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Competitive Research Grants and Awards Management

National Research Initiative Competitive Grants Program

Annual Report
Fiscal Year 2002

"Knowledge for Tomorrow's Solutions"

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Materials Available on the Internet

This annual report and other NRI materials, such as Abstracts of Funded Research and the current Request for Applications (RFA) are available on the CSREES home page at *www.csrees.usda.gov/funding/nri/nri.html*

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Message from the Chief Scientist

Dear Colleagues and Interested Parties:

The National Research Initiative (NRI) Competitive Grants Program invests in the future of agricultural and natural resource research opportunities. In FY 2002, the funding for the year was $120 million, up from the FY 2001 base of $105.6 million. The increase enabled a supplemental program announcement in three areas: Plant Genome Program (emphasizing bioinformatics and data management), Animal Genome Basic Reagents and Tools, and Improved Utilization of Wood and Wood Fiber. In addition, NRI funds supported the genomic sequencing of microorganisms relevant to agriculture, through an interagency effort between CSREES and the National Science Foundation (NSF). Details are provided later in this report. Further support for the NRI was indicated by the President's budget, which requested $240 million for FY 2003.

The NRI enables people at different levels of education, stages of their career and at many different types of institutions to compete successfully. Bright, innovative and creative researchers are not only found among established investigators at land-grant institutions. For example, as a post-doctoral investigator, Dr. Dan Peterson, now an assistant professor at Mississippi State University discovered and perfected a new method for genomic sequencing of higher organisms that may significantly improve upon current methods. The method is based on removing repetitive elements, which are the principal complicating factor in genome research, leading to an enrichment of relevant genetic information. The cost and quality of the method surpass current procedures and the method has been published in peer-reviewed scientific literature (Peterson, D. G., et al., 2002, Efficient Capture of Unique Sequences from Eukaryotic Genomes, Trends in Genetics, 18:547-550). Another new investigator, Dr. Louise Temple of Drew University, Madison, New Jersey, had the top ranked proposal in the Microbial Genome Sequencing Program. She proposed to sequence *Bordetella avium*, a bacterium that causes serious diseases in turkey, chicken, ostriches and cockatiels. The project will also lead to the development of new educational tools for the science of genomics.

The NRI uses a time-tested, competitive peer-review process to award grants supporting research in the biological, environmental, physical, and social sciences and engineering on regional and national problems relevant to agriculture, food, forestry and the environment. The ultimate goal of the research is to ensure that U.S. agriculture and forestry are sustainable and globally competitive. Competition for NRI research funds is open to researchers at all U.S. academic institutions, federal research agencies, private and industrial organizations, as well as to individual researchers.

NRI-supported research at a small business highlights how an investment in science may

accelerate the generation of critically needed agricultural solutions. NRI funds supported the interagency U.S. Rice Genome Project. The interagency and international effort for the completion of the draft sequence of the rice genome in FY 2002 is highlighted. Special recognition is given to Dr. Mahfuzur Sarker, who received a Presidential Early Career Award for Scientists and Engineers (PECASE).

The NRI assessed its program portfolio to determine the broader areas in which research needs were greatest and in which the NRI contributes to the agricultural enterprise. Thus, two strategic issues were highlighted. The concept for strategic issues has been identified in several reviews, including those by the National Research Council (NRC) in 2000 for the NRI[1]. The initial issues are 1) agricultural security and safety through functional genomics and 2) new and re-emerging diseases and pest threats. Several NRI programs are addressing these areas.

The NRI has been remarkably successful as measured by recognition of the high quality research that is applicable to consumers and growers of food and fiber, and used by new and established businesses. Individuals wishing to learn more about NRI-funded research can do so by reading *NRI Research Highlights* and *NRI Cover Stories*. These publications are a series of fact sheets featuring successful NRI-funded research projects and their potential impact on U.S. and world agriculture and, a series of flyers depicting NRI-funded research that has been featured on the covers of prominent peer-reviewed scientific journals. These publications are available on the CSREES home page *www.csrees.usda.gov/funding/nri/nri.html*.

The report that follows is an overview of some of the research the NRI will be supporting over the next two to three years from its FY 2002 congressional appropriation. I have chosen to highlight just a few of the 597 grants funded through the FY 2002 congressional appropriation. I have selected grants that have wide range of interest and grants that exemplify the broad mission of the USDA.

As Chief Scientist, it is an honor and privilege to be associated with such an exemplary program. I am also impressed with the very capable and dedicated staff that, despite very small numbers, does a superb job in program administration and management. I also thank those who support competitive research and the many fine scientists who contribute to the mission of the NRI through their participation in the peer-review process. Competitive research in agriculture is essential for our country's future economic prosperity and security of the food and agricultural system.

Anne K. Vidaver
NRI Chief Scientist

[1] National Research Initiative: Vital Competitive Grants Program in Food, Fiber, and Natural Resources Research. 2000. National Academy Press, Washington, DC, 189pp.

The National Research Initiative: Overview

USDA's National Research Initiative was established in FY 1991 in response to recommendations outlined in *Investing in Research: A Proposal to Strengthen the Agricultural, Food and Environmental System,* a 1989 report by the National Research Council's (NRC) Board on Agriculture. This publication called for increased funding of high priority research, funded by USDA through a competitive peer-review process, directed at:

- Increasing the competitiveness of U.S. agriculture.
- Improving human health and well-being through an abundant, safe, and high-quality food supply.
- Sustaining the quality and productivity of the natural resources upon which agriculture depends.

Continued interest in and support of the NRI is reflected in two subsequent NRC reports, *Investing in the National Research Initiative: An Update of the Competitive Grants Program of the U.S. Department of Agriculture,* published in 1994, and *National Research Initiative: A Vital Competitive Grants Program in Food, Fiber, and Natural-Resources Research,* published in 2000.

Competitive Review Process

The NRI competitive review process encourages innovative ideas that are likely to open fundamentally new research approaches to enhancing agriculture, food, forestry, and the environment. A proven mechanism for stimulating new scientific research, the competitive review process increases the likelihood that investigations addressing important, relevant topics using well-designed and well-organized experimental plans will be funded. Each year, panels of scientific peers meet to evaluate and recommend proposals based on scientific merit, investigator qualifications, and relevance of the proposed research to U.S. agriculture.

At least 10 percent of NRI funds support Agricultural Research Enhancement Awards. These awards enhance the U.S. agricultural research system through funding of postdoctoral fellowships and research by new investigators as well as through Strengthening Awards.

