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INNOVATION TO PROFIT

A Retaking The Field Publication

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FED BY SCIENCE

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INNOVATION TO PROFIT: THRIVING IN A COMPETITIVE WORLD

Agriculture depends on scientific innovation to thrive. In an increasingly competitive world, U.S. farmers and ranchers must continually adapt to grow safe, affordable, and nutritious food for our nation and the world. They tackle complex and rapidly evolving challenges including destructive pests, too much or too little water, emerging plant and animal diseases, and changing weather.

Our nation's agricultural achievements have resulted from decades of collaborative research, education, and extension. Partnerships among the federal and state governments, land-grant colleges and universities, farmers, ranchers, extension agents, and businesses have been critical for success. Today, the accelerating pace of disruption in agriculture creates new demands, but also presents exciting opportunities to build profitable businesses.

As farmers and ranchers strive to improve their operations and compete in the global arena, they depend on long-term, cutting-edge USDA research. However, the U.S. agricultural research budget has declined in real dollars since 2003. The Chinese government spending on agricultural research and development rose nearly eightfold in real (inflation-adjusted) terms between 1990 and 2013, surpassing U.S. spending in 2008 and more than doubling it in 2013[1].

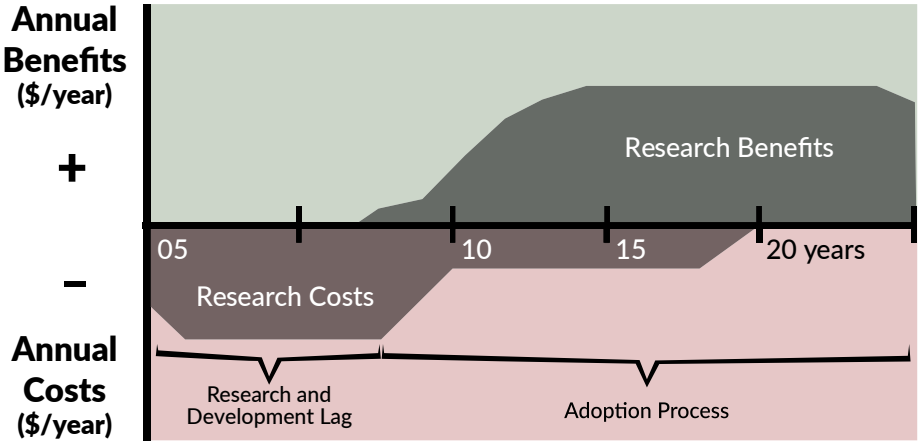
U.S. federal investment strengthens producers' bottom lines by reducing risks and costs, increasing profits, and laying the groundwork for new products and industries. These investments result in other strong returns including more abundant food supply, lower costs for consumers, and improved economies in rural America.

From discovery to value, this report demonstrates the strong return on investments from U.S. public agricultural science, which paves the path for dynamic growth now and in the coming decades. It is also a call to action to ensure vital federal funds continue to be invested so farmers and ranchers can thrive in a competitive world.

[1] **https://www.ers.usda.gov/data-products/chart-gallery/gallery/chart-detail/?chartId=85038**

AGRICULTURAL RESEARCH: STRENGTHENS THE BOTTOM LINE

Flows of Research Costs and Benefits Over Time

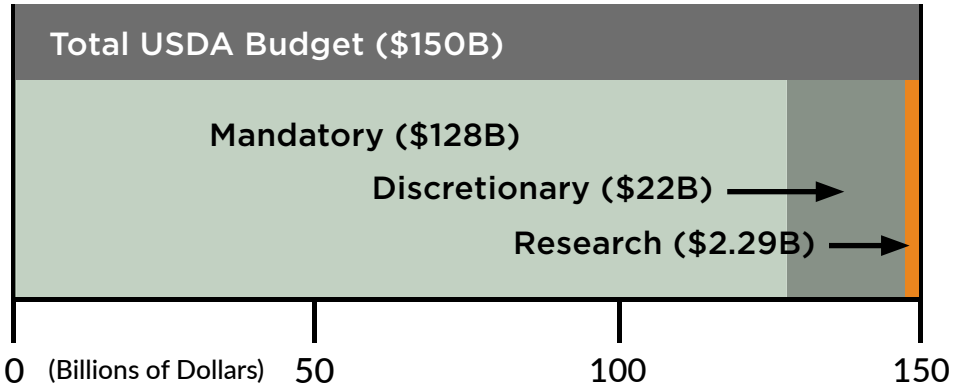


Source: Alston, Norton, and Pardey 1995

Robust public and private investments are critical for a steady pipeline of agricultural benefits. Farmers and ranchers depend on this research for safe, effective, and affordable innovation to help them produce food, feed, fiber, and fuel.

Investments in advanced technology (e.g. a more resilient plant or animal) may require 3 to 10 years to develop. Additional time is often required for regulatory compliance before the innovations can be brought to market. Benefits grow over time as more farmers and ranchers use the technology. It may take between 7 and 15 years for producers to fully adopt the technology and achieve maximum benefits.

2020 USDA Budget Authority



Total USDA Budget	$150 Billion
Mandatory	$128 Billion, or 85%
Discretionary	$22 Billion, or 15%
Research	**$2.29 Billion (only 2% of entire USDA Budget)**

Collaborative research is urgently required to ensure that the U.S. can meet today's food, feed, fiber, and fuel needs and help provide the food required for 10 billion people on earth by 2050. Yet around only 2% of USDA's entire annual budget is regularly invested in these critical endeavors.

The research challenges are complex. Farmers and ranchers need multi-faceted approaches in partnership with land-grant institutions, non-profits, and the private sector. USDA brings together expertise from a wide range of scientific disciplines to boost sustainable agricultural growth, food security, food safety, U.S. competitiveness, and innovation.

SOURCE
OECD (2016), Innovation, Agricultural Productivity and Sustainability in the United States, OECD food and Agricultural Reviews, OECD Publishing, Paris.

BOOSTING BROCCOLI

With USDA funding of $8.2 million, a collaborative team of universities and producers has galvanized a brand-new broccoli industry in the Eastern U.S. in 8 years. To date the industry has achieved $90 million in value and expects to meet the full goal of $100 million value in the next two years. (see page 20)

BUILDING BLUEBERRY BUSINESSES

The dramatic growth of the Florida's blueberry industry is thanks, in part, to USDA grants of $2.5 million that supported research of genetic traits and breeding for the best berries. The state's blueberry industry has grown from $500,000 in the 1980s to an estimated $82 million annual value today. (see page 18)

CAPITALIZING ON CRANBERRIES

USDA is providing $6.4 million in funds that mobilized an additional $6.4 million in matching funds (total of $12.8 million) to improve the quality and attributes of cranberries. The results will enable U.S. cranberry producers to ramp up both production and quality and increase the annual wholesale value from $2 billion today to even more value in the future. (see page 22)

BENEFIT$ FROM AGRICULTURAL RESEARCH INVESTMENTS

RAISING RESILIENT PIGS

Scientists in partnership at several universities have used USDA funds of $3.3 million to identify a genetic marker in pigs associated with resistance to porcine reproductive and respiratory syndrome (PRRS). By using precision genomics, the scientists are on the path to reducing the annual PRRS cost of $664 million to the U.S. pork industry. (see page 9)

SEARCHING FOR SOLUTIONS

USDA's investment of $9.5 million is enabling university researchers to map the genes of cattle to identify markers that could reduce bovine respiratory disease. With improved breeds, the research could save cattle ranchers and dairy farmers $692 million annually as well as the loss of over a million animals from the disease each year. (see page 12)

STERILIZING SCREWWORM

USDA investment of $257 million (1930 - 1960s) resulted in the complete eradication of the New World Screwworm that ravaged livestock in the U.S., Mexico and Central America. With eradication, U.S. livestock producers have realized benefits of $796 million with economy-wide benefits of $2.8 billion for a combined total benefit of $3.6 billion from the original investment. (All numbers are in constant 1996 $ equivalents). (see page 7)

CONQUERING COTTON PESTS

The boll weevil pest cost over $23 billion in economic losses and nearly wiped out the U.S. cotton industry. In the 1970s, the USDA launched an eradication program that has provided a 12:1 return on investment. In Georgia, the result was a rebound in cotton production between 1987 and 2000, increasing cotton crop revenue from $70 million to $400 million annually, and protecting 53,000 cotton-related industry jobs. (see page 17)

