The Future of Food and Agriculture
National Institute of Food & Agriculture’s Role
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An Existential Threat
Nutritional Security
Path Forward

• Transformative discoveries
• 21st Century Extension
• Farming systems
• Education
• Policies, regulation, marketing
• Human dimensions
• Communications
**TIMELINE**

4000–10,000 BCE | First crops and animals domesticated

2500 BCE | First use of natural biocntrol methods (neem in India)

2500 BCE | First use of manure as fertilizer

1400 CE | First use of arsenic as a pesticide

1700–1800s | Modernization of fertilizer

1862 | Abraham Lincoln establishes the USDA

1862 | Morrill Act of 1862 establishes the Land-Grant University System

1873 | First modern grain silos

1887 | Hatch Act establishes State Experiment Stations

1890 | Morrill Act establishes Black Land-Grant Colleges and Universities

1892 | First gasoline-powered tractor

1914 | Smith-Lever Act establishes Cooperative Extension

1940s–1950s | Development of first high yielding hybrid corn varieties

1950s | First software developed

1953 | Watson and Crick describe the structure of DNA

1961 | First digitally operated, programmable robot

1960s | Green revolution

1980s | Emergence of nanotechnology

1994 | First transgenic crop approved for sale

1994 | Equity in Educational Land-Grant Status Act establishes Tribal Land-Grant Colleges and Universities

2000 | Introduction of next-generation DNA sequencing technology launches the ‘omics era

2008 | The Farm Bill of 2008 establishes NIFA

2011 | Food Safety and Modernization Act signed into law

2010s | Development of genome editing technologies

2010s | Internet of Agricultural Things and Smart Systems

10,000 BCE | AGRICULTURE BEFORE USDA

1860 CE | THE FIRST 100 YEARS OF USDA

1960 | USDA/MODERN AGRICULTURE

PRESENT
TIMELINE

4000-10,000 BCE | First crops and animals domesticated
2500 BCE | First use of natural biocontrol methods (neem in India)
2500 BCE | First use of manure as a source of arsenic

10,000 BCE | Agriculture begins
1862 | Abraham Lincoln establishes the USDA
1862 | Morrill Act of 1862 establishes the Land-Grant University System
1873 | First modern grain silos
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USDA/Modern Agriculture
Ecological Footprint of Food and Agriculture

NIFA’s vision is to help facilitate approaches – including biophysical, behavioral, social, regulatory, and policy – to reduce footprint by at least 50 percent in the next 15-20 years.
NIFA Focus

• Vision
  – Catalyze transformative discoveries, education, and engagement to address agricultural challenges

• Discovery through Delivery Continuum
  – Discovery ➞ Translation ➞ Innovation ➞ Solution

User Inspired Science, Transforming Lives
Food Waste and Food Loss

- Double food production in 40 years
- Cut loss/waste by half?
- Cut water loss
  - One quadrillion liters/year
- Impact climate change
  - 1.4 kilograms (kg) CO$_2$-eq capita$^{-1}$day$^{-1}$; emissions of 33 million cars/year
NIFA SUPPORTS RESEARCH AND EDUCATION THAT SUSTAINABLY INCREASE PRODUCTIVITY BY:

**INCREASING** photosynthetic, water use, and nutrient use efficiency in crops and animals

**DIVERSIFYING** the product stream through novel crops, organisms, and processing technologies

**PROTECTING** these products against predators, parasites, diseases, and pathogens to ensure food safety

**DEVELOPING & DEPLOYING** the industrial, physical, and digital technologies to revolutionize planting, cultivation, harvest, storage, and transportation

**PREPARING** the next generation of agriculture professionals through education, training, and leadership development.
Productivity

- **Abiotic Variables**
  - Soil characteristics, water, nutrients, sunlight, temperature, and other weather and climatic conditions

- **Biotic Variables**
  - Plant and animal genes and physiology, pathogenic and non-pathogenic microbes, invertebrates
  - Microbiomes and plant and animal performance
  - Nematodes, arthropods, other invertebrates and plant and animal performance
• Genotyping and Phenotyping Technologies
  – High-throughput next-gen tools
  – Data management and processing
  – Computational infrastructure and cyberinformatics
  – Standards for metadata and machine inter-operability
  – Access and human resources

• Statistical and Quantitative Genetics
  – Genomic selection and new technologies (e.g., genomics, phenomics, image analysis) for rapid, low cost breeding