Strengthening Awards include Research Career Enhancement Awards, Equipment Grants, Seed Grants, and Strengthening Standard Research Projects. These grants fund researchers at small and mid-sized institutions ($\leq$ 15,000 total enrollment) with limited institutional success or in states and other entities that are part of the Experimental Program for Stimulating Competitive Research (EPSCoR).

The NRI encourages multi-disciplinary research, which is needed to solve complex problems, and seeks to initiate research in new areas of science and engineering that are relevant to agriculture, food, forestry, and the environment. The NRI also supports scientific conferences to facilitate the exchange of information necessary to achieve the most rapid advances in these

areas. Both mission-linked research and fundamental research are supported by the NRI. Mission-linked research targets specific problems, needs, or opportunities. Fundamental research – the quest for new knowledge about agriculturally important organisms, processes, systems, or products – opens new directions for mission-linked research. Both mission-linked research and fundamental research are essential to the sustainability of agriculture.

Identification of Research Priorities

Setting research priorities is an important means of facilitating the scientific and technological advances needed to meet the challenges facing U.S. agriculture. Congress sets the basic budgetary framework for the NRI. In the legislation that authorized the establishment of the NRI, Congress defined high-priority research as basic and applied research that focuses on both national and regional research needs (and methods for technology transfer). The authorizing legislation requires that, as appropriate, grants be consistent with the development of systems of sustainable agriculture. Congress further specified that no less than 30 percent of funds be used to support multi-disciplinary team research, no less than 40 percent be used for mission-linked research, and no less than 10 percent be used to strengthen the research capacity of individuals and institutions. Members of Congress also make recommendations for the scientific and programmatic administration of the NRI through appropriation language and through their questions and comments during Congressional budgetary hearings.

Input into the NRI priority-setting process is sought from a wide range of NRI customers, stakeholders and end-users. The scientific community provides direction for the NRI through the research proposals it submits each year, as well as through the research proposal evaluations and funding recommendations of individual scientific peer-review panels. In addition, the NRI receives comments on its programs from academic administrators, other staff members, and scientists from universities; the Experiment Station Committee on Policy; and the research administrators of the 1890 land-grant institutions.

NRI scientific staff members play an important role in providing continuity of programmatic leadership and scientific administration from year to year. Staff members attend scientific and professional meetings to stay current on scientific trends that need to be reflected in the *NRI Program Description* and in the coordination of priority setting with other federal agencies. NRI staff also participate in meetings with representatives of key commodity groups and other user groups to discuss these stakeholders' current research priorities, to learn ways the NRI can assist in meeting their needs, and to solicit comments and suggestions on NRI research priorities.

Input from several coalitions has proved to be an important source of information. NRI staff members meet with groups such as the Institute of Food Technologists, CoFARM, C-FARE, FAIR 2002, and the Animal Agriculture Coalition to gain a broad perspective on current research needs and priorities.

The NRI Chief Scientist, the Deputy Administrator of Competitive Programs, and NRI scientific staff are responsible for assimilating the input of diverse stakeholder groups into a program description that will solicit the highest-quality proposals to meet the needs of U.S. agriculture, food, forestry and the environment. The NRI research areas, which are evaluated and updated

each year, are listed in the *NRI Request for Application* issued annually. The *NRI Request for Application* is accessible to the public – on the Internet via the CSREES home page (*www.csrees.usda.gov/funding/nri/nri.html*).

Program Implementation

The *NRI Request for Application* is distributed widely within the scientific community and among other interested groups. The FY 2002 *NRI Request for Application and Guidelines for Proposal Preparation* identified 25 research programs within the following eight major research areas:

- Natural Resources and the Environment
- Nutrition, Food Safety, and Health
- Animals
- Biology and Management of Pest and Beneficial Organisms
- Plants
- Markets, Trade, and Rural Development
- Enhancing Value and Use of Agricultural and Forest Products
- Agricultural Systems Research

A total of 2,581 research proposals were considered for funding in FY 2002. Twenty-nine peer panels reviewed and ranked the proposals, evaluating them on scientific merit, the qualifications of personnel carrying out the proposed project, the adequacy of the proposed facilities, and the relevance of the proposed project to long-range improvements in – and the sustainability of – U.S. agriculture.

Each peer panel was composed of individuals with the expertise required to review each proposal thoroughly and fairly. Proposals for Postdoctoral Fellowships, New Investigator Awards, Strengthening Standard Research Projects, Research Career Enhancement Awards, Equipment Grants, and Seed Grants were reviewed within the specified research program.

Criteria for the selection of panel members included knowledge of the relevant scientific discipline, educational background, experience, and professional stature within the scientific community. The membership of each panel was carefully balanced to reflect diversity in geographical region, type of institution, type of position, and gender and minority status (see Table 1).

Additional expertise was brought to proposal evaluation by a number of scientists and other experts representing a wide variety of fields, who conducted *ad hoc* reviews. These reviews provided the additional expertise that made it possible to select the highest quality, most meritorious proposals for funding.

More than 9,000 scientists contributed their time and expertise to the NRI proposal evaluation process in FY 2002. Participation in the panels and in writing *ad hoc* reviews provided many individuals the opportunity to gain experience in the review process and to become more familiar with the nature of the science supported by the NRI. The pool of *ad hoc* reviewers also provided a resource from which future panel members may be selected.

At the conclusion of the review process, a summary of the panel evaluation and the written reviews were forwarded to the investigators, providing them with critical assessments of their proposed research by recognized leaders in the appropriate fields. The reviewers' comments and suggestions also were important for purposes of refining the proposals for future resubmission.

Continuing a practice begun in 1993, non-technical summaries describing each research project funded in FY 2002 are posted as *Abstracts of Funded Research* on the CSREES home page (*www.csrees.usda.gov/funding/nri/nri.html*).

Grantsmanship Workshops

NRI program staff conducted a number of workshops in FY 2002 to increase applicants' and administrators' understanding of the philosophy, directives, and procedures of the NRI competitive review process. In FY 2002, staff held a well–attended grant-writing workshop in Syracuse, New York, as part of its ongoing practice of conducting a major grant-writing workshop annually in one of the five U.S. regions (North Central, Northeast, South, West and 1890's). The workshop was hosted by Cornell University and included previous panel managers as part of the program. The workshop focused on guidelines for preparing proposals, individual program descriptions, and recent funding statistics. In addition, the NRI staff conducted individualized workshops or made presentations at national meetings of scientific and/or professional societies, for regional research groups and other audiences, including Food Safety Educators. Other workshop sites included Experimental Program for Stimulating Competitive Research (EPSCoR) entities and 1890 Land Grant Institutions.

