

RESEARCH, EDUCATION, & ECONOMICS



Science: The Foundation of Agriculture

THE RESEARCH, EDUCATION, AND ECONOMICS MISSION AREA is USDA's foundation builder. REE provides the groundwork of knowledge that policymakers, researchers, Federal agencies, and others can draw upon to meet challenges confronting America's food and agriculture system. REE's scientific research, economic and statistical analysis, and education programs result in sound information and data used by USDA in making policy decisions to benefit all citizens of the Nation.

The REE program ranges from basic research to problem solving to technology transfer. The scope of its mission reaches from seed to table, spanning the entire spectrum of the food system from production to marketing, from trade to nutrition, from biological discovery to economic analysis.

The emphasis in the following pages is on science, because science is the foundation of agriculture—the foundation for producing safe, affordable, nutritious food; for enhancing farmers' incomes; for competing in global markets; for mitigating agriculture's environmental impacts; and for giving consumers the confidence to make sound choices from the abundant available foods. The knowledge base developed by REE also includes reliable information on the economics of the food and agriculture system, as well as essential agricultural statistics that document the progress science makes possible.

We invite readers to visit the websites of the REE agencies or contact the individual agencies to further explore REE programs. In particular, we welcome young people to consider joining us in a rewarding profession in which the creation and dissemination of knowledge contributes to the well-being of the entire human race.

Joseph J. Jen

Under Secretary for Research, Education, and Economics

RESEARCH, EDUCATION, & ECONOMICS

The Research, Education, and Economics (REE) mission area of the U.S. Department of Agriculture has Federal leadership responsibility for the discovery and dissemination of knowledge spanning the biological, physical, and social sciences, and involving agricultural research, economic analysis, statistics, outreach, and higher education. The four REE agencies are the Agricultural Research Service, Economic Research Service, National Agricultural Statistics Service, and Cooperative State Research, Education, and Extension Service.

The REE mission area is dedicated to the creation of a safe, sustainable, competitive U.S. food and fiber system and strong, healthy communities, families, and youth through integrated research, analysis, and education.



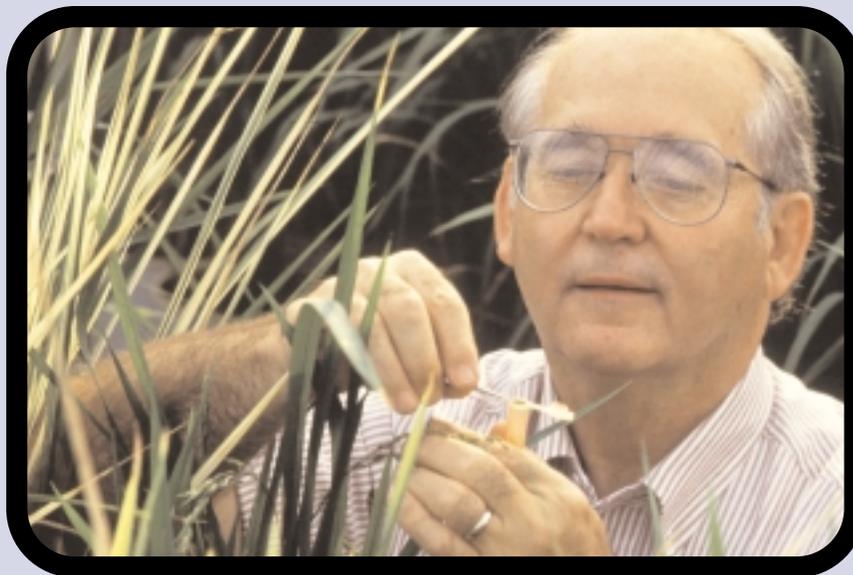
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KNOWLEDGE THROUGH RESEARCH

Science is the foundation of agriculture, and research generates the knowledge that underpins science. Advances in scientific knowledge have driven the impressive productivity of American agriculture, providing an abundance of food and fiber as well as inputs for industrial uses. These advances have benefited all Americans, who today spend a smaller portion of their incomes on food than any other consumers in the world.



High productivity levels in agriculture have freed up resources to be used in developing other sectors of the economy. Relatively low prices for U.S. agricultural commodities have made the United States the world's leading agricultural exporter. All this is possible as the direct result of scientific advances through research.

