboration with Acclima, Inc., a company that sells three commercial models of the sensors to farmers worldwide.

FAST FORWARD: PRECISION & INNOVATIVE TECHNOLOGIES

ROBOTIC RESEARCHERS BRAVE THE ELEMENTS

Sandstorms can make collecting wind erosion data a painful experience for ARS researchers who get pelted while studying ways to protect rangeland used to graze cattle. One solution to the problem could come in the form of a six-legged robot that mimics the movements of a cockroach—creepy to see perhaps, but ideal for navigating sandy, rugged terrain and collecting data beyond what a human could comfortably or safely endure. ARS researchers, with University of Pennsylvania collaborators as part of a National Science Foundation-funded project, are exploring the potential of robots to take on hazardous duties related to studying global threats, such as wind erosion of soils and the expansion of deserts. In this instance, the ARS-Penn team is evaluating a robot prototype known as "RHex" to carry instrumentation that collects data on wind speed and sediment deposition in western rangelands, where changing weather patterns can limit the available grasses for cattle to eat. Ultimately, data generated by RHex the robotic researcher will help its human counterparts better understand and manage the effects of windstorms on the soils and vegetation of millions of acres of rangeland.

"SMART" SPRAYER TECHNOLOGY CUTS PESTICIDE USE

When applying chemicals to floral, nursery, or orchard crops, where the chemical lands is sometimes more important than how much is applied to control stealthy pests and pathogens. One solution being tried involves using lasers—but not to blast these scourges into fiery oblivion. Rather, the lasers are part of a high-speed scanning system that enables new sprayer technology to "see" the size, shape, presence, and density of a fruit tree's foliage and deliver variable rates of pesticide to it in real time. A team led by ARS scientists in Wooster, OH, developed and tested the smarter sprayer technology. In apple orchard trials, use of the smart sprayer reduced pesticide loss beyond the tree canopy by 40 to 87 percent. The sprayer also prevented between 68 and 93 percent of pesticide from reaching the ground below trees. The 2-ton prototype can treat one to six rows of trees at a time and can be retrofitted onto conventional sprayers commonly used in orchards, nurseries, and vineyards.

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ROBOTIC ARM ADDS MUSCLE TO TREE PRUNING

Fruit trees go dormant during the winter and must be pruned so that they'll bear plenty of high-quality fruit the following summer. However, it can be hard to find someone willing to stand on a ladder all day in the cold and operate a handheld lopper to prune the trees. Enter the Robotic System for Tree Shape Estimation, RoTSE. Another team led by ARS scientists in Kearneysville, WV, investigated the robotic vision system to take over the task from human pruners. As with the smart sprayer, the system takes stock of the tree's shape and other features—but using multiple images taken from a camera mounted on a robotic arm rather than laser scanning. Algorithms merge the information from the images to calculate such things as branch angle, diameter, and length. These features are used in tree-pruning protocols for deciding which branches to cut. The current RoTSE prototype system rides atop a mobile platform that can be driven through the orchard. The system also is being used to collect information on the shape and other physical attributes of the trees, which is important in breeding new varieties with desirable traits.

PRECISION SORTING KEEPS BAD APPLES OUT OF THE BUNCH

Two other labor-intensive practices that ARS researchers in East Lansing, MI, hope to streamline are fruit harvesting and sorting. In the apple business, for example, harvesting accounts for around 15 percent of total production costs, and postharvest storage and packing can account for one-third or more of those costs. All harvested apples, regardless of their quality grades, are placed in the same bins and then hauled to sheds for storage. However, during harvest, pickers don't have time to inspect each one. One solution comes from a self-propelled apple-harvest and in-field sorting machine developed by ARS researchers and their industry partners. The current prototype works by transporting harvested fruit to a vision inspection chamber via a system of conveyors. The chamber aligns the apples in single file, separates them equally, rotates them, takes multiple pictures of each fruit, assigns a quality grade, and then sends the graded fruit to a specific bin. Trials indicate that, under certain orchard configurations, growers could achieve gross savings of $34,000 in postharvest storage and packing if the machine was used for one full season.