Funded Research

In FY 2002, a total of 2,581 proposals were submitted to the NRI, requesting a total of $722,484,903. Awards totaling $109,613,947 were made to the 597 highest-ranked proposals (see Table 2).

The success rate (in terms of number of proposals funded and excluding conferences, supplements, and continuing increments of the same grant) was 23 percent. The average grant award for new standard research projects (excluding Research Career Enhancement Awards, Equipment Grants, Seed Grants, Conferences, Continuing Increments, and Supplements) in FY 2002 was $183,608 for 2.25 years. (For FY 2001, the comparable figures were $188,116 for 2.4 years.)

The NRI provided funds totaling $288,966 in partial support of 38 conferences in FY 2002. These conferences brought scientists together to identify research needs, provide an update on research information, and/or advance an area of research important to U.S. agriculture, food, forestry and the environment.

In FY 2002, the NRI provided funds totaling $11,474,377 in Agricultural Research Enhancement Awards. This support included Postdoctoral Fellowships, New Investigator Awards, and Strengthening Awards (see Table 3).

Crosscutting Areas

A number of research topics of major importance to USDA involve several research areas or programs. NRI support for these crosscutting program areas in FY 2002 is indicated in Table 4. The data show the total amount of funding from all research areas for a specified research topic. For example, the Water Quality area includes projects from the Water Shed Processes and Water Resources Program as well as projects from other programs relevant to water quality such as Soils and Soil Biology. The Integrated Pest Management area includes projects funded from the programs on Biologically Based Pest Management, Entomology and Nematology, Biology of Plant-Microbe Associations, and Biology of Weedy and Invasive Plants. The $11.6 million funding allocation for sustainable agriculture represents projects identified from many NRI programs, including the Agricultural Systems Research Program, that are directly relevant to sustainable agriculture. This figure is probably an underestimate since, in a broad sense, all research supported by the NRI is germane to sustainable agriculture.

Research Dimensions

As noted earlier, research programs can be examined from perspectives such as type of investigation (fundamental or mission-linked) and organization of research approach (single discipline or multi-disciplinary).

- The NRI defines *fundamental research* as that which tests scientific hypotheses and provides basic knowledge that allows advances in applied research and from which major conceptual breakthroughs are expected to occur.
- In contrast, *mission-linked research* is that which focuses on specifically identified agricultural problems which, through a continuum of efforts, provide information and technology that may be transferred to users and may relate to a product, practice, or process.
- *Multi-disciplinary research* is defined as work on which investigators from two or more disciplines are collaborating closely. These collaborations, where appropriate, may integrate the biological, physical, chemical, and social sciences. NRI funding in FY 2002 for these three categories is shown in Table 5.

Interagency Research

NRI program directors work closely with their research-funding counterparts in other federal agencies to avoid duplication and maximize interagency cooperation. An example of cooperation is seen in the research that NRI funds jointly with other federal agencies, including:

- The Interagency Metabolic Engineering Program, established in 1998 with the Department of Energy (DOE), the National Science Foundation (NSF), the Department of Commerce (DOC), the Department of Defense (DOD), the Environmental Protection Agency (EPA), National Institute of Health (NIH/NIGMS), the National Aeronautics and Space Administration (NASA) and USDA. FY 2002 is the fifth year of this program. The NRI co-funded the award "Quantitating and Manipulating Seed Metabolic Networks". More information is available at the metabolic engineering website (*http://www.metabolicengineering.gov*)

- The USDA in partnership with NSF and DOE provided supplemental FY 2002 funding to the U.S. Rice Genome Sequencing Project. A Rice Genome Celebration was held in Washington, D.C. and Tokyo, Japan on December 18, 2002 in honor of the interagency and international effort that produced 10X draft sequence of the rice genome.
- The Microbial Genome Sequencing Project has been supported jointly by the USDA/CSREES and NSF since FY 2001 building on a Microbial Genome Sequencing Program offered by the USDA/CSREES in FY 2000. In FY 2002, the USDA-CSREES / NSF Microbial Sequencing Project jointly supported the sequencing of 15 microorganisms including plant and animal pathogens and biological control agents which are important to agriculture, food, forestry and the environment.

Each interagency research program issues a single request for proposals, and representatives of the agencies work together to assemble a panel of scientific peers to identify the most meritorious proposals. From this group, representatives of each agency select proposals that are the most germane to the mission of that agency. Thus, the NRI is able to attract researchers from a wide applicant pool, which are important to agriculture, food, forestry and the environment.

Table 1. Characteristics of NRI Peer Panels, FY 2002

Geographic Region	**Number**	**Percentage**
North Central[1]	107	30
Northeast[2]	71	20
South[3]	91	26
West[4]	86	24
Type of Institution		
Land-Grant	231	65
Public/Private	65	18
Federal	40	11
Industry/Other	19	6
Type of Position		
Assistant Professor	77	22
Associate Professor	94	26
Professor	111	31
Federal	38	11
Industry	18	5
Other	17	5
Gender/Minority Representation[5]		
Non-minority Males	185	52
Non-minority Females	96	27
Minority Males	49	14
Minority Females	25	7

[1] Northeast region includes the following states plus DC: CT, DE, MA, MD, ME, NH, NJ, NY, PA, RI, VT, WV
[2] Northcentral region includes the following states: IA, IN, IL, KS, MI, MO, MN, ND, NE, OH, SD, WI
[3] Southern region includes the following states: AL, AR, FL, GA, KY, LA, MS, NC, OK, SC, TN, TX, VA
[4] Western region includes the following states: AK, AZ, CA, CO, HI, ID, MT, NM, NV, OR, UT, WA, WY
[5] Minorities include Asians, African Americans, Hispanics, Pacific Islanders, and Native Americans

Table 2. NRI Funding Allocations[1], FY 2002

Research Area/Program	Number of Grants Awarded	Total Dollars Awarded
Natural Resources & Environment		
Plant Responses to the Environment	29	$3,300,000
Water Shed Processes and Water Resources	20	4,370,000
Soils and Soil Biology	23	4,774,000
Managed Ecosystems	14	3,685,357
Total: Natural Resources and Environment	**86**	**$16,129,357**
Nutrition, Food Safety, & Health		
Improving Human Nutrition for Optimal Health	24	4,337,215
Food Safety	28	5,987,555
Epidemiological Approaches to Food Safety	7	5,545,000
Total: Nutrition, Food Safety, & Health	**59**	**$15,869,770**
Animals		
Animal Reproduction	24	3,906,549
Animal Health and Well-Being	55	11,047,597
Animal Genome Basic Reagents and Tools	20	6,000,000
Animal Growth, Development, and Nutrient Utilization	26	4,419,594
Total: Animals	**125**	**$25,373,740**
Biology and Management of Pest Beneficial Organisms		
Entomology and Nematology	34	5,725,000
Biology of Plant-Microbe Associations	33	6,080,000
Biologically Based Pest Management	17	3,140,000
Biology of Weedy and Invasive Plants	14	2,640,000