GROWING GUAYULE AND GUAR

With $15 million from USDA, university scientists are working to scale-up profitable domestic production of guar gum and guayule. The research is enabling U.S. farmers compete for the annual market demand of $1 billion which is currently met through imports. (see page 24)

SOURCE FOR USDA INVESTMENTS: USDA NIFA Data Gateway https://nifa.usda.gov/data

STRENGTHENING CITRUS

To combat the highly destructive citrus greening disease, USDA has funded approximately $55 million of research at the University of Florida. A portion of this funding is directed to advancing gene-editing in order to increase the potential of citrus' own immunity. Along with other research, the investment will help stem the financial losses to Florida and California citrus farmers and the broader citrus industry in these states with a total economic impact at $15.7 billion. (see page 26)

WINNING WITH WHEAT

With $15.5 million of USDA funding, the International Wheat Yield Partnership Coordinated Agricultural Project (CAP) and its predecessor Triticeae CAP (T-CAP) focused on improving wheat and barley for climate adaptation. T-CAP varieties now represent about 15% of the wheat and 4% of the barley harvested in the U.S., with a production value of $1.8 billion and $61 million, respectively. (see page 32)

Research Funding Results Legend

Increase Profits

Reduce Risks

Lower or Avoid Costs

Lay the Groundwork for New Competitive Products and Industries

STORIES

ANIMALS

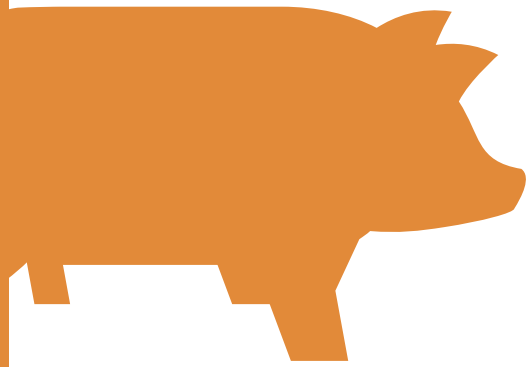
FEDERALLY FUNDED RESEARCH HELPS RANCHERS RAISE HEALTHY LIVESTOCK WHILE BUILDING PROFITABLE BUSINESSES.

PLANTS

FARMERS NEED INCREASED FEDERAL INVESTMENT TO PROSPER WHILE GROWING SAFE, NUTRITIOUS, AND AFFORDABLE FOOD.

POWERFUL SOLUTIONS

WITH FEDERAL RESEARCH INVESTMENT, AGRICULTURAL SCIENTISTS CREATE INNOVATIVE SOLUTIONS TO 21ST CENTURY CHALLENGES.



ANIMALS

The Vital Importance of Investment in Animal Agricultural Research

People around the world are demanding more protein and consuming more meat, dairy, and other animal products. To meet this growing market, U.S. farmers and ranchers need significant increases in animal agriculture research to increase the productivity, quality, and safety of animal food products while ensuring animal well-being and environmental sustainability.

Animal agriculture accounts for 60 to 70 percent of the U.S. total agricultural economy and contributes significantly to the U.S. agricultural trade balance. The U.S. is the world's largest producer of beef and poultry and the third largest producer, consumer, and exporter of pork.

Livestock producers face mounting challenges, including global outbreaks of diseases (e.g. African Swine Fever, avian influenza), impacts of changing weather, and desire to reduce environmental impacts. Consumers increasingly want assurance that food is safe to eat and animals are humanely raised.

Breakthroughs in genomics are helping to reduce and manage animal disease while contributing to human health by providing models that are extremely close to the human genome. Scientists are also unlocking natural solutions to fight parasites and lower livestock methane emissions. Research will ensure that farmers can deliver better nutrition and food safety to consumers at lower cost while improving animal well-being and environmental sustainability.

Our nation's ranchers depend on more powerful federal investment in animal science to succeed today and deliver high quality products for U.S. and global consumers into the future.

Sterilizing Screwworm

A highly successful example of public research for animal health began in the 1950s in the fight to eradicate the **New World Screwworm**. The screwworm is a maggot that feeds off the flesh of livestock as well as humans, which causes animal suffering, requires expensive treatments, and has ruined farm businesses.

Researchers from **Texas A&M University** and **USDA** devised and implemented the sterile-male-release approach to control screwworm. Young males, made sexually sterile, were air-shipped to other facilities for screwworm control programs. Mating between native females and sterilized males produced no offspring. This method eventually led to the pest's eradication in the U.S., Mexico, and Central America and has been used successfully to control other agricultural pests. Today, USDA remains vigilant in keeping screwworm out of the U.S.

USDA's **investment of $257 million** (1930s through the 1960s) has resulted in the complete eradication of a costly pest. With eradication, U.S. livestock producers have realized **benefits of $796 million**, along with **economy-wide benefits of $2.8 billion** for a **combined total benefit of $3.6 billion** from the original research investment. (All numbers are in constant 1996 $ equivalents).

SOURCE
"New World Screwworm Ready Reference Guide—Historical Economic Impact"
https://www.aphis.usda.gov/animal_health/emergency_management/downloads/rrg_econimpact-nws.pdf

CRACKING LIVESTOCK CODES

The Human Genome Project accelerated the discovery of disease genes in humans, provided a new paradigm for medical research, and opened doors to analyze the genomes of various livestock. The **Livestock Genome Sequencing Initiative**, funded by USDA and led by **University of Illinois**, represented a new wave of livestock research by applying comparative genomics and other advanced technologies to rapidly identify genes that affect animal health. The initiative sequenced genes in dairy and beef cattle, sheep, and pigs to identify genetic disease traits.

For example, genome sequencing has helped the Angus cattle industry identify and reduce incidence of a lethal genetic defect, **Neuropathic Hydrocephalus (NH)**, which results in stillborn calves, with extremely large craniums and little or no brain or spinal cords.

Researchers at the **University of Illinois,** in collaboration with the **University of Nebraska-Lincoln** have identified the gene mutation responsible for NH, which is caused by a recessive mutation at a distinct location on a single chromosome. Tests using Angus hair follicles, blood, or semen samples have subsequently been commercialized by private-sector animal health companies. This has created new diagnostic tools for breeders to identify carriers of genetic defects and reduce the incidence of NH disease in herds.

With comparative genomics and other advanced technologies, livestock research can identify many more genes responsible for disease and production traits. This is helping ranchers reduce livestock losses, improve animal health, and strengthen their bottom lines.

ADAPTED FROM:
"Livestock Genome Sequencing Initiative"
https://comparativegenomics.illinois.edu/research/livestock-genome-sequencing-initiative

Benefitting Boars

Instead of surgically castrating young boars, researchers at the **University of California, Davis** and **Washington State University** are developing a practical and humane way to remove "boar taint" (an unpleasant odor in the meat of uncastrated male pigs).

With USDA funding, scientists are using genome-editing (CRISPR/Cas9) technology that allows genetic material to be added, removed, or altered at precise locations in the pig genome. They are testing how to "edit out" the enzyme that leads to the development of boar taint.

The approach has an added advantage because uncastrated male pigs grow more quickly and use feed more efficiently compared with castrated male pigs. With more productive growth and tastier meat, farmers can avoid the cost of boar castration while improving animals' well-being.

ADAPTED FROM
"Boar Taint Box"
https://portal.nifa.usda.gov/web/crisprojectpages/1018166-boar-meat-without-boar-taint-a-model.html

RAISING RESILIENT PIGS

Through cutting-edge genome editing, scientists are working to help the swine (pig) industry produce healthier, more resilient animals. Genome editors are enzymes that allow scientists to cut the DNA strands in cells at a specific position and introduce very precise genetic changes.

With funding from USDA, scientists at **Iowa State University** and **Kansas State University** have discovered a genetic marker in pigs that is associated with resistance to **porcine reproductive and respiratory syndrome (PRRS).** PRRS costs the U.S. pork industry an estimated **$664 million per year** and can kill between 25 and 80 percent of a farmer's herd.