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MONITORING ANIMAL HEALTH...PRECISELY

Instead of uniform rates of water, fertilizer, or pesticide, precision farming calls for giving crops only what they need—when they need it and where—for optimal health and productivity. This can cut down on costs, conserve resources, and help safeguard the environment, among other benefits. But precision farming isn't just for crops; the practice also applies to managing livestock animals. ARS researchers in Woodward, OK, have fitted beef cattle with special collars to monitor their movements and behavior. The researchers download the information to a computer and analyze it in relation to each animal's body mass as opposed to taking a group average. This allows better estimates of the relationship between individual animal's use of the pasture and its productivity in different feed or pasture management regimens. Elsewhere, ARS researchers are testing precision farming technology to continuously monitor the health, welfare, and performance of swine. Besides helping producers adjust their management practices, the technology could speed their detection and treatment of sick pigs. Researchers are also testing imaging methods to better sort pigs by their market weights as well as monitor sow behavior for information on farrow crate designs and sizes. The latter is important in preventing sows from accidentally crushing their piglets.

A FIELD KIT FOR FIRE ANTS

Accurately identifying red imported fire ants at ports of entry, inspection points, and quarantine areas could get a lot easier and faster to do, thanks to a new field kit developed by scientists with ARS and the USDA Animal and Plant Health Inspection Service (APHIS). The invasive ant, *Solenopsis invicta,* is a biting and stinging pest that poses a danger not only to people and small animals but also to property and crops. Indeed, since arriving in the United States in the 1930s, the species has infested 367 million acres and caused an estimated $6 billion in control costs and damages. Drawing on decades of expertise, ARS and APHIS researchers used a protein from the fire ant's own venom to develop a highly specific antibody-based field kit that, in 10 minutes, can tell the pest apart from other ant species. This speed and accuracy is especially critical at ports of entry and truck inspection stations, where authorities must quickly but thoroughly check cargo or other items in transit to ensure they're free of invasive stowaways. The field kit, which has been commercially developed by Agdia, Inc., under the trade name InvictDetect™ ImmunoStrip®, is equally important in maintaining fire ant quarantine zones. A new version is under development that will also identify the black imported fire ant, *S. richteri.*

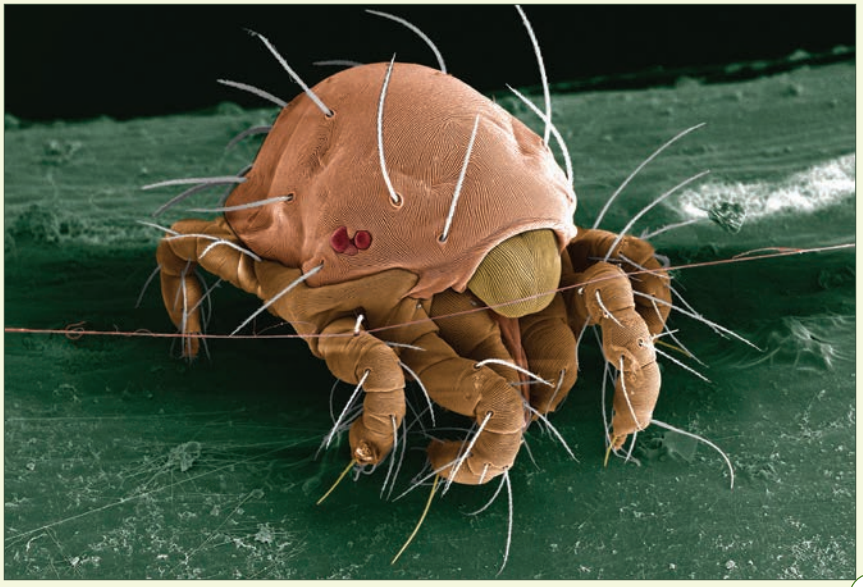
Since arriving in the United States in the 1930s, the species has infested 367 million acres and caused an estimated $6 billion in control costs and damages.