USDA research has led to better soil management; improved use of fertilizers; superior strains of seed; advanced control of insects, crop diseases, and weeds; and more efficient methods of harvesting, storing, and transporting farm products to market. A number of research findings have had applications beyond agriculture, notably in the field of medicine. Social science and economic research has introduced new ways of looking at the farm and food sectors as technology

alters their operations and as they adapt to a competitive global economy.

The Research, Education, and Economics (REE) mission area of USDA is committed to advancing knowledge through research. A key component of the REE mission is an interdisciplinary program of scientific research. Research funded and conducted by REE has led to hundreds of new products, as well as to countless

improvements in food safety, human nutrition, and environmental quality.

Social science and economic research adds to the knowledge base by analyzing the effects of technological and structural changes in the food and farm sectors. REE agencies have pioneered data collection techniques and statistical methods to support the research. And they have partnered with colleges and universities through sponsorship and cooperative programs that combine resources for research initiatives and help build the institutional capacity for training future agricultural researchers and educators.

Research and analysis by REE agencies provide credible scientific information to other USDA agencies and to the entire Federal government, aiding in the goal of making sound policy decisions.



HIGHLIGHTS OF SUCCESS

Scientific advances in the United States have enabled farmers to produce more on the same amount of land, have created new products from agricultural commodities, have developed farming methods that protect

the environment, and have pioneered food preservation techniques. The work of USDA researchers and analysts has also significantly improved farm-derived products and even led to significant medical findings.

Over the years, USDA researchers have:

- Transformed insect control strategies from chemical dependence to the use of biological means to disrupt insect reproduction
- Reduced topsoil losses by using computers to predict and curb the erosion rate of cropland under specific cropping and management conditions
- Improved livestock breeding and worked to successfully eradicate major animal diseases including hog cholera and Avian influenza
- Developed new plant varieties with better resistance to cold and insects, and with greater tolerance of drought and flooding—a notable result was the elevation of soybeans from a minor forage crop to the Nation's second most valuable crop
- Revolutionized the food industry through early research and experimentation on frozen foods that perfected their taste, quality, storage, and packaging
- Produced survey-based estimates of farm inventories, acreage, yield, and output, widely used by decisionmakers in government and agribusiness
- Developed chemicals and techniques for making cotton fabrics wrinkle-free and fire-resistant
- Invented a cornstarch derivative, "superslurper," that can absorb hundreds of times its weight in water and is used in dozens of products from diapers and baby powder to batteries and fuel filters.

The Penicillin Story

An agricultural byproduct unlocked the key to mass production of the wonder drug penicillin, the first antibiotic and one of the most valuable products to be generated through public funds in the 20th century. First isolated by a British scientist in 1928, this antibiotic—a mold with bacteria-killing powers—could at first be produced only in small quantities.

At the onset of World War II, the need for mass-produced penicillin became apparent, since it would be invaluable in treating often-fatal infections in wounded soldiers.

Scientists at USDA's laboratory in Peoria, Illinois had been growing molds for nutritional purposes in deep vats of corn steep liquor, a byproduct of corn processing. Chances were good that the Peoria lab could multiply the miracle mold in their vats. Using their deep fermentation process, they succeeded in multiplying penicillin yields tenfold. Not satisfied with the yields, the researchers searched for a superior strain of penicillin. From a mold found growing on an ordinary supermarket cantalope, the scientists isolated a strain that grew rapidly enough in the deep tanks to make commercial production possible.

The combined efforts of public and private scientists produced enough penicillin to treat wounded Allied troops on D-Day, and launched the modern antibiotics industry.



Frozen Foods: Making Them Freezer Friendly

It wasn't enough to invent frozen foods. Although frozen food was available in retail markets as early as the 1930s, consumers were dissatisfied with the cardboard texture, odd colors, and lack of taste, and well as lost nutrients and possible bacterial contamination during processing. Enter USDA scientists, who began their 17-year Time-Temperature Tolerance Project. They experimented with every step in the process, from selecting varieties to harvesting, handling, blanching, freezing, packaging, storing, and transporting. Their findings helped ensure the survival and growth of the U.S. frozen food industry. To commemorate the researchers' discoveries, the American Chemical Society, the world's largest scientific organization, designated USDA's Western Regional Research Center as a National Historic Chemical Landmark.

It was USDA researchers who uncurdled the gravies and sauces in the early frozen dinners by using a special rice flour instead of wheat flour as a thickener. And USDA scientists collaborated with the Florida Citrus Commission to find a method for transforming orange juice concentrate into a nutritious, flavorful drink.