The identification of this marker gene will help animal breeders increase PRRS-resistant pigs. Genome editing has also been used to "knock out" a precise part of a gene in pregnant sows, which protects the offspring from the virus. The research may also help identify similar genes responsible for resistance to other diseases.

Other swine diseases are being addressed through genome-editing. Newborn pigs are highly susceptible to **transmissible gastroenteritis virus (TGEV)** and **porcine epidemic diarrhea virus (PEDV)**. Infection with PEDV is almost always fatal. In 2013, PEDV infection killed nearly **7 million pigs** in the United States.

Researchers at **Kansas State University** and **University of Missouri** have used genome-editing techniques to change two letters in the three billion-letter pig genome sequence. This deletes a molecule in the pigs' genomes with an interesting outcome: pigs without the molecule helped protect them from TGEV, but the pigs were still susceptible to the PEDV virus.

Continued investment in research will help identify the best way to protect pigs against the deadly PEDV virus, improve animal well-being, and reduce economic risk for pig farmers.


ADAPTED FROM
"USDA Scientists Make Breakthrough in PRRS Research"
https://www.usda.gov/media/blog/2012/04/10/usda-scientists-make-breakthrough-prrs-research

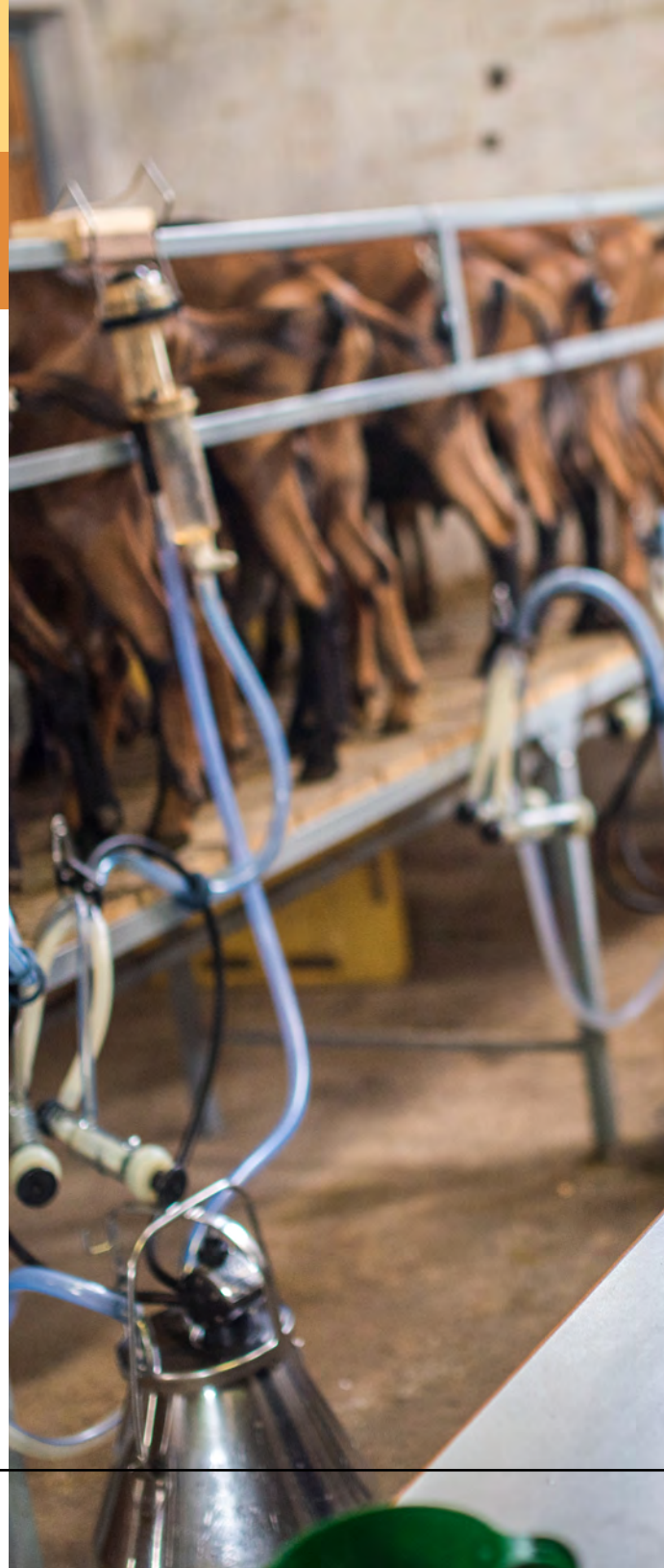
SAFEGUARDING GOATS AND SHEEP

The barber pole worm poses a great threat to the small ruminant (sheep and goat) industry. These harmful miniature predators cause irreversible damage to sheep and goats, including disease and death. Different populations of the parasite have developed resistance to most pharmaceutical anti-parasitic remedies.

With USDA funding, researchers at **Fort Valley State University** investigate the role of a forage plant, sericea lespedeza, in fighting parasites. They learned that this legume plant with high-tannins reduces the presence of parasites, including barber pole worm in sheep and goats. The plant also reduces methane from digestive processes, controls fly larvae in manure, and prevents bloat in animals. It grows well on lower quality soils, helps restore nitrogen to improve soils, and requires no fertilizer or other inputs to grow. Small ruminants also enjoy eating the forage plant.

This USDA-supported research also sparked new business opportunities for small-scale farmers by expanding markets for dried sericea lespedeza products. The team provided training sessions to farmers across Georgia, Alabama, and South Carolina on planting, harvesting, and marketing sericea lespedeza as silage to sell to other farmers through feed stores.

Using sericea lespedeza products has reduced the cost to farmers of controlling parasites by replacing more expensive pharmaceuticals. The research has also ensured farmers have a nutritious, sustainable source of feed for their sheep and goats, and created new and profitable business opportunities.



ADAPTED FROM:
"Fort Valley State University's research improves parasite management in goats"
https://www.fvsu.edu/news/fort-valley-state-universitys-research-improves-parasite-management-in-goats/

SEARCHING FOR SOLUTIONS

The leading natural cause of death in beef and dairy cattle is Bovine Respiratory Disease (BRD), a combination of viral and bacterial infections. The disease causes **losses of more than a million animals and $692 million annually** to dairy and beef farmers.

To tackle the disease, USDA funded a multi-institutional research program to search for a proven genetic link that helps identify and predict resistance to the disease. The team included **Texas A&M University, Colorado State University, University of California - Davis, Washington State University, University of Missouri, New Mexico State University,** and others.

Scientists took samples from several thousand healthy and sick calves and then tested the DNA to find variations between the animals. Finding and tying genetic markers to the actual gene that is causing the variation helps breeders to incorporate the information into the estimated breeding value of cattle.

The process is beginning to yield results with dairy cattle, which tend to have more genetic uniformity. It is more complicated for beef cattle, since there is a wider range of breeds and crossbreeds. Researchers are sequencing the entire genome of 60 beef animals to identify the genetic link to the BRD causal mutation.

By identifying resistant animals through their genetic profile, breeders can reduce the prevalence of the disease and death in cattle, reduce antibiotic use, and improve ranchers' bottom lines.

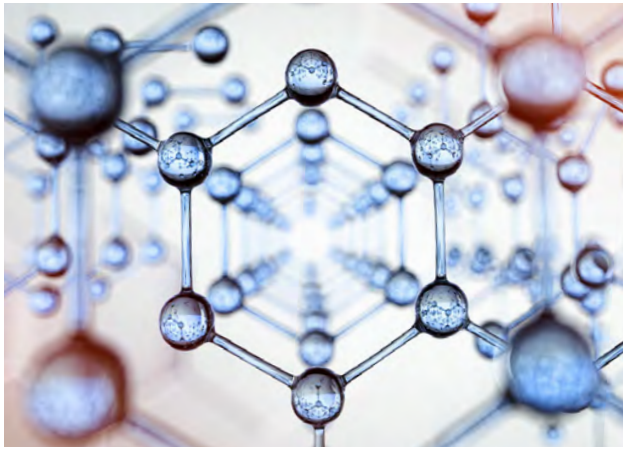
ADAPTED FROM
"Animal Health and Production and Animal Products"
https://nifa.usda.gov/announcement/animal-health-and-production-and-animal-products

PROTECTING PEOPLE AND POULTRY

Salmonellosis is a disease passed from chickens infected with Salmonella bacteria to humans through their contaminated meat and eggs. It causes **nearly 94 million infections with 155,000 deaths globally**[1] each year, and in the United States it is the leading food-borne illness and can lead to hospitalization and death.