CUTTING-EDGE FACILITIES & INFRASTRUCTURE

ARS LOCATIONS

EYE SPY WITH MY HIGH-TECH EYE...

When it comes to cutting-edge research facilities, the ARS Electron and Confocal Microscopy Research Unit (ECMRU) is one to put on the proverbial short list. Located in Beltsville, MD, the climate-controlled facility houses eight different types of microscopes and a team of specialists who are world-renowned for their skill in creating high-resolution images of the unseen, from proteins and pathogens to plant chloroplasts and flat mites. The ARS team has the ultimate set of tools—a confocal laser-scanning microscope among them. Moreover, they have the know-how. For example, they pioneered a procedure for flash-freezing mites in liquid nitrogen and coating them in a thin layer of platinum. In addition to capturing the mites' final moments for imaging, the procedure preserves the integrity and shape of the creature's delicate bodies for future study. But wait, there's more! Using special printers, the team can transform the images they create into hand-sized, 3-D models for use as instructional and research aides. Most importantly, their expertise helps expand the scientific understanding—and control—of many of the microbes, pests, and pathogens that live in the soil, attack crops, infect livestock, and sicken thousands of people each year. Want to read about ECMRU in action? Then read the *AgResearch* article "Identifying Mites That Spread Citrus Leprosis" online at https://agresearchmag.ars.usda.gov/2016/oct/mites/ .



USMARC: WHERE ANIMAL SCIENCE AND SOLUTIONS CONVERGE

The U.S. Meat Animal Research Center (USMARC) in Clay Center, NE, is tasked with providing scientific information and new technologies that can be brought to bear on high-priority problems affecting the Nation's beef, sheep, and swine industries. Multidisciplinary teams carry out these tasks within and across four research units: Genetics, Breeding, and Animal Health; Nutrition and Environmental Management; Reproduction; and Meat Safety and Quality. Much of their research is done in collaboration with Federal, State, university, and international partners. The multidisciplinary, multi-organizational nature of the Center's work is directly reflective of the often complex, interconnected, and overlapping nature of the problems being investigated—from curbing greenhouse gases emitted by livestock and their wastes to improved production systems and slaughterhouse protocols for reducing bacterial contamination of beef and ensuring consumer safety.

USMARC's many accomplishments include development of genotyping methods to expedite cattle and swine breeding with desirable traits (like meat tenderness), identification of the *Mannheimia haemolytica* bacterial strain that causes bovine respiratory disease in cattle, development of imaging- and behavior-analysis methods to warn of disease onset in swine and automate weighing, and markers associated with resistance to ovine progressive pneumonia in sheep. USMARC's impact is far-reaching and substantial, as evidenced by the following two examples:

- Contamination of ground beef by *E. coli* O157:H7 bacteria fell by 80 percent, in part due to the meat processing industry's adoption of USMARC intervention procedures starting in 2010.

- About 3.6 million or 4 percent of all piglets in the United States don't get enough colostrum from their mothers and usually die before weaning. USMARC researchers developed a method to measure immunoglobulin levels in piglet blood samples that enables producers to improve the young animal's colostrum intake as well as assess the effectiveness of measures like split-suckling.

With a history of contributions too long to list here, it's sufficient to say USMARC is a national asset.

NATIONAL GENE BANK SYSTEM SAFEGUARDS OUR CROPS

The National Plant Germplasm System (NPGS) refers to a collection of seeds, cuttings, bud wood, rootstocks, and other plant material—known as "germplasm"—stored at 19 ARS locations around the country in collaboration with Federal, State, and private organizations. All told, the collection encompasses more than 593,000 germplasm accessions (unique samples) representing 243 families, 2,550 genera, and 15,899 plant species from around the world, including wild relatives of major crops. The NPGS serves as a sort of bank of genetic diversity that's critical to the continued health and productivity of our crops, especially in the face of emerging pest and disease threats, environmental change, and other natural events. The diversity stored within the NPGS also is critical to breeding new crop varieties that are more nutritious, tastier, marketable, and versatile in terms of products that can be made from them. Indeed, the value of a single accession from the collection can last decades. Not surprisingly, the demand for NPGS accessions used in research, breeding new varieties, and other applications is quite high. In 2018 alone, more than 209,700 accessions were shipped to 81 countries, making the collection a world resource that truly "pays it forward."