CONSUMER-DRIVEN RESEARCH

Agricultural research in the past focused on farm production—boosting crop yields and enhancing food and fiber production. This goal remains as global population rises, but American agriculture is rapidly changing from a commodity-driven system to one driven by consumers. Today's consumers are concerned with the safety, variety, and nutritional value of the food they put on the table. They want variety in agriculture-based products, and they want to protect the environment.

USDA researchers have:

- Discovered a link between cataract development and insufficient levels of vitamin B6, folate, and taurine in diets of the elderly, and demonstrated the relationship between vitamin C intake and blood pressure in the elderly
- Developed a treatment for milk and milk products that enabled lactose-intolerant people to consume them without abdominal discomfort
- Designed software to help track foodborne pathogens, to support USDA adoption of the Hazard Analysis and Critical Control Points (HACCP) system for modernizing inspection of food processing plants
- Provided the first comprehensive estimate of the societal costs of unsafe food, including the costs of foodborne illness caused by major pathogens *E. coli*, *Salmonella*, and *Campylobacter*

- Created custom-tailored molecules to detect *E. coli* and other disease-causing strains of this bacterium in meat and other food products
- Conducted economic research to examine costs and benefits of Federal food safety rules
- Created a fat substitute, Nutrim, from enzyme-treated oats and barley, which cuts calories in baked goods without affecting taste
- Launched a website to provide a database of public and private food safety research projects for researchers and the general public
- Conducted organic farming experiments with novel cover crops, paper mulches, soil solarization, and biological control agents
- Set up an extensive program that compiles and disseminates widely used data on the nutritive value of individual foods.





USDA operates an extensive research program aimed at conserving natural resources, mitigating the effects of agriculture on the environment, and developing biodegradable products.

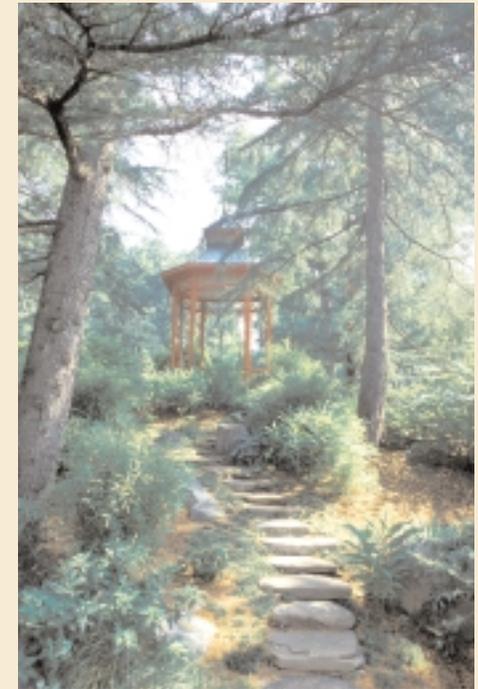
Researchers and scientists at USDA have:

- Partnered with farmers and Land Grant universities to generate nontoxic, lower cost strategies to control pests via the Integrated Pest Management (IPM) approach
- Demonstrated the effectiveness of IPM in controlling the destructive codling moth in apple orchards with reduced use of chemical pesticides
- Invented ways of using wheat starch to make biodegradable alternatives to petroleum-based, plastic containers
- Patented a soy-based ink for newspapers that does not rub off and a soy-based ink for printing books and magazines, that are alternatives to petroleum-based inks and contain no volatile organic compounds
- Developed an index of environmental benefits to help select farmland for retirement under USDA's major conservation program, helping to ensure the best results for the costs incurred
- Investigated how farmers might respond to economic incentives for adopting practices to reduce greenhouse gases.

The National Arboretum: A Garden of Horticultural Knowledge

Located along a major traffic artery in Northeast Washington, D.C. is a hidden garden of trees and flowers covering 444 acres. USDA's National Arboretum is a setting for both research and public education. Each year, more than a half million visitors from all parts of the world view the 9,000 different kinds of plants growing at the arboretum. Another half million visit via the Internet to learn about current research and about gardening.

Researchers at the National Arboretum have developed more than 650 new and improved varieties of trees, shrubs, and floral plants. They apply classical breeding and genetic engineering to solve horticultural problems in the floral and nursery industry and in recreational gardening. Arboretum researchers conceive techniques to detect and control plant diseases, and breed hardy plants that are resistant to diseases and pests. They have also devised methods to preserve plants shipped over long distances.