Poultry vaccines have been used to reduce Salmonella in flocks, but do not control the disease completely. Live vaccines are sprayed on chickens, but FDA regulations prohibit the use of live Salmonella vaccines within 21 days of slaughter. Killed vaccines are available, but must be injected, making such products difficult to administer to poultry.

With USDA funding, researchers at the **University of Georgia** designed a killed vaccine that can be delivered to poultry through either drinking water or through feed using nanoparticle (submicroscopic-sized particle) technology. In the last several years, the use of nanoparticle-based vaccines has been demonstrated to improve vaccine efficacy, immunization strategies, and targeted delivery to achieve desired immune responses at the cellular level.



The project is the first to develop a safe and effective nanoparticle-based Salmonella vaccine for oral delivery in chickens. The model can be modified to deliver additional vaccines against other food-borne pathogens like E. coli and Campylobacter, thereby improving food safety for consumers and productivity in poultry flocks.

ADAPTED FROM:
"Impact Statement: 'Developing oral vaccines for Food borne pathogens in poultry"
https://secure.caes.uga.edu/impactstatements/index.cfm?referenceInterface=IMPACT_STATEMENT&subInterface=detail_main&PK_ID=8662

[1] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4451910/

PLANTS

The Vital Importance of Investment in Plant Research

America's farmers are rapid adopters of innovation, growing high quality crops and horticulture. Federal agricultural research investments have helped them boost the yields and variety of crops. Widespread adoption of innovation born in the research labs of USDA and land-grant colleges and universities has resulted in lower prices of food, feed, fiber, and fuel for consumers.

The value of all U.S. crop sales are forecast to be $198.6 billion in 2020.[1] Corn, the most widely produced feed grain in the U.S., is also processed into a wide range of food and industrial products (e.g. fuel ethanol). The U.S. is the world's leading soybean producer and exporter. Our vegetable and pulse sectors generate about $17.4 billion annually.

Yet, in an increasingly competitive world with emerging risks from pests, crops disease, and adverse weather, farmers will require significant increases in research to profit and thrive while supplying the growing global demand for food.

Breakthroughs in gene editing, crop nutrients, water and soil management, and precision agriculture are enabling farmers to produce more high-value crops per acre while reducing costs and the environmental footprint of production. Research kickstarts new agricultural products and industries and creates local jobs in the farm sector and the national economy.

To continue this story of success, America's farmers require increased federal investment in plant science to prosper and provide the nation and world with safe, nutritious, affordable food.

[1] https://www.ers.usda.gov/topics/farm-economy/farm-sector-income-finances/farm-sector-income-forecast/

Conquering Cotton Pests

The boll weevil is a pest that devastates cotton plants by feeding on its buds and flowers. Native to Central Mexico, the beetle spread throughout the southwest by the 1920s and nearly destroyed the entire cotton industry. Since arrival in the U.S., the boll weevil has cost over $23 billion in economic losses.

In the 1970s, the USDA launched a major boll weevil eradication program in partnership with farmers. The program developed techniques including using pheromone traps and chemical treatments, as well as modifying habitats. By 2014, the pest had been eliminated from all U.S. cotton-growing areas except a few parts of Texas.

The economic benefits of boll weevil eradication have been dramatic. For example, Georgia's average gross crop revenues between 1987 and 2000 increased from $70 million per year prior to eradication to $400 million per year afterwards. In Georgia, this protected 53,000 cotton-related industry jobs. Eradication has allowed growers to rebuild our nation's cotton industry.


ADAPTED FROM:
"Questions and Answers: Boll Weevil Eradication"
https://www.aphis.usda.gov/publications/plant_health/2013/faq_boll_weevil_erad.pdf
"We Don't Cotton to Boll Weevil 'Round Here Anymore"
https://agresearchmag.ars.usda.gov/2003/feb/boll

BUILDING BLUEBERRY BUSINESSES

The Florida blueberry industry got its start in the 1970s when the **University of Florida (UF) Institute of Food and Agricultural Sciences** developed the first Southern Highbush blueberry plants grown commercially in the state. The industry's growth has been dramatic and spectacular. **In the 1980s, the blueberry industry in Florida was worth less than $500,000. Today, the state's industry is worth an estimated $82 million dollars per year.**

USDA has supported UF's research on blueberry production over the course of 20 years. The UF team has developed blueberry varieties that thrive in Florida's climate and soils and produce the best quality berry. Scientists select for the best genetic traits to help resist diseases, pests, heat, and other stress factors. The breeders developed blueberry cultivars with a focus on factors such as machine harvestability, fruit quality, and yield.

Florida blueberries are now available earlier than berries grown in other parts of the country, which allows growers to command higher prices during the beginning of the season. The scientists collaborate with breeders and growers to test new varieties on farms throughout the state.

To protect Florida farmers, UF patents and licenses blueberry varieties so that they can use UF varieties a few years before international growers. UF's research and outreach has helped the state's blueberry growers stay profitable and blossom.

ADAPTED FROM:
"Born at UF, Florida Blueberries Stay Competitive in Global Market"
http://blogs.ifas.ufl.edu/news/2019/03/25/born-at-uf-florida-blueberries-stay-competitive-in-global-market/

BOOSTING BROCCOLI

Broccoli is a high-value crop worth **nearly one billion dollars per year.** Although there is growing consumption in the Eastern United States, very little broccoli has been produced there. About 85% of the broccoli consumed annually on the East Coast is shipped from California and Mexico.

The Eastern Broccoli Project began in 2010 with the ambitious goal of **creating a brand-new, $100 million broccoli industry** in the Eastern U.S. within 10 years. Currently, the industry is valued at around $90 million. With two remaining years of funding, scientists and their collaborators are on schedule to meet their goal and create a reliable, high-quality, year-round supply of Eastern-grown broccoli for East Coast markets.

Funded by USDA, **Cornell University** leads the team that includes researchers from **North Carolina State University, University of Tennessee, University of Georgia, University of Florida, Virginia Tech** and others. For example, the team identified and exploited chromosomal markers for a cross-breeding process that results in broccoli with a dark green color, which appears more "healthy to most people" and stands to boost sales. The hybrid broccoli is being worked on by project scientists, companies, and farmers to provide a steady supply of more uniform eastern variants to the commercial markets.

Several hybrids of broccoli have been commercialized recently, and more are nearing release by seed companies. Over the next two years, the project team will work with these companies and farmers to ensure a steady flow of seeds and broccoli through the pipeline on the way to creating a $100 million industry.

ADAPTED FROM:
"Eastern Broccoli Project on track to meet $100M goal"
https://news.cornell.edu/stories/2019/10/eastern-broccoli-project-track-meet-100m-goal

CAPITALIZING ON CRANBERRIES

Both cranberries and blueberries are botanically part of the Vaccinium species. The U.S. Vaccinium industry's domestic wholesale **value exceeds $2 billion per year.** Although production and consumption is growing worldwide, the growth of U.S. production has slowed in the past five years. Producers have not yet benefited from advanced breeding technologies used in other crops, which limits their ability to grow new varieties with improved fruit quality and market value.

To improve cranberries and blueberries based on producer and consumer interests, **North Carolina State University** leads a nationwide, transdisciplinary team that includes researchers from **Washington State University, University of Florida, Michigan State University, University of Wisconsin-Madison, and University of Georgia.** Funded by USDA and others, the team's goal is to leverage genomic resources to develop new cultivars with enhanced quality and attributes (e.g. taste, appearance, disease resistance, nutritional benefits).

Scientists are collaborating to reveal the genetic factors and characteristics that influence fruit quality. The team is exploring genes, traits, and tools in order to develop new DNA tests that will help them speed up selection of varieties with better traits. They are also working to improve production efficiency, handling, processing, and profitability.

By discovering new approaches to improve yields, efficiency, and market value, the team is helping farmers and strengthening the future of our nation's cranberry and blueberry industries.