Total: Biology and Management of Pest Beneficial Organisms	**98**	**$17,585,000**
Plants		
Plant Genome – Bioinformatics and Data Management	5	1,800,000
Plant Genetic Mechanisms	38	5,435,490
Plant Growth and Development	41	4,787,510
Agricultural Plant Biochemistry	41	4,735,000
Total: Plants	**125**	**$16,758,000**
Markets, Trade, & Rural Development		
Markets and Trade	21	2,065,200
Rural Development	18	1,849,200
Totals: Markets, Trade & Rural Development	**39**	**$3,914,400**
Enhancing Value and Use of Agricultural and Forest Products		
Food Characterization/Process/Product Research	27	4,000,000
Non-Food Characterization/Process/Product Research	17	3,000,680
Improved Utilization of Wood and Wood Fiber	13	1,700,000
Total: Enhancing Value and use of Agricultural & Forest Products	**57**	**$8,700,680**
Inter-Agency Programs		
Metabolic Engineering Program	2	300,000
U.S. Rice Genome Project	2	1,018,000
Microbial Genome Sequencing Project	4	3,965,000
Total: Inter-Agency Programs	**8**	**$5,283,000**
GRAND TOTAL	**597**	**$109,613,947**

[1] The content of this table varies from tables provided in documents supporting the President's budget to Congress each year in that these data represent all awards made in FY 2002 regardless of the year funds were appropriated. Previous year funds may include some carried over from the proceeding year to achieve flexibility in proposal due dates and small unused amounts returned from awardees as grants expire.

Table 3. Agricultural Research Enhancement Awards, FY 2002

Type of Award	**Number of Grants**	**Total Dollars Awarded**

Postdoctoral Fellowships	13	$1,169,893
New Investigator Awards	20	2,648,533
Strengthening Awards		
Research Career Enhancement Awards	4	342,160
Equipment Grants	23	594,106
Seed Grants	19	1,350,245
Standard Strengthening Research Projects	27	5,369,440
Total	**106**	**$11,474,377**

Table 4. Crosscutting Program Areas, FY 2002

Research Topic	Number of Grants	Total Dollars Awarded
Plant Genome	29	$4,840,074
Forest Biology	27	5,166,503
Global Change	55	8,882,810
Sustainable Agriculture	55	11,646,981
Animal Genome	15	3,170,100
Animal Health	84	19,839,034
Water Quality	55	5,464,738
Food Safety	48	14,764,397
Integrated Pest Management	62	13,613,856

Table 5. Dimensions of NRI Research, FY 2002

Dimension	Amount of Support	Percent
Fundamental	$73,334,821	67

Mission-linked	36,279,126	33
Multi-disciplinary	59,114,172	54
Single discipline	50,449,775	46

The National Research Initiative: Achievements

In FY 2002, the NRI funded 597 grants. This section provides examples of fundamental and mission-linked research targeted at problems important to the USDA mission, funded through the 29 panels, and related to the five broad outcomes outlined in CSREES' *Government Performance and Results Act Strategic Plan*.

Outcome 1: An agricultural production system that is highly competitive in the global economy

Genetic Engineering of Nematodes as Suppression of Insect Cellular Immune Response. While nematodes have been shown to be effective in controlling insect populations in a variety of conditions, the number of different types of insects that can be controlled is sometimes limited. One limitation is the immune response to the insect pest, which can lead to encapsulation and the eventual death of the nematode. **Dr. Diana Cox-Foster** and her colleagues at **Pennsylvania State University** will identify a gene from one nematode that allows this species to avoid the insect immune response. This gene will be incorporated into the genome of a second species that is normally incapable of avoiding the immune response of the insect. Incorporation of this gene through genetic engineering will allow this second species to avoid the immune response of the insect host and to become a more effective biological control agent. Engineering nematodes to evade immune responses would potentially increase the pool of effective natural enemies of pests by increasing their potential range of hosts that can be successfully attacked.

Towards in silico Gene Mapping from Phenotypic, Pedigree, and Genomic Data in Plant Breeding. Information on the genes controlling economically-important traits is important for future improvements in crop productivity and quality. Specifically designed experiments are typically needed in genome mapping; such experiments permit the study of the relationship between variation in DNA (i.e., genomic data) and variation in the trait of interest (i.e., phenotypic data). On the other hand, public and private breeding programs in major crops accumulate massive amounts of phenotypic data each year. These data, which are routinely generated in the course of a breeding program, are underutilized in gene mapping. **Dr. Rex Bernardo** of the **University of Minnesota** will develop methods for mapping genes from (1) phenotypic data that are routinely generated in a plant breeding program, (2) pedigree records that are kept in the course of a breeding program, and (3) genomic data that are generated from genomic screens of experimental varieties used in breeding. By computer modeling, the usefulness of this *in silico* mapping approach will be evaluated in the context of breeding programs for two of the major crops in the U.S., corn and soybean. The usefulness of *in silico* mapping will be examined under different genetic models. Because this research aims to exploit existing data in mining for genes, a greater leverage of current investments in crop variety

development and in plant genome research can be achieved.

Characterization of Ds Transposition in the Soybean Genome. Significant research investments have been made in the area of soybean genomics. These efforts are rapidly accumulating a wealth of information on soybean genes, whose functions promise to greatly expand our knowledge on this important crop plant. The utility of the genomics information being generated will be enhanced by the development of additional tools for the elucidation of gene function. **Dr. Thomas Clemente** of the **University of Nebraska** is proposing to use a high throughput transposon tagging system (using the maize Ds transposable element) that is coupled with gene trap and enhancer trap elements, which will permit rapid identification of genes and promoter elements, respectively. Once developed, this system will provide a valuable resource for soybean geneticists and breeders.