The National Arboretum offers lectures and group tours as well as exhibits and displays of flowers, herbs, and shrubs. Its programs draw researchers, students, tourists, and plant lovers. Among the Arboretum's recent accomplishments is the development of trees resistant to Dutch elm disease, and preserving and propagating the historic Japanese cherry trees that ring Washington's Tidal Basin and attract countless tourists to the city each spring.



BUILDING KNOWLEDGE OF THE FARM AND RURAL SECTORS

The American food and agriculture system is the subject of continual counting, measuring, pricing, analyzing, and reporting to provide constantly needed information to private stakeholders and to State and Federal policymakers. USDA researchers analyze the performance of the food and agriculture sectors and the rural economy, track their progress, project struc-

tural changes, and assess the acceptability and feasibility of new technologies.

USDA researchers:

- Conduct an annual national survey of farms—the Agricultural Resource Management Survey—that

yields information and data on resource use and technology adoption, as well as financial conditions and farm structure



- Developed a farm classification system or "typology" based on characteristics other than amount of farm sales, which policymakers find invaluable in targeting technical and educational programs for farmers
- Conduct the Census of Agriculture every 5 years—the most comprehensive source of uniform agricultural data for every county in the United States
- Designed techniques for collecting and analyzing data on farm practices, crop conditions, and other information on the farm and rural sectors
- Conduct hundreds of farm surveys annually and prepare reports covering virtually every facet of U.S. agriculture, including production and supplies of food and fiber, prices paid by and to farmers, and farm labor and wages
- Were first to report that the huge flow of people from rural to urban areas—the prevailing pattern of U.S. population movement after World War II—had reversed in the early 1970s as urban residents moved to rural areas in large numbers; research continues on the changing rural population and racial/ethnic trends
- Provided leadership in the preservation of documents and publications in print, digital, and other formats, and preservation of information on microforms.

The National Agricultural Library: Gateway to Knowledge

The National Agricultural Library (NAL) boasts 3.5 million items on 48 miles of shelves, with materials on agriculture and related sciences dating from the 16th century to the present, some not available anywhere else. Located in Beltsville, Maryland near Washington, D.C., the NAL is the primary U.S. resource for information about food, agriculture, and natural resources. The NAL manages the world's largest and most accessible collection of information and databases about agriculture.

An electronic gateway to a widening array of science-based information, the NAL maintains more than 40,000 Web pages and provides access to U.S. agricultural libraries and information resources for users worldwide. The Library's AGRICOLA bibliographic database (AGRICultural OnLine Access) contains more than 4 million citations to agricultural literature, with links to the full texts of many publications. The NAL provided leadership in establishing the Agriculture Network Information Center (AgNIC) to link agricultural information networks throughout the world for "one-stop Web shopping." The AgNIC alliance with Land Grant universities and other agricultural organizations, involving citizen groups and government agencies, continues to expand.



The NAL is a leader in preserving publications in print, digital, and other formats to ensure long-term access to information, and is nationally recognized for its expertise in preserving microforms. The breadth, depth, size, and scope of the Library's collection and services make it an irreplaceable resource for agricultural researchers, policymakers, and scholars.

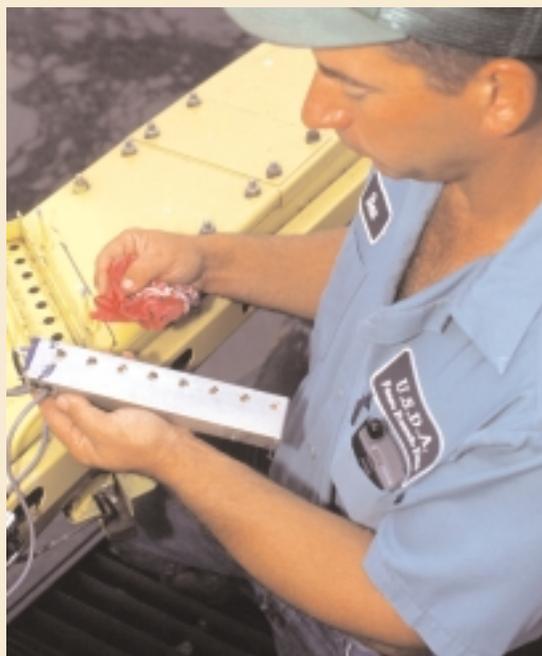
Precision Agriculture: Leadership in the Field

Farmers have long known that some parts of a field have better yields than others. Precision agriculture (PA) is a technology-based approach aimed at varying input use across a field according to the crop needs and soil conditions in specific areas. USDA researchers are among the leading innovators in this relatively young management system, which can potentially cut farmers' input costs, reduce chemical runoff, and conserve water.