ADAPTED FROM:
"PHHI team lands $12.8 Million to improve fruit quality of Blueberry and Cranberry"
https://plantsforhumanhealth.ncsu.edu/2019/12/03/phhi-team-lands-12-8-million-to-improve-fruit-quality-of-blueberry-and-cranberry/


1 FT.

GROWING GUAYULE AND GUAR

Although they are not household words, guar gum (an extraction from guar beans) and guayule (a desert shrub) represent huge domestic and global markets. Demand for guar gum in the United States is up to $1 billion annually. Today, most guar gum is imported.

Researchers at **New Mexico State University, Colorado State University, University of Arizona,** and others are collaborating with the goal of scaling-up the profitable production of domestic sources of guar gum and guayule. These crops are drought-resistant and heat-tolerant. They require low amounts of water and grow well in the arid Southwest U.S.

Both guayule and guar are potential feedstock for biofuel and for high-value products such as rubber, resin, and polysaccharide. Guar gum powder is also used for ice cream, chocolate, sausage, pasta, jams, jellies, and thickening agents. Guayule produces natural rubber that is almost identical to natural rubber harvested from trees in Southeast Asia. The crop could serve as a valuable source of rubber to produce tires and for other commercial applications.

Funded by USDA, this research supports U.S. farmers in the Southwest as they face challenges to maintain or improve their farm profits. Guayule and guar can serve as alternatives that can help farmers grow new markets and take advantage of the tremendous demand for these crops.

ADAPTED FROM:
"NMSU collaborating in Sustainable Bio-economy for Arid Regions project"
https://newscenter.nmsu.edu/Articles/view/12961/nmsu-collaborating-in-sustainable-bio-economy-for-arid-regions-project

STRENGTHENING CITRUS

The Florida citrus industry, directly and indirectly, generates approximately 45,000 full-time jobs with a total economic impact of approximately **$8.6 billion per year in the state**.

Florida's citrus industry has **lost approximately half of its $1.5 billion on-tree fruit value in just 10 years** due to citrus greening (Huanglongbing), a destructive disease that causes trees to produce small, bitter, undesirable fruit that drop prematurely and cannot be sold. The disease has reached epidemic proportions — 95 percent of commercial groves are infected in every Florida county. Since 2005, Florida's citrus production has shrunk by more than 50 percent, which **caused billions of dollars of damage** to one of the state's primary crops. A tiny insect, the Asian citrus psyllid, carries the bacterial pathogen. The disease has spread rapidly to Georgia, Louisiana, South Carolina, Texas, and California and threatens to destroy our nation's citrus industry.

With USDA funding, scientists at **University of Florida** are examining different strategies to increase the potential of citrus' own immunity and develop trees resistant to the disease. To do so, they are leveraging the latest advances in gene editing by using CRISPR, a new gene-editing technique. The team is identifying the critical genetic factors that lead to resistance, and then editing segments of DNA. By breeding new, resilient tree varieties, the team is protecting our nation's citrus industry so it can survive and thrive once again.

ADAPTED FROM:
"UF/IFAS researchers awarded $10.5M to work on citrus greening resistance or tolerance"
http://blogs.ifas.ufl.edu/news/2018/01/19/uf-ifas-researchers-awarded-10-5m-work-citrus-greening-resistance-tolerance/

PHOTO BY Kieth Weller

PHOTOS ON THIS PAGE FROM:
UF/IFAS Citrus Research & Education Center 100th Anniversary Celebration
https://crec.ifas.ufl.edu/about-us/history/crec-100th-anniversary-celebration/

COLLABORATING ON CORN

U.S. farmers produce 41 percent of the world's corn on 400,000 farms located primarily in the Midwest Corn Belt region. American production value of corn was over $50 billion in 2018. The U.S. exports between 10 and 20 percent of its corn crop. An increasingly variable climate and weather extremes, including flooding and droughts, threaten crop production and degrade soil.

To sustain one of the nation's most important farm crops, USDA funded the "Sustainable Corn Project", a regional collaboration and research partnership. **Iowa State University** led a multidisciplinary team, which included **University of Illinois, Michigan State University, Purdue University, University of Wisconsin**, and several others. The project's purpose was to determine how to best help Corn Belt farmers mitigate, adapt, and make their operations more resilient to the impacts of climate change.

The project focused on ways to equip farmers with the practices to build resiliency to weather variability, maintain crop yields, and reduce negative environmental impacts. Scientists and farmers worked together to create a suite of practices for corn-based systems that are drought resilient, reduce soil and nutrient losses under saturated soil conditions, and ensure crop and soil productivity.

The team shared farm management strategies with farmers, educators, and other stakeholders. They trained undergraduate through post-doctoral students to become the next generation of scientists. This research, education, and extension helps farmers become more profitable and protects the U.S. corn industry.

ADAPTED FROM:
https://sustainablecorn.org/

SAVING SOYBEANS

The total value of the U.S. soybean crop was **$41 billion in 2016** according to the American Soybean Association.[1] Soybean is heavily impacted by root and stem rot diseases caused by oomycete pathogens, fungal-like microbes that cause highly destructive plant diseases and plague almost every type of row crop grown. Oomycetes, which contain hundreds of species, along with the rest of the plant pathogens, are **estimated to cost billions of dollars** in crop losses annually.[2] A type of oomycete, Phytophthora sojae, is one of the most disruptive pathogens in soybean fields across our nation.

USDA funded a multi-disciplinary team of researchers to combat oomycete diseases. **Virginia Tech** led the challenge in collaboration with 19 universities including **Michigan State University, University of Georgia, Iowa State University** and others. The team harnessed genomic advances to develop new diagnostic tools, identify genes for breeding disease-resistant soybeans, and manage the pathogen.

New tools to decode oomycete genomes were recently reported by Virginia Tech's David Haak and John McDowell. They proved that combining two generations of genomic sequencing technology has immense advantages. Using first-generation technology, it takes one-and-a-half years and around $2 million to sequence the P. capsici (an oomycete) genome. By combining technologies, it takes just nine days, only costs $1,000, and can sequence 100,000 times more information in roughly 1.5 percent of the time.[3]

Preliminary estimates by agricultural economists suggest that these and other tools to fight oomycetes could **generate billions of dollars in savings globally.**

1 https://www.agri-pulse.com/ext/resources/AgSummit/2017-SoyStats.pdf
2 https://theconversation.com/pathogens-attack-plants-like-hackers-so-my-lab-thinks-about-crop-protection-like-cybersecurity-98595
3 https://www.sciencedaily.com/releases/2020/01/200129120142.htm

WINNING WITH WHEAT

Funded by USDA, the **International Wheat Yield Partnership** Coordinated Agricultural Project (CAP) and its predecessor Triticeae CAP (T-CAP) focused on improving wheat and barley for climate adaptation. The project bridged the gap across the academic research, industry, and the farming communities to produce higher yielding crops and support sustainable farming. **More than 100 commercial varieties have been developed** through the wheat CAPs.

Led by **University of California, Davis**, the T-CAP team also includes **Kansas State University, University of Nebraska, Colorado State University, Texas A&M University, North Carolina State University, Cornell University**, and others. Triticeae is a taxonomic group of grasses that include many domesticated grains (e.g. wheat, barley, and rye). The scientists utilized markers to identify the gene variants that control the most desirable of the plant's traits. They subsequently created the Triticeae Toolbox, which provides important information to plant breeders so they can develop improved wheat and barley lines.

T-CAP varieties now **represent about 15% of the wheat and 4% of the barley harvested in the U.S., with a production value of $1.8 billion and $61 million**, respectively.

T-CAP supports partnerships by uniting the breeding and genetic research communities and encourages public-private collaboration. It integrated breeding efforts to avoid duplication, and funded 28 institutions.

By developing new wheat and barley varieties for changing environments and advancing science to maximize productivity, T-CAP empowers wheat and barley breeders and growers and helps ensure the prosperity of American growers.

ADAPTED FROM:
"NIFA's Contributions to America's Agriculture Research and Innovation"
https://www.usda.gov/media/blog/2020/02/25/nifas-contributions-americas-agriculture-research-and-innovation

POWERFUL SOLUTIONS

Creating Innovative Breakthroughs for the Future

With USDA's support, scientists at universities across the country are creating powerful solutions to the 21st century agricultural challenges. Protecting pollinators, developing biodegradable mulch, transforming water management, and supercharging protein production are just a few examples of the power of innovation.