Phase Change and Seasonal Floral Initiation in Populus. Forest tree domestication is hindered by long generation times and the presence of inter-fertile wild relatives that typically grow near plantations. The ability to keep forest trees in a reproductively juvenile state when grown in production plantations, and the ability to induce flowering on demand to accelerate conventional breeding, will facilitate the full integration of biotechnology and traditional breeding into an optimal tree improvement program. Towards these goals, **Drs. Amy Brunner and Richard Meilan of Oregon State University** will take advantage of the biology of *Populus* (poplar or aspen) and its genomics resources to study the transition from juvenility to maturity in trees. One way to investigate the phase transition in poplar is by studying homologs to genes that regulate flowering time in the model species *Arabidopsis*. The investigators have already identified several poplar homologs of *Arabidopsis* flowering-time genes, including dosage-dependent regulators. The function of one such gene, *TERMINAL FLOWER 1 (TFL1)*, will be analyzed in greater detail in early- and late-flowering poplar genotypes.

BarleyBase, a Prototype Online Database for Cereal Microarrays with Integrated Tools for Data Visualization and Statistical Analysis. In small grain Triticeae crops, the molecular characterization of genes coincident with disease, response to biotic or abiotic stresses or cellular development has traditionally followed a "one-gene-at-a-time" approach. However, recent advances in microarray technology now allow the study of thousands of genes in a single experiment. Instead of checking genes individually in smaller scale experiments, the genes of an entire organism can be studied simultaneously. The long-range goal of this project is to utilize barley as a model grain crop to develop genomic tools for the functional analysis of Triticeae genes. To perform these large-scale studies, scientists must be able to easily access, compare, and manipulate physical, genetic, and expression data. **Dr. Julie Dickerson, Dr. Volker Brendel, Dr. Roger Wise, Dr. Dan Nettleton and Dr. Diane Cook** at the **Iowa State University** will create an on-line interactive database component, BarleyBase, and develop a set of web-accessible tools for the analysis of Affymetrix GeneChip data. BarleyBase will feature "click through" integration of the data on the web, and it will be interoperable with the Gramene comparative mapping resource for grains (*http://www.gramene.org/)*. The web-based analysis tools will enable database users to identify subsets of genes that change expression in response to drought, cold stress, disease, or other treatments. As data begin to accumulate, it will be possible to ask broad biological questions by performing *in silico* comparisons of data sets not only from one location, but also among data sets worldwide. This will accelerate agronomic and quality

research in cereals, one of the world's most important food sources.

Genes Controlling Inflorescence Structure in Arabidopsis. The physical structure and stature of domesticated plants strongly influence their utility as food crops. Important agricultural properties such as pollination rates, the efficiency of harvesting, and overall plant productivity are dependent upon the structure of the inflorescence, the flower/fruit-bearing shoot. However, little is known about the genetic control of the overall structure or "architecture" of the inflorescence. **Dr. Robert Sharrock** of **Montana State University** is investigating the molecular pathways that regulate the changes in growth and division of internode cells that are induced in many plants at the transition to the plant reproductive phase. These pathways control stem elongation in the inflorescence and, therefore, determine critical aspects of reproductive development. It may be possible to modify the activities of these pathways in targeted ways and, ultimately, to exert agriculturally-useful control over important aspects of plant structure. This project is also an excellent example of an Experimental Program for Stimulating Competitive Research (EPSCoR) success since this award is a renewal of a strengthening project supported by EPSCoR funds.

Molecular and Genetic Analysis of Fiber Differentiation. One of the fundamental plant biological questions concerns the differentiation of cell types that constitute a plant body. Fiber cells, being the longest plant cells and having mechanical strength, represent an excellent model for dissecting the molecular mechanisms regulating initiation of differentiation, cell elongation, and cell wall deposition. **Dr. Zheng-Hua Ye** of the **University of Georgia** has made significant progress towards understanding how fiber cells are formed. He has identified a large number of mutants that specifically affect fiber development and cloned several key genes that will provide major fundamental insights into the control of cell differentiation processes in general. Fiber cells have many economic uses such as paper production and textiles. Therefore, study of fiber differentiation will not only contribute to our knowledge on cell differentiation, but also have economic and agronomic implications.

Novel Statistical Methods for Generation of Integrated Genomic Maps. This project aims to formulate novel statistical methods for the generation of integrated genomic maps from three sources of information, namely, physical maps, genetic linkage maps and DNA sequence data. Several fungal genome mapping projects are faced with the problem of integrating the wealth of information derived from genetic linkage maps, physical maps and DNA sequence data. **Dr. Suchendra Bhandarker and Dr. Jonathan Arnold** at the **University of Georgia** will formulate statistical integration methods with sound theoretical foundation such as the maximum likelihood principle and Bayesian *a posteriori* estimation. Efficient algorithms and computational schemes for the realization of the statistical methods will be investigated and designed in a manner to make them amenable to parallel and distributed computing. Integrated genomic maps in which the information from genetic linkage maps, physical maps and DNA sequence data are reconciled, will aid in the understanding of fundamental metabolic processes underlying biological clocks, the cell cycle and fungal pathogenicity. The genomic maps will provide a means for identifying the genes involved in these processes and for manipulation of these genes for crop improvement by targeted transformations and knockouts. More specifically, informatics and algorithmic tools for the generation of integrated genomic maps of the *Aspergillus* genus of fungi will assist in the identification of genes involved in aflatoxin

production in peanuts, signal transduction pathways for aflatoxin production, new targets for antifungal agents transformed into peanuts, and differences between toxigenic and atoxigenic strains of the *Aspergillus* genus for the purposes of biocontrol.

Developing Indicators of Chicken Stress and Well-Being. Cannibalism and aggression are among the major stressors in poultry that cause suffering and death of chickens. Certain genetic methods of selection have been shown to be effective in addressing these problems, but those methods are difficult or impossible to implement by commercial breeders, as no reliable indicators of stress and well-being are available. A research team led by **Dr. Heng-wei Cheng** at **USDA-ARS** and **Dr. William Muir** at **Purdue University** will use chickens from three genetic lines (genetically selected kinder and gentler strain; its counterpart; and a commercial strain) to examine physiological mechanisms that control chicken behavior and well-being in response to both acute and chronic stress. The study will provide the basis for development of reliable indicators for evaluation of chicken stress and well-being. The objective and quantifiable indicators could also be used as guidelines by scientists and the breeder industry in future selections of animals with greater resistance to stress and by the poultry industry to improve animal well-being.