• Observational Science to Information Science to Predictive Science
  – Genotype X Environment X Management
• Genome Editing, Heterosis, Doubled Haploids
  – Defined genetic changes to complement traditional marker-assisted breeding approaches
  – Ploidy and genome editing challenges
  – Genes to change, delete, or substitute to enhance productivity and other traits in plants and animals
  – Optimizing heterosis and mechanisms to increase yields
  – Innovative technologies to enable creation of high throughput doubled haploids
  – Communicating value of genome editing technologies to ease public angst
  – Carbon constraints; environmental and animal welfare legislation

• Systems and synthetic biology
• **Productivity and Efficiency**
  – Genetic gains, feed efficiency, and animal productivity
  – Photosynthesis: C3 to C4
  – Cisgenics versus transgenics
  – N fixation in cereals
  – N, P, and water use efficiency in plants and animals
  – Resistance and tolerance to biotic and abiotic constraints

• **Traits**
  – Taste, quality, appearance
  – E.g., Resistant starch: TCAP project
  – E.g., Bioavailability of macro- and micronutrients in bean and rice bran: Colorado State University
  – E.g., Traits in beef cattle: Thermal tolerance, production, reproduction, and product quality. University of Florida
Smart Systems: Opportunities and Challenges

- Cyberphysical Systems
- Robotics
- Drones
- Sensors: Biological, Bio-NEMS, Bio-MEMS
- Big Data

Farm  Food Systems  Table
21st Century Farm

Outcome of Big Data and Analytics

2014 National Corn Yield Average: 171 Bushels
Randy Dowdy, farmer from Georgia: 503 Bushels

Randy Dowdy used sensors, optimal varieties, irrigation and fertilizers, pest control, and Big Data analytics with the help of Monsanto and Climate Corp.
Transforming Lives
Breeding and Genetics

- T-CAP Project
  - 95 new varieties & germplasm
  - 20 percent of US wheat acreage
    - ~$3.5 billion
  - 20 postdocs
  - 117 graduate students
    - 14 MSI students
  - 87 undergraduate students
  - 36 MSI faculty
  - 25 visiting scientists
• Beef Cattle Feed Efficiency
  – Identified chromosomal regions with “feed conversion genes”
  – Cattle producers use this information to build their herds by selection of breeding stock
  – Increasing nutritional efficiency results in higher profits by reducing feed intake
  – Reduce manure and greenhouse gases
  – University of Missouri
• Hypoallergenic Peanuts
  – 12th most valuable cash crop
  – Allergies in ~2.8 million people; 400,000 children
  – Soaking peanuts in food-grade enzyme solution reduces or eliminates up to 98 percent of allergens
  – No effect on flavor
  – NC A&T University
• Water Saving Technologies
  – Improved irrigation/water management technologies
  – Over 1.5 million acres of cropland
  – Savings of 114 billion gallons of water annually—enough water to supply a city the size of Tucson, AZ, for a full year
  – University of Nebraska
• **Harvest-Assist System**
  - Labor shortages and costs are driving innovation
  - In newer orchards, harvest-assist systems can increase efficiency 30-40%
  - Less physically demanding and safer (older or less-capable workers accommodated)
  - Two commercial products marketed (and a third, soon)
  - Carnegie-Mellon University, LGUs, and industry partners
• Citrus Greening
  – Florida has lost over $3.6 billion since 2007
  – Bacterium secretes effector proteins into host plant’s circulatory system, increasing the plant’s susceptibility to infection
  – Develop citrus resistant to citrus greening effectors
  – University of California-Riverside

https://ufhortscience.wordpress.com
https://nifa.usda.gov
@USDA_NIFA
• **Biomass Research & Development**
  - 25 new patents and invention disclosures
  - 49 new products/processes developed
  - 60 new jobs created
  - 125 jobs retained
  - 17,665 learners reached
  - 422 publications
  - $68 Million leveraged post-award
• **Nitrate Test Kit**
  
  – SBIR-funded
  – Severe droughts increase nitrates in plants
  – Nitrate poisoning in livestock
  – Nitrates prevent the bloodstream from transporting oxygen
  – Test kit for safe forage
  – The Nitrate Elimination Company, Inc.
• 4-H Tech Wizards
  – Began as pilot program through CYFAR grant
  – Replicated nationally through OJJDP grant
  – Now in 26 states, 85 sites, 10K+ youth & adults
  – 95 percent high school graduation rate
  – 70 percent pursuing post-secondary education
  – Oregon State University
• Smarter Lunchrooms
  – Increased consumption, reduced plate waste, increased cost savings
  – Naming vegetables
    • Saved 6 cents/serving
  – Moving fruit next to register
    • Saved 3 cents/serving
  – Smarter Lunchrooms makeover
    • Saved 2 cents/serving of fruits and vegetables and 3 cents/entrée
  – Slicing fruit
    • Saved 4 cents/serving
  – Cornell University
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User Inspired Science, Transforming Lives