In February 2020, USDA announced the Agriculture Innovation Agenda, an initiative to position American agriculture to better meet future global demands. Specifically, the USDA will stimulate innovation so that American agriculture can achieve **the goal of increasing production by 40 percent while cutting the environmental footprint of U.S. agriculture in half by 2050.**

To help achieve this goal, USDA will utilize innovative breakthrough opportunities identified in the **2018 National Academies of Science report, "Science Breakthroughs to Advance Food and Agricultural Research by 2030."** The report identifies the greatest scientific opportunities to make the U.S. food and agricultural system more efficient, resilient, and sustainable. It recommends prioritization of five research areas: **Genomics, Microbiomes, Sensors, Data & Informatics, and Transdisciplinary approaches.**

Highlighting Human Health

Investments in agricultural research provide a boost to improve human health. With the sequencing of the swine (pig) genome, there are new opportunities to research with models that are extremely close to the human genome. The pig genome is of similar size, complexity, and chromosomal organization as the human genome and can be useful for human health studies.

USDA invested in the original research to map the swine genome. With NIH funding, scientists at the National Swine Resource and Research Center at **University of Missouri**, along with medical researchers from **University of Iowa**, are using the mapped swine genome to create swine models that are available to biomedical investigators. These models provide opportunities to develop cures for cystic fibrosis, lymphocytic leukemia, spina bifida, cardiovascular, and other diseases.

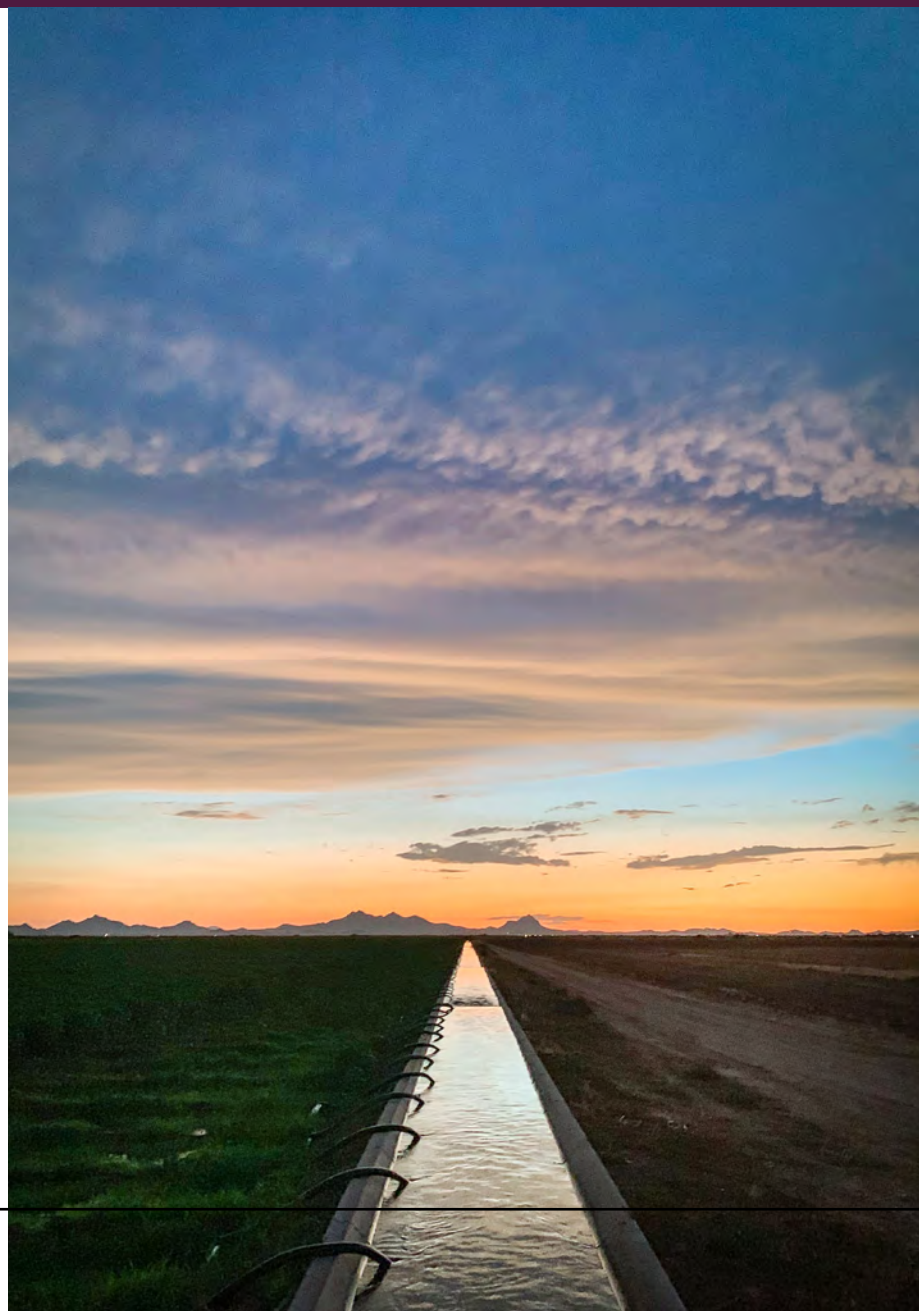
ELEVATING WATER MANAGEMENT

To ensure proper moisture content for productive soils in the U.S. Corn Belt region, farmers use drainage strategies on approximately 25% of their cropland. While this is some of the most productive land in the world, it is at risk from too much or too little water in any given year. This limits crop productivity and threatens water quality. Climate change is resulting in more intense rainfall and scorching droughts, which makes water management problems worse for farmers.

Funded by USDA, **Purdue University** leads a team that includes researchers and extension specialists from **Iowa State University, The Ohio State University, South Dakota State University, North Dakota State University, University of Missouri,** and **University of Minnesota**. The collaborative team helps farmers with their water management challenges through the 5-year "Transforming Drainage" project. They integrated research, education, and extension to improve drainage strategies and implement water storage solutions.

The team is providing tools and strategies to farmers, watershed managers, and policymakers to inform decisions about storing drainage water in the agricultural landscape. Practices such as controlled drainage, saturated buffers, and drainage water recycling are useful.

The project also educates the next generation of farmers, engineers, and scientists about drainage and water storage. The result is that farmers' operations will be more resilient, sustainable, and profitable in the Corn Belt and beyond.