Outcome 2: A safe and secure food and fiber system

Protecting Turkeys from Fungal Toxins. Mold-produced toxins are unavoidable contaminants of poultry feeds. Aflatoxin B1 is the most important toxin in occurrence and potency. Among poultry, turkeys are most susceptible to the toxin's harmful effects which include reductions in growth rate, feed efficiency, hatchability and increased susceptibility to diseases. The annual economic impact of aflatoxin-related diseases to the poultry industry exceeds $100 million. Recently, researchers at **Utah State University** led by **Dr. Roger Coulombe** discovered that adding the inexpensive food additive butylated hydroxytoluene (BHT) protects turkeys against aflatoxin B1. This discovery was initially supported through an NRI award made in FY 1997. While BHT is an FDA-approved antioxidant for use in foods for human consumption, it is not approved as a chemopreventive additive in animal feeds. Now, as part of a follow up award made in FY 2002, the team will: establish the safety of BHT in poultry feeds; determine the mechanism(s) by which it confers protection in turkeys; and determine whether similar antioxidants also protect turkeys. This renewal award paves the way for industry-wide implementation of a simple dietary intervention to prevent an important problem in turkeys.

Cracking the Genetic Code for Johne's Disease and Accelerating the Search for Improved Diagnostics. Johne's disease is a chronic, infectious, wasting disease of cattle caused by the bacteria *Mycobacterium paratuberculosis*. It is responsible for the annual loss of more than $220 million to animal production in the United States. An important milestone that will now speed the development of effective vaccines and accurate and sensitive diagnostics for this disease was reached in September 2002 when the complete genome sequencing of the bacterium was completed as a collaborative effort between the **University of Minnesota** and the **USDA-ARS National Animal Disease Center.** The Minnesota team was led by **Dr. Vivek Kapur** and the USDA-ARS team was led by **Dr. John Bannantine.** The sequencing was supported by a FY 2000 award. In FY 2002, two awards were made to accelerate the efforts to eradicate this disease. With the complete genetic code now known, one award brings together the **USDA-ARS**

(**John Bannantine; Judith Stabel**), the **University of Minnesota** (**Vivek Kapur; Scott Wells**), and the **University of Nebraska** (**Raul Barletta**) to identify unique DNA sequences that can be used to develop improved diagnostics. Specifically, the team will first identify *Mycobacterium paratuberculosis* DNA sequences not present in any other mycobacteria. Unique parts of the genetic code will then be evaluated as specific antigens or proteins for detecting infected cattle. Diagnostic tests that are developed will be validated in well-characterized cattle herds in Minnesota.
A second complementary award will apply genetic diversity to the diagnosis and epidemiology of *Mycobacterium paratuberculosis* at **Texas A&M University**. **Drs. Allison Ficht, Tom Ficht**, and **Garry Adams** have developed a sensitive detection method for Johne's disease organisms that employs magnetic bead recovery of organisms from milk and fecal samples. They will further develop this method while also using a newly developed genetic approach, Amplified Fragment Length Polymorphism (AFLP), in combination with bioinformatics to develop new tools for tracking individual and herd isolates of this disease.

Increased Research Emphasis to Protect Swine from Porcine Reproductive and Respiratory Syndrome (PRRS) Virus. PRRS is the most economically important infectious disease in the swine industry with over 60% of hog operations affected. The causative virus spreads rapidly and causes multi-million dollar losses each year. Effective control programs are lacking. Four awards totaling just under $1 million are addressing various aspects of the virus' biology in an effort to better understand its pathogenesis and spread among pigs. Results are expected to influence the design and quality control of new, better vaccines, as well as the control and clearance of PRRS virus infected herds. A research team at **Iowa State University** led by **Drs. Kyoung-Jin Yoon, Jeff Zimmerman,** and **Philip Dixon** will study the genetic and antigenic evolution of PRRS virus in persistently infected pigs. They will assess the rate of genetic and antigenic changes in PRRS virus during replication in individual pigs and groups of pigs. They will also develop biological computational models and evaluate their ability to predict PRRS virus evolution. A second award will allow **Dr. Lynn Rust** at **North Dakota State University** to better understand how and why PRRS virus strains differ in virulence. Specifically, high- and low-virulence strains of PRRS virus will be compared to determine if they replicate and transcribe their genomes at different rates, thus resulting in different viral propagation rates. Host cell attachment, translation and packaging will also be investigated. An award to **Drs. Fernando Osorio** and **Osvaldo Lopez** at the **University of Nebraska** will follow up a previous finding that humoral immunity plays a principal role in protection against PRRS virus infection. The central hypothesis is that antibodies generated by a pig during infection confer significant protection against infection, however, for some unknown reason, these protective antibodies are absent during the early phase of the infection. The team will map protective proteins by screening libraries with highly protective hyperimmune serum. **Drs. Mark Rutherford, Scott Dee, Kay Faaberg,** and **Kurt Rossow** at the **University of Minnesota** are using the power of genomics to study interactions between PRRS virus and the pig innate immune system. Specifically, pig macrophages which are cells that form part of the frontline defense against infectious agents will be used. The team will study macrophage gene expression over the course of chronic or persistent infection using DNA microarray technology. PRRS virus strains that vary significantly in their ability to cause clinical disease will be examined. Gene expression patterns will be profiled over a 150 day period under a production setting and will be correlated

with pathological changes within infected tissues.

Reducing the Risk of Foot and Mouth Disease in the United States Through Animal Disease Control Abroad. Foot and mouth disease (FMD) is highly contagious affliction of cloven hoofed animals that has the potential to inflict billions of dollars worth of losses on an economy, should it become epidemic as it did in Great Britain in 2001. The United States currently protects itself from FMD through restrictions on the import of livestock products from FMD-endemic regions. Given the failure of similar controls in other countries, **Dr. Alex Winter-Nelson** at the **University of Illinois, Urbana-Champaign** will assess the economics of reducing the risk of a foot and mouth disease outbreak in the U.S. by investing in animal disease control in FMD-endemic countries. Specific objectives of the research are to (1) evaluate the internal costs and benefits of FMD-control in FMD-endemic Latin American countries; (2) evaluate the value to the livestock sector of reduced risk of FMD outbreaks when FMD is eradicated in other countries; (3) evaluate the net impact on the U.S. livestock sector of changes in the international market that might follow eradication of FMD in other countries; and (4) determine whether the volume and distribution of internal and external benefits of FMD control warrant joint U.S./host country financing of FMD control in the host country. These objectives will be achieved through simulation modeling of the epidemiological and economic impacts of FMD in the U.S. and a set of Latin American countries. A simulation model of the international meat market that distinguishes products by source and quality will be used to assess trade impacts of FMD eradication abroad.