TRANSFERRING ARS TECHNOLOGIES TO MARKET

ARS works across the research and development (R&D) continuum to identify, develop, and transfer technological and knowledge-based solutions to our Nation's most pressing agricultural problems. ARS is uniquely qualified to take on basic, long-term research to the point it can be handed off to private industry for the next phase: commercialization of a new technology, product, or process. The ARS Office of Technology Transfer (OTT) facilitates this hand-off in several ways, including cooperative, material transfer, and confidentiality agreements, as well as patent protection, licensing, and participation in the Small Business Innovation Research (SBIR) programs, managed by the USDA National Institute of Food and Agriculture.

An exciting example of the latter is with Pancopia, Inc., a small company based in Hampton, VA, that's using a group of bacteria known as "anammox" to help recycle the water used by astronauts in outer space, particularly those staying in the International Space Station. The approach could open the door to significant savings on the current cost of hauling water into space—about $83,000 per gallon or $24 million in annual resupply costs! ARS researchers in Florence, SC, discovered the bacteria in manure sludge and cultured them for use in removing pollutants from wastewater and septic systems. Besides ARS, Pancopia has teamed up with the National Aeronautics and Space Administration (NASA) to harness the bacteria's powers of nitrogen removal to develop a high-performance water recycling system for space exploration. Back on Earth, Pancopia will also explore developing commercial units for swine lagoons using adaptations of the space technology.

Soheila J. Maleki

Matthew N. Rouse

ARS PRESTIGIOUS AWARD WINNERS

Since its establishment in 1953, ARS has attracted some of the best and brightest minds to fill its scientific ranks and put their considerable talents to work addressing agricultural issues of high national importance—food safety, consumer nutrition, environmental stewardship, rural development, natural resource conservation, and global competiveness among them. This year, ARS is proud to highlight the achievements of Soheila J. Maleki and Matthew N. Rouse, researchers who exemplify the innovation, creativity, and commitment that the agency values in leveraging science to sustain a growing world.

Maleki, an ARS research chemist in New Orleans, LA, was a finalist for a Samuel J. Heyman Service to America Medal, which recognizes Federal employees for outstanding achievement in making our Nation safer, stronger, and healthier. Maleki was recognized in the science and environment category for her pioneering research to improve the quality of life for millions of Americans who suffer from food allergies, particularly from peanuts. Her research changed how people are tested for peanut allergies today and showed that food processing methods can also affect the allergic potential of food. A key discovery showed that roasting peanuts can increase their allergenicity, while cooking them at high heat and pressure can have the opposite effect. The research findings Maleki co-authored on preempting peanut allergies in at-risk infants prompted the American Medical Association to revise its guidelines on managing and diagnosing food allergies, which affect 4 out of every 100 children. Her holistic approach embraces not only the detection and diagnosis of food allergens but also the development of treatments and low-allergy peanut varieties.

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Rouse, an ARS plant pathologist in St. Paul, MN, won the 2018 Norman Borlaug Award for Field Research and Application, making him the first USDA recipient. Presented in August by the World Food Prize organization and endowed by the Rockefeller Foundation, the prestigious award recognizes the science-based achievements of individuals under the age of 40 who have advanced human development by improving the quality, quantity, or availability of food in the world. The award also recognizes scientists who have demonstrated the same intellectual courage, stamina, and determination that Norman E. Borlaug (1914-2009) did in his fight against world hunger and poverty as a world-renowned wheat researcher and Nobel Peace Prize recipient (1970). Rouse was honored for outstanding genetics research on Ug99, a devastating race of stem rust disease that threatens wheat crops worldwide. His achievements include coordinating ARS spring wheat nursery projects in Kenya and Ethiopia as well as leading international research teams to rapidly respond to new outbreaks of stem rust and counter the disease by developing new, resistant wheat lines.

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