Research on satellite-based remote sensing is important to precision agriculture. USDA has a broad program in remote sensing that involves more than 20 laboratories around the country, often operating in cooperation with other agencies and industries here and abroad. PA began with the use of global positioning system (GPS) sensors to monitor crop yields in small areas of a field. USDA research is aimed at expanding remote sensing to include live monitoring of crop growth, soil conditions, and plant water and fertilizer needs down to each square foot of land, over entire regions.

The work of USDA scientists and engineers includes evaluating several techniques to reduce the cost of collecting information across a field. One example is the use of remote sensing rather than expensive lab analysis to determine where nitrogen is adequate. Another initiative would use remote sensing to achieve faster and less expensive ways of making weed maps for farmers to use in applying herbicides.

USDA researchers are also working with industry to develop irrigation-based methods of delivering fertilizer and herbicides at low levels, through modifications of standard commercial sprinkler systems. A key goal of USDA's research on PA is to create a support system to help farmers make informed management decisions.



INVENTING THE FUTURE



Preparing the Researchers of the Future

Prospects for future agricultural research and advancement of knowledge depend on the talents of new food and agricultural scientists, agricultural economists, social scientists, demographers, and statisticians. Equally important is disseminating knowledge to those who can use it. The REE mission area of USDA helps lay the groundwork for advancing knowledge through university grant programs and support of all universities. Turning research results into successes in the field depends heavily on cooperation among researchers in multiple disciplines and institutions. Through the State Agricultural Experiment Stations and the Cooperative Extension System, USDA mobilizes public university resources to advance research in the food, agricultural, and related sciences.

The unique educational partnership with Land Grant institutions is a key part of USDA's mission. This partnership includes over 130 colleges of agriculture, 27 colleges of veterinary medicine, 42 schools of consumer sciences, 18 "1890 Land Grant institutions" (historically Black colleges and universities), 31 Native American Land Grant institutions, and over 200 Hispanic-serving institutions.

In addition to Land Grant programs, REE agencies maintain strong ties with the academic community through research collaboration, cooperative research agreements, intern programs, and grants for specific projects. These programs promote advances in virtually every area of food and agricultural science, and lay the foundation for further advances by future researchers.

The Shape of Things to Come

In the 21st century, new technologies will not only increase yields and enhance the efficiency of the food and agriculture system, but will also lead to products unimaginable just a half century ago.

U.S. farmers will grow highly specialized crops bred for unique applications in manufactured food and industrial products. Biotechnology and genetics will be key scientific tools. "Nutraceuticals," "farmaceuticals," and "functional foods" will become familiar terms as traditional crops are genetically modified to provide health benefits beyond their basic nutritional functions. Precision farming and other technology applications could revolutionize the use of agricultural inputs such as water and chemicals.

USDA researchers will continue to develop plants and animal products that help meet the needs of consumers, growers, and industry. They will explore ways to harness new technologies to improve food safety and nutrition, protect the environment, find new uses for agricultural products, develop more biofuels and biobased industrial goods, and uncover medicinal and other "functional" properties in food and other agricultural commodities.

USDA researchers and their partners in government and universities are already at work on shaping the future.

Among the many REE projects underway:

- Robotic cameras will detect contamination in foods at the processing stage. "Machine-vision" systems have been tested for fruit juice and poultry processing, to identify signs of contamination the human eye cannot see.
- Industrial lubricants derived from crops like sunflowerseed, soybeans, and canola are being lab-tested for their ability to replace petroleum-based lubricants with biodegradable, environmentally benign fluids.



Not by Yield Alone...