Tomato Resistance to Late Blight. *Phytophthora infestans*, the oomycete plant pathogen responsible for late blight of potato and tomato, continues to cause major agricultural losses**.** **Drs. Christine Smart and William Fry** of **Cornell University** are investigating tomato resistance to this pathogen in the laboratory and in the field. By identifying the differences in tomato host defense response that occur during highly compatible (very susceptible), partially compatible or incompatible (resistant) interactions, the researchers will be able to identify the suite of responses uniquely associated with resistance. They will use a common set of techniques to study hypersensitive response, pathogenesis related gene expression and global gene expression profiles in relation to resistance during compatible, partially compatible and incompatible interactions between tomato and *P. infestans*. A major aspect of this study is to determine if responses to pathogen attack under controlled laboratory conditions are consistent with those under field conditions.

Disease Control Smut and Bunt Fungi through Disruption of their Sexual Cycle. Fungal plant pathogens routinely develop resistance to currently used fungicides. As such, there is a constant need to discover new targets for disease control. For many fungal pathogens, the sexual cycle is critical for the formation of resistant spores and for genetic diversity. Other fungal pathogens, such as the smuts and bunts, are only pathogenic after mating. The molecular events leading to mating in fungi are complex, but rely on pheromone-mediated cell-to-cell signaling. The research of **Dr. John Sherwood** of **Montana State University** is aimed at understanding the mating system of the basidiomycete fungi *Ustilago hordei* (barley covered smut), *Tilletia tritici* (wheat common bunt) and *Tilletia indica* (wheat Karnal bunt). A key enzyme in the processing of fungal pheromones is farnesyl transferase. The investigators have shown that breakdown products of *U. hordei* pheromones inhibit mating of *U. hordei* and teliospore germination of

Telletia sp. Different antagonists block different stages in pheromone processing, which allows the investigators to target specific enzymes involved. They plan to determine the effects of mating/teliospore germination inhibitors on farnesyl transferase extracted from *U. hordei, T. tritici* and *T. indica* at the biochemical and molecular level. The results of this study will further the development of a novel strategy for control of fungal plant diseases.

Plant Gene Expression in Response to Viral Infection. Viral infection and disease of plants are dependent on plant genes that are induced or repressed during infection. Plant viruses alter the expression of many plant genes by interfering with or overriding normal plant processes. **Dr. Steven Whitham** of **Iowa State University** plans to identify sets of plant genes that have altered patterns of expression when plants become infected with viruses. To do this, he will use DNA microarrays (DNA chips) to detect changes in the expression of plant genes at various time points during the course of viral infections. He will also infect mutant plants that do not respond normally to stress in order to determine if viruses are activating known stress responses during susceptible interactions. Identification of these plant genes is expected to lead to the understanding of mechanisms that enhance infections and cause disease. This knowledge will lead to new strategies for controlling viral diseases in plants.

Advanced Spectral Techniques for the Rapid Quantitative Characterization of Wood. **Dr. Timothy Rials** of the **University of Tennessee** will be assessing the potential for using multidimensional forms of IR (infra red), NIR (near infra red) and Raman Spectroscopic techniques for the rapid and quantitative measurement of chemical, mechanical, physical and macromolecular properties of wood. Part of this work will use 2D correlation analysis to relate NIR and Raman spectral features. The 2D correlation analysis tools will improve our understanding of the chemical structures responsible for specific NIR vibrations. This information will help us understand the molecular origin of macroscopic wood properties that determine use. Better understanding of these relationships will be critical for optimal use of the wood currently being recovered from fast-grown plantation trees.

Outcome 3: A healthy, well-nourished population

High Pressure Dependence of Compressibility, Density and Viscosity of Model Food Systems. High quality and fresh flavor are generally reduced when foods are pasteurized (heated) to assure their safety. "Non-thermal" pasteurization methods, such as high pressure, increase the competitiveness and consumer appeal of food products by preserving these desirable attributes and also assuring their safety. For the high pressure technology to be successfully commercialized, properties of foods under pressure need to be made predictable. **Drs. Murat Balaban and Arthur Teixeira** of the **University of Florida** will develop methods and instruments to measure a key property of foods, compressibility, under high pressure. The instruments and methods developed can also be used to measure other properties of the foods under pressure. Compressibility is important because it controls the magnitude of temperature increase when foods are compressed to a given pressure. An excessive increase in temperature is not desirable since high pressure processing loses its "non-thermal" advantage. Another objective is to develop thermodynamic models to predict the compressibility of foods made-up of complex mixtures of materials by using the compressibility of "binary" mixtures, e.g. glucose and water. This is an advantage since "binary" data is available for most food components. The

data obtained from this project at different food compositions, temperatures and pressures will allow thermodynamic modeling, and therefore prediction of compressibility under commercial processing conditions. This will allow for the optimization of the high pressure processing, making the food industry more competitive, and offering the consumer more desirable, yet safe, foods.

Characterizing Cranberry Proanthocyanidins that Promote Urinary Tract Health. Improved characterization of cranberry proanthocyanidins is urgently needed to support research on their potential benefits to urinary tract health. Proanthocyanidins are also referred to as condensed tannins. Cranberry proanthocyanidins may prevent urinary tract infections by preventing adherence of pathogenic bacteria to the cells that line the urinary tract. The heterogeneity in cranberry proanthocyanidins structure may account for variable results from animal and clinical trials. Therefore, biomedical research on the urinary tract health and cranberry needs to be linked to research on molecular characterization of proanthocyanidins. **Drs. Jess Reed, Martha Vestling, D. G. Cunningham and Amy Howell** of the **University of Wisconsin** will characterize cranberry proanthocyanidins fractions that inhibit the adherence of uropathogenic bacteria to uroepithelial cells. The researchers will use two methods of mass spectrometry to characterize the range in degree of polymerization and structural heterogeneity of proanthocyanidins fractions, (1) matrix-assisted laser desorption/ionization time-of-flight mass spectrometry, and (2) direct infusion electrospray ionization mass spectrometry. The proanthocyanidins fractions will be assayed for their ability to inhibit the adherence of uropathogenic bacteria to uroepithelial cells. These methods will allow the researchers to identify the most active cranberry proanthocyanidins fractions. Pursuit of this objective will help further our knowledge of what types of cranberry proanthocyanidins may prevent urinary tract infections and promote urinary tract health. This information will be used in future *in vitro*, *in vivo* and clinical research on urinary tract health in relationship to content of active proanthocyanidins fractions in cranberry products. The cranberry industry may use the results to standardize, enhance and monitor stability of active proanthocyanidins fractions in fruit, juice and other products.