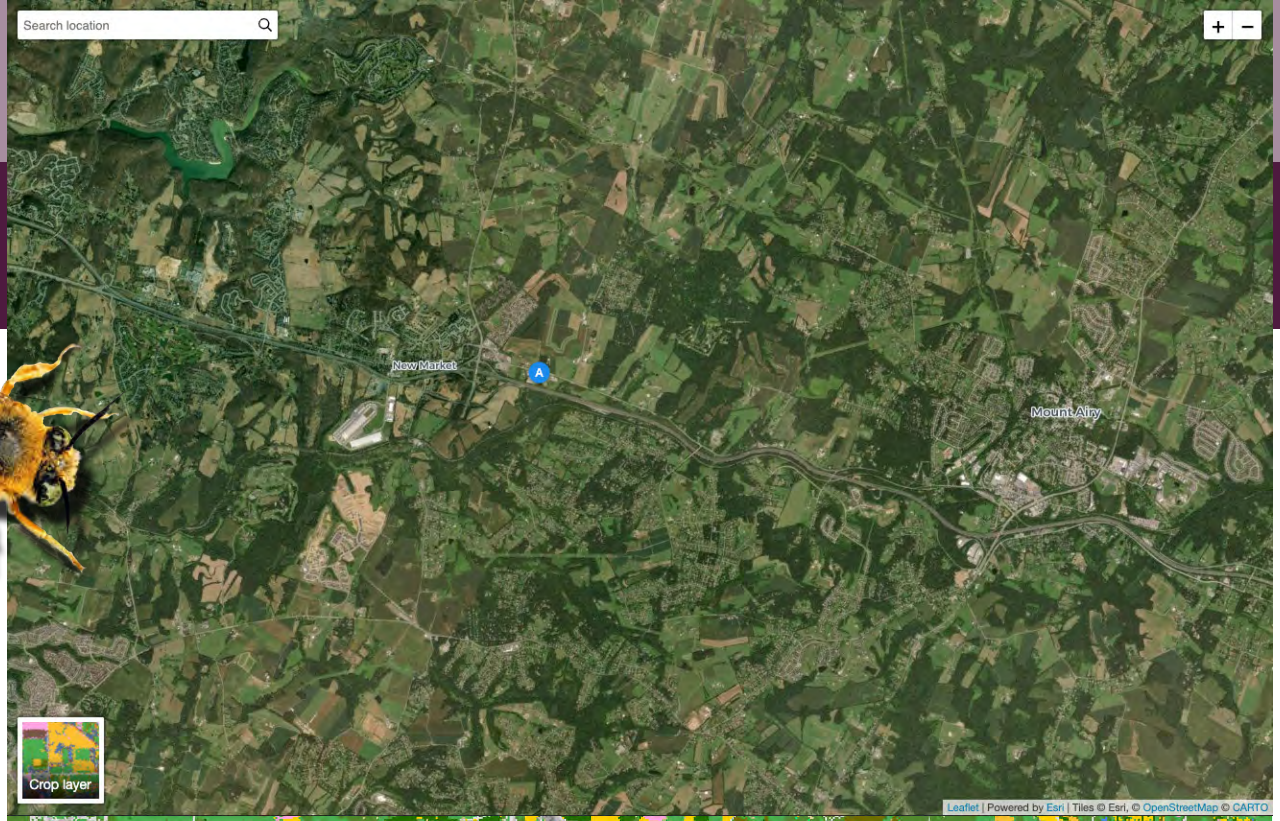


ADAPTED FROM:
https://transformingdrainage.org/

PHOTO BY BEN REINHART

PHOTO BY BEN REINHART

PHOTO BY GIORGI CHIGHLADZE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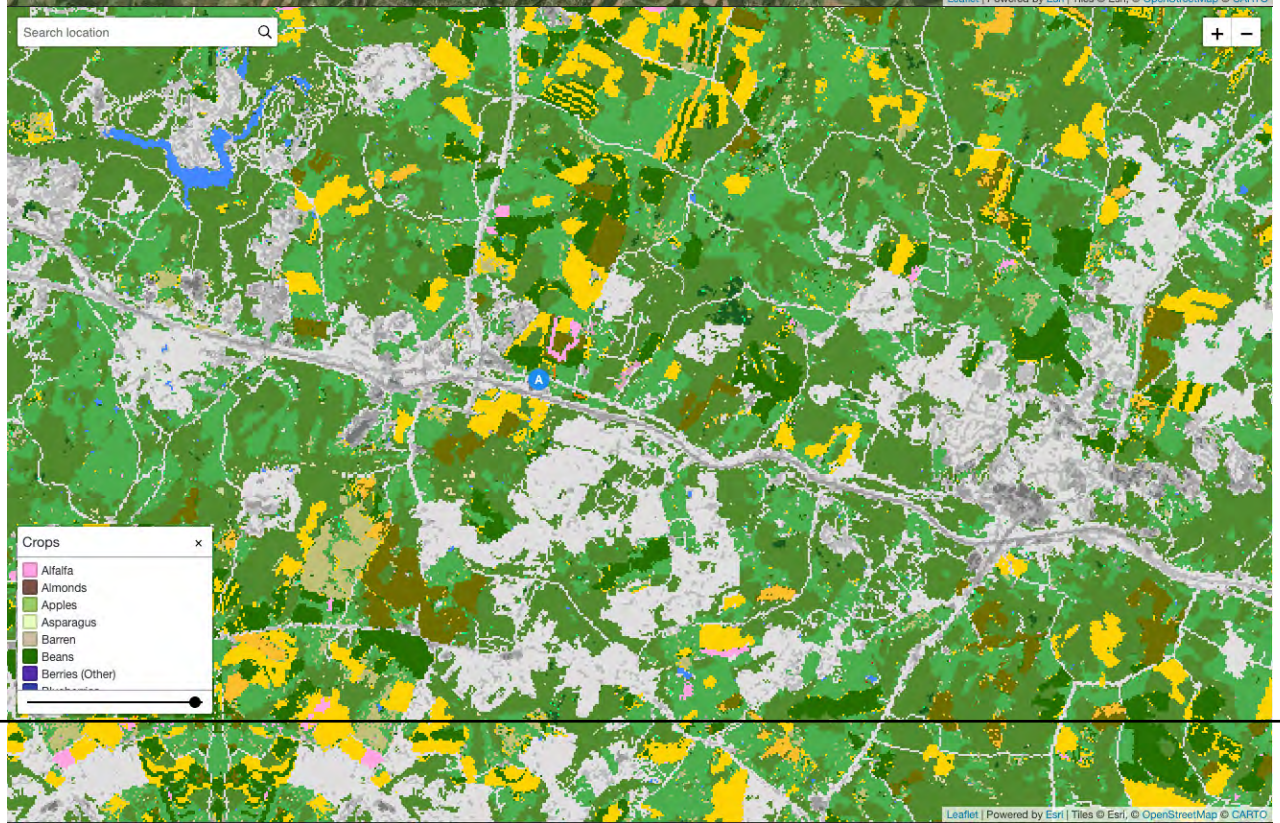
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HELPING HONEY BEES

Insect pollinators are essential to U.S. growers of fruits, vegetables, nuts, and seeds. Honey bees are the premier managed pollinators of most crops, **accounting for $11.7 billion** of the $15 billion of agricultural output attributable to insect-mediated pollination.[1]

Since the mid-2000s, beekeepers have consistently suffered annual honey bee **colony losses of 31-46%**. Current management tools are costly and may not be sufficient to indefinitely sustain the honey bee colony numbers or strength needed for pollination. The consequences of inaction are decreased yields and quality of fruits and vegetables, and potentially higher produce prices. The causes of honey bee and pollinator declines in the U.S. are varied, complex, and involve many stressors.

Funded by USDA and others, **Penn State University** leads a multi-institutional research team. Partners include **Purdue University, University of Illinois at Urbana-Champaign, University of Wisconsin, University of California – Davis**, and others. The team developed Beescape, a new online tool and community to support bees and to help beekeepers understand what resources and risks bees may encounter when they leave the hive.

Beescape enables researchers to partner with beekeepers and gardeners to gather information about the health of their bees. For example, Beescape allows a user to select a specific location and get information about the surrounding area, the amount and type of applied insecticide, and the availability of nesting habitat for wild bees. This partnership has generated data so that they can better calculate how these landscape-quality scores translate to bees' health outcomes. The collaboration protects pollinators, our fruit and vegetable supply, and farmers' profits.


ADAPTED FROM:
Beescape
https://beescape.org/
Introducing Beescape: A new online tool and community to support bees
https://news.psu.edu/story/564399/2019/04/01/research/introducing-beescape-new-online-tool-and-community-support-bees
[1] https://portal.nifa.usda.gov/web/crisprojectpages/1004928-sustainable-solutions-to-problems-affecting-bee-health.html

MAXIMIZING BIODEGRADABLE MULCH

SOURCE:
https://ag.tennessee.edu/biodegradablemulch/Documents/Important-considerations-BDM-in-crop-production.pdf

Vegetable and fruit growers pay for a lot of plastic– **$3.4 billion in worldwide sales** in 2017. Farmers use plastic mulch to suppress weeds, retain moisture, prevent soil erosion, and increase yields. Disposal at the end of each growing season is a costly problem. Plastic mulches are stockpiled on farms, burned illegally, and/or transported to landfills. Conventional plastic mulch materials are not biodegradable and can persist in the soil for decades if not centuries. Residual pieces of plastic film remain in the soil, where they can form microplastics, damage soil, and may even enter the food chain.

To lessen the costly side-effects of conventional materials, USDA funded a team of scientists, engineers, and extension experts at the **University of Tennessee Institute of Agriculture, Washington State University,** and **Montana State University** to explore and verify biodegradable plastic mulches' benefits and long-term impacts on soil, crop quality, and yield.

The partners investigated biodegradable plastic mulch to evaluate effects on soil health, crop production, pests, and diseases at two diverse geographical locations. They also assessed

the economic costs and benefits for growers and consumers. They engaged stakeholders to increase adoption and developed important informational resources (see biodegradablemulch.org).