- Breeding crops for enhanced nutritional traits, such as carotenoid content, mineral composition, and other essential health-promoting properties, can counteract malnutrition in developing countries and promote health everywhere. Potatoes, for example, with orange, red, or purple flesh may provide added health benefits as well as new flavors.
- Genetic retooling can assist in postharvest processing. Key genes in wheat, for example, can improve its milling and mixing quality, which can lower processors' costs and result in more flavorful products better adapted to today's lower fat baked goods.
- Recruiting plants for cleanup of industrial and military waste sites and chemical spills is becoming a reality. A natural bacteria that lives on the roots of alfalfa and other legumes is being genetically altered to secrete an enzyme that breaks down hydrocarbons and other hazardous chemicals in soils.
- Nutrition research can benefit the environment, as cutting-edge science enables dairy farmers to better manage feed nutrients to avoid feeding livestock excess phosphorus and nitrogen that might otherwise contaminate groundwater, lakes, and rivers.
- Phytonutrients are the beneficial compounds in plants that, while not nutritionally essential, can apparently ward off ailments like cardiovascular disease and cancer. Research is proceeding on screening germplasm to locate these compounds and on finding ways to increase or preserve them in standard food crops.

Improving crop yields will not be enough to ensure a well-nourished population. USDA's Research, Education, and Economics mission area will continue its broad human nutrition program. REE scientists are nationally recognized leaders in the nutrition field. Their work includes examining how vitamins, minerals, and other food components improve cardiovascular health, strengthen immune systems, and reduce risk of chronic disease. Studies on obesity have become a major REE focus. The six USDA Human Nutrition Research Centers around the country conduct cutting-edge research on child nutrition, diet intervention, nutritional needs of the aging, and other studies.

Public and private decisionmakers look to REE for comprehensive studies of food programs and policies, and for analysis of how industry trends and consumers' economic well-being affect food and nutrient intake. Evaluation of food and nutrition assistance programs by REE provides guidance to the USDA agency administering the programs. REE agencies make grants to universities for nutrition and obesity research, and to local communities for nutrition education and outreach. REE publications on the nutritive value of foods are a time-honored source of information and data for other scientists and the general public.

In the 21st century, REE scientists will use findings from the Human Genome Project to expand knowledge of nutrition and disease, and will continue research to develop "functional foods" that provide health benefits beyond their basic nutrients.