Over a four-year period, the team found no change of soil quality or microbial communities and no major differences in crop growth in two diverse regions using biodegradable compared to conventional plastic mulch. This is encouraging news for farmers as they protect their soil and profits.

ADAPTED FROM:
UTIA's biodegradablemulch.org
https://ag.tennessee.edu/biodegradablemulch/Pages/default.aspx

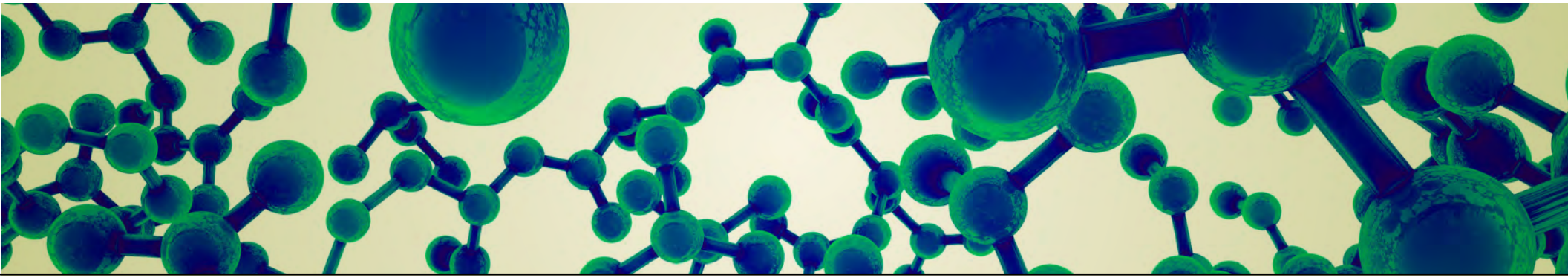
SUPERCHARGING PROTEIN PRODUCTION

Scientists at Washington University in St. Louis have discovered a way to supercharge protein production up to a thousandfold. The researchers employed a tool used in biomedical research that estimates the amount of protein in a sample by measuring the amount of fluorescent light produced. Tubes of green fluorescent protein glow more brightly when they contain more of the protein.

Project collaborators randomly changed the sequence of the first few amino acids in green fluorescent protein, generating over 9,000 distinct versions. The researchers discovered that the brilliance of the different versions of green fluorescent protein varied a thousandfold from the dimmest to the brightest. This indicates a thousandfold difference in the amount of protein produced. With careful analysis and further experiments, collaborators from **Washington University School of Medicine** and **Stanford University** identified combinations of amino acids at the third, fourth, and fifth positions in the protein chain that gave rise to sky-high amounts of protein.

Beyond medical applications, the findings could help increase production of proteins in food, agriculture, and other industries. According to Washington University scientist Sergej Djuranovic, "There are many benefits to optimizing protein for use in the food industry – for example, there's one called chymosin that is very important in cheese-making. There is a broad range of commercial benefits to supercharging protein production."

ADAPTED FROM:
Scientists find way to supercharge protein production
https://medicine.wustl.edu/news/scientists-find-way-to-supercharge-protein-production/



SPECIAL THANKS:

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The Association of Public and Land-grant Universities (APLU) institutions strive to fulfill the world's food, feed, fiber and fuel needs while protecting our world's natural resources and improving our human communities. APLU's Board on Agriculture Assembly advocates on behalf of agricultural research, extension, and education funding.

The member institutions of the **Association of American Veterinary Medical Colleges (AAVMC)** promote and protect the health and well-being of people, animals and the environment by advancing the profession of veterinary medicine and preparing new generations of veterinarians to meet the evolving needs of a changing world.

ASSOCIATION OF PUBLIC & LAND-GRANT UNIVERSITIES

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Association of American Veterinary Medical Colleges

PHOTO BY DAVID NANCE

ABOUT USDA NIFA

USDA's **National Institute of Food and Agriculture (NIFA)** directly contributes to America's agriculture research and innovation, ultimately benefiting our farmers, ranchers, and foresters. Through strong partnerships with colleges of agriculture, scientists, stakeholders, and other Federal agencies – NIFA ensures that groundbreaking discoveries reach the people who can put them into practice. Food and agricultural research—both capacity and competitive investments—have a remarkable return on investment for society, resulting in approximately $20 for every $1 spent depending on the nature of the applied research.[1]

- USDA NIFA's Agriculture and Food Research Initiative (AFRI) is the nation's leading **competitive** grants program. AFRI provide resources to improve rural economies, increase food production, address water availability issues, ensure food safety and security, enhance human nutrition, and train the next generation of the agricultural workforce.

- USDA NIFA provides **capacity** funds to support applied research, education, and extension at land-grant institutions and address key agricultural problems (e.g. emergent pests and diseases) of national, regional, and multi-state importance in order to develop impactful solutions. Capacity funds are matched at the state level.

- USDA NIFA supports **Cooperative Extension**, the nationwide transformational education system operating through land-grant universities in partnership with federal, state, and local governments. With offices in or near approximately 3,000 counties, extension agents help farmers and ranchers achieve greater success. Cooperative Extension delivers 4-H, America's largest youth development organization—empowering nearly six million young people with the skills to lead for a lifetime.

USDA

United States Department of Agriculture
National Institute of Food and Agriculture

[1] OECD, 2016. Food and Agricultural Reviews Innovation, Agricultural Productivity and Sustainability in the United States

NORTH CAROLINA COOPERATIVE EXTENSION CREATES $300 MILLION ECONOMIC IMPACT

At **North Carolina State University,** Cooperative Extension educators taught classes that empowered people to make better-informed decisions in communities across the state. Extension professionals and volunteers provided 13,000 educational programs to 1.9 million residents, improved the health and well-being of 115,000 North Carolinians through food and nutrition programs, prepared more than 263,000 youth through 4-H programs, and **provided $300 million of economic impact to the state.**

At the Virginia Tech Shenandoah Valley Agricultural Research and Extension Center, technician Marnie Caldwell (left) and farm manager Dave Cuddy record plate meter measurements, which are used to estimate forage yields in cow-calf grazing paddocks.

Source: https://www.ars.usda.gov/ARSUserFiles/oc/graphics/photos/300dpi/kesa/k10983-1.jpg

Photo by Peggy Grebb

NEBRASKA EXTENSION TACKLES EXTREME WEATHER

Nebraska has **experienced five $1 billion severe storm events since 2010. University of Nebraska** Extension educators are helping Nebraskans increase their knowledge and use of climate and weather information and resources through four focus areas: climate literacy, natural resource management, extreme weather resiliency, and scenario-based planning. The team hosted climate science presentations for more than 1,000 producers and crop consultants and held field-to-market workshops.

SOURCES:
USDA NIFA Annual Reports
https://nifa.usda.gov/nifa-annual-report-archives
APLU
https://www.aplu.org/members/commissions/food-environment-and-renewable-resources

Left to right: Systems program analyst Jim Powell; farmer J. W. Law, Sr.; Terrell County (Georgia) extension agent Forrest Connelly; and mechanical engineer James Davidson discuss soil temperature, rainfall, pesticide use, and other data being gathered from Law's peanut field.

Source: https://www.ars.usda.gov/oc/images/photos/oct97/k7797-1/

Photo by David Nance

ABOUT *FedByScience*

FedByScience is a collective communications initiative to raise the visibility of public investment in food and agricultural research. Participating universities are joining together to tell impactful and inspiring stories about food and agricultural research. Its goal is to secure increases in congressional appropriations for capacity, extension, and competitive funding through the USDA's National Institute of Food and Agriculture (NIFA). The SoAR Foundation coordinates *FedByScience*.

To join *FedByScience* or for more information, please contact Andrea Putman, Senior Vice President, SoAR Foundation at: aputman@supportagresearch.org

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The Retaking the Field series is available at:
www.supportagresearch.org

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ABOUT SoAR

The Supporters of Agricultural Research (SoAR) Foundation is a non-profit, non-partisan coalition of partners that represent more than 6 million farming families, 100,000 scientists, universities, consumers, veterinarians, and others. Together, we are working to increase federal investments in agricultural research to produce the best possible agricultural science to help feed America and the world. SoAR advocates for full funding of the Agriculture and Food Research Initiative (AFRI), the USDA's flagship competitive grants program.

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