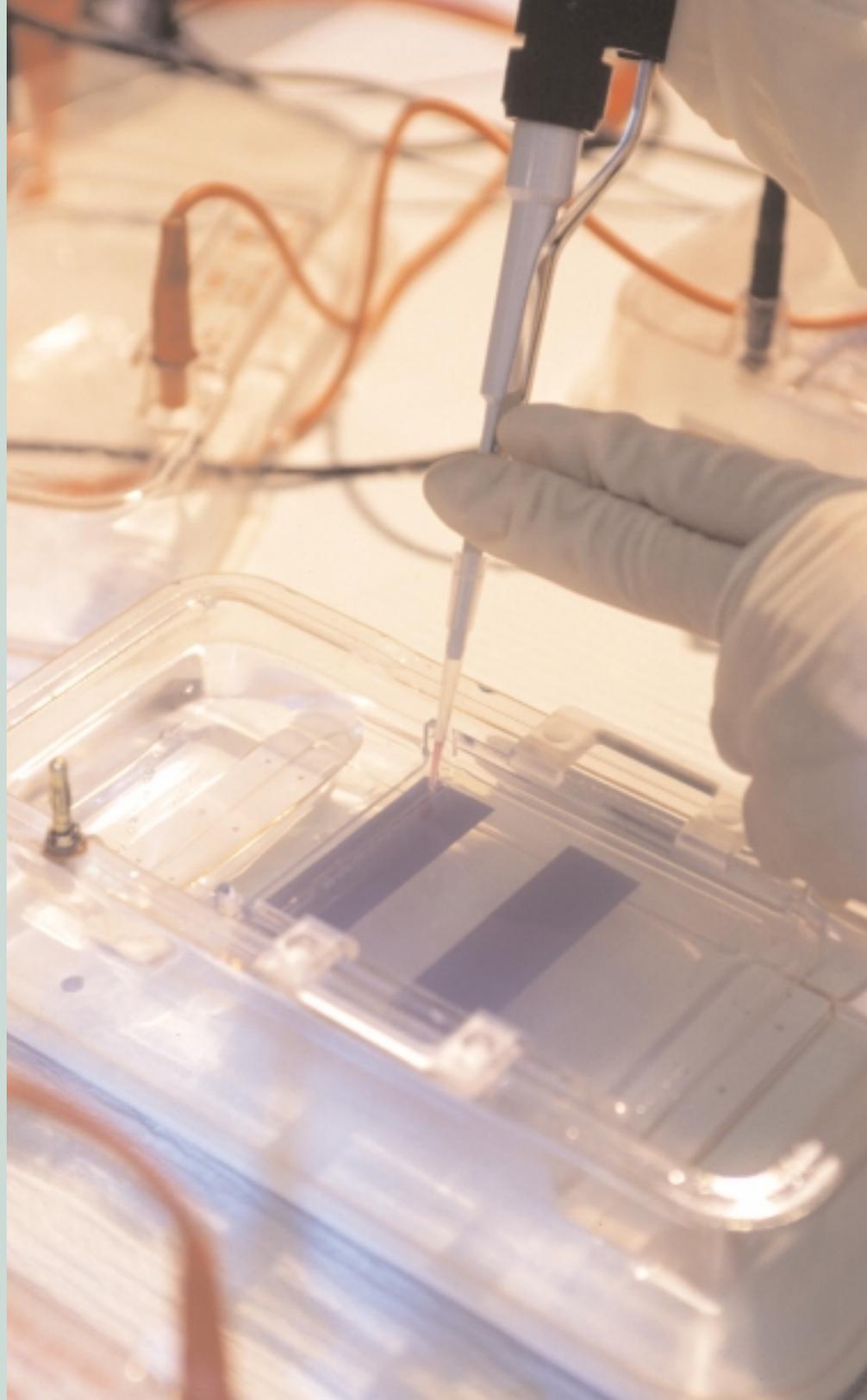


- Gene mapping of plants, animals, and microbes can help to inhibit harmful pathogens. Rebuilt genes, for example, could make tomorrow's plants and animals unsuitable hosts for pathogens. Mapping of the bovine genome began in spring 2000.
- More economical biofuels are on the horizon. A radically alternative method of producing ethanol, now in the making, could be far less costly than conventional methods. And the possibility of using the whole crop instead of just the grain could make biofuels less expensive to producers and consumers.

Science will inevitably alter the farm and food system and even create new industries. Farmers might, for example, contract to grow specialty crops containing nutraceuticals—the plants or chemical compounds with health-promoting, disease-preventing or medicinal properties.

In addition to performing cutting-edge scientific research, USDA's research program will include monitoring farmers' adoption of new technologies, examining costs and benefits of the various technologies, and predicting consumer acceptance of new products.

As the food and agricultural system adapts, USDA researchers will be called upon to track and project the resulting changes in the structure of the system and in the economy of the Nation.



REE AGENCIES



Agricultural Research Service (ARS) is USDA's in-house science research agency, working to advance knowledge, technologies, and solutions to support the agriculture and food sectors and conserve natural resources. ARS research promotes the quality, safety, and variety of America's agricultural products. The research results are transferred to the marketplace to serve a wide range of users. The National Agricultural Library, a component of ARS, plays a key role in information dissemination.

www.ars.usda.gov



Cooperative State Research, Education, and Extension Service (CSREES) partners with Land Grant and other universities, State Agricultural Experiment Stations, and the nationwide Cooperative Extension System in programs that advance research and education in the food, agriculture, and related sciences. The CSREES outreach agenda supports programs that provide real-world solutions for farms, consumers, and communities, and that enhance education facilities for training future researchers.

www.reeusda.gov



Economic Research Service (ERS) is USDA's main source of economic research and analysis. Its economists and social scientists analyze and project developments in the food industry, farm structure and income, agricultural trade, commodity markets, conservation, and the rural economy. The ERS program includes policy analysis and development of economic and statistical indicators. The work of ERS informs decisionmakers in the public and private sectors.

www.ers.usda.gov



National Agricultural Statistics Service (NASS) is the major source of statistics on U.S. agriculture. NASS field offices regularly survey thousands of operators of farms, ranches, and agribusinesses. These scientifically designed surveys provide the basis for estimates of production, supply, price, chemical use, and other aspects of the agricultural economy. NASS conducts the Census of Agriculture every 5 years—the most comprehensive source of county-level agricultural data.

www.usda.gov/nass

Visit us on the web to learn more about REE programs

Research, Education, & Economics

www.reeusda.gov/ree

National Agricultural Library

www.nal.usda.gov

U.S. National Arboretum

www.usna.usda.gov

Photo of GPS satellite on page 14 courtesy of U.S. Air Force

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