Expression of Phenylalanine-free Zein Protein in Transgenic Soybean as a Value-added Trait for PKU Patients. Phenylketonuria (PKU) is an inherited genetic disease that causes mental retardation unless dietary treatment is started in the newborn. Mental retardation and birth defects also occur in the offspring of PKU women who are not under strict dietary control before and during pregnancy. The current PKU diet therapy utilizes low protein foods and phenylalanine-free amino acid formulas. The nutritional formulas are poorly tolerated by most adolescent and adult patients due to poor odor, taste, and heat stability. The low phenylalanine content and physical properties of gamma zein, a naturally occurring corn protein, makes it a suitable candidate. A phenylalanine-free gamma zein gene has been constructed and expressed in *Escherichia coli* in which two phenylalanines were replaced by tyrosine while maintaining physical and nutritional characteristics of the native protein. **Drs. Harold Trick and Subbaratnam Muthukrishnan** of **Kansas State University** will produce these proteins in soybean, isolate the pure phenylalanine -free proteins and incorporate these proteins into the diet of PKU patients. In addition, this project will produce a value-added or a nutraceutical trait in soybean that will produce a new market for this crop. The proposed work is the first phase of this project. In the current proposal the researchers will: (1) complete the construction of

expression vectors for soybean seed-specific expression of a recombinant phenylalanine-free gamma zein protein; (2) perform particle bombardment of soybean embryogenic cultures with the zein gene vector constructs and isolate fertile plants; and (3) perform genetic and protein analyses on transgenic plants.

A Multi-Country Analysis of Consumer Acceptance of Genetically Modified Organisms and genetically Modified (GM) Foods. Consumer acceptance of genetically modified organisms (GMOs) and GM foods is a key for success of biotechnology applications in U.S. agriculture. The U.S. competitiveness for exporting GM crops such as soybeans and corn depends critically on consumer acceptance of these GM products in exporting markets. **Drs. Wen Chern** and **Timothy Haab** of **Ohio State University** will conduct a comparative analysis and assessment of consumer acceptance of GM foods in Japan, Taiwan, and the United States. Japan and Taiwan are among the largest importers of U.S. soybeans and corn. Since Japan imposed mandatory labeling of selected GM foods in 2001 and Taiwan will impose similar regulations in 2003, it is important to understand the consumer sentiment towards genetically modified foods in these countries as compared to the U.S. In this project, researchers will develop a unified survey instrument for conducting a national telephone survey in all three countries. These surveys will collect data on knowledge, perception and attitude, support for labeling regulation, willingness to consume GM foods with different product attributes, demographic information, and indicated choices of GM vs. non-GM product with different prices for vegetable oil, corn flake cereal, and tofu. These data will be used for a comparative qualitative assessment of consumer sentiment on GM foods and for estimating the consumer willingness to pay for GM vs. non-GM foods. The results will provide timely information regarding the acceptance of GM foods by consumers and support for GM food labeling in both GMO producing and consuming countries.

Evaluating Effects of Unprecedented Forces on Southwest Georgia Irrigated Agriculture & Rural Economies: Water Security & New State Water Policies. This research is designed to provide information to irrigators and policy makers regarding implications regarding the increasing problem of water scarcity and new state water policies for agriculture and rural economies of Southwest Georgia. Increasing demands for water for urban uses, irrigated agriculture, industry/energy sectors, and in-stream flow requirements are stretching water supplies. Five years of drought and new state policies, including a moratorium in Southwest Georgia on new water permits and recent legislative provisions for mandatory reductions of irrigation water use, are of concern. The implications of reduced water for irrigation on crop production, exports, and rural economies must be made known to policy makers. **Dr. Virgil Norton** and his colleagues of **Albany State University** in Georgia will combine the experimental plot research with economic analysis to determine the effects of limited irrigation on crop yields and producer net returns for corn, cotton, and peanuts. Reductions in crop yield, input purchases, and producer revenue resulting from state imposed drought-related actions to reduce surface-water irrigated acres will be estimated. A regional economic model (REMI) will be used to quantify regional/local impacts of state water policies. Alternatives to current policies will also be evaluated. The research team will provide expertise on the economic viability of farming and rural communities in southwest Georgia, as well as providing guidance to the state on how to encourage efficient use of the available water resource base.

Changing Income Inequality in a Period of Economic Expansion, 1990-2000. Spatial patterns in changes in household income inequality from 1980 to 1990 raised important questions about why such variation exists. Is it due to industrial restructuring, changes in household structure or labor supply, or other attributes of places? This question is currently being addressed. What is not known is whether these factors will have the same influence during a period of economic expansion (1990 to 2000). Prior research has documented stronger effects of industrial restructuring on change in income inequality in non-metropolitan than metropolitan counties. Will this difference persist or will it widen as the economy expands? The availability of data from the 2000 U.S. Census of Population and Housing makes it possible to answer these questions. This research will provide evidence that changes observed at the national level play out differently in localities and will aid in developing policy related to consequences of social and economic change. The overall objective is to examine factors affecting changes in household income inequality across counties from 1990 to 2000. More specifically, **Dr. Diane McLaughlin** of **Pennsylvania State University** will 1) examine the geographic patterns of change in household income inequality, 2) identify counties that have experienced increases or decreases in income inequality, 3) estimate the association between industrial restructuring, family structure and labor supply and income inequality during a period of economic expansion, and 4) examine the factors associated with changes in race-specific household income inequality across counties**.**

Genetic Characterization of Fruit-Specific Ethylene Signaling in Tomato. Fruit is a major component of the human diet contributing a large portion of vitamins, minerals, antioxidants and fiber. These nutritional benefits are only realized after the fruit has ripened. The positive nutritional attributes that ripening imparts are counterbalanced by the problem of over-ripening and subsequent loss of fruits to rot and physical damage. Expensive harvest, transport and storage conditions for both the horticultural and retail industries are currently used in order to produce a quality product. The plant hormone ethylene regulates the ripening and over-ripening of many fruits including tomato, peach, banana and melon. An understanding of how ethylene regulates ripening will enhance our understanding of plant biology and will provide us with information to optimize the balance between ripening and loss resulting in increased fruit quality. **Drs. Cornelius Barry and James Giovannoni** of **Boyce Thompson Institute for Plant Research** will study the role of ethylene in regulating fruit ripening. Two tomato mutants, *Green-ripe* and *Never-ripe 2* show greatly reduced rates of ripening due to impaired action of ethylene. The investigators plan to implement a strategy that will identify these mutant genes and in so doing will provide molecular tools for potentially modifying fruit ripening and quality either by modified cultural practices, traditional breeding and/or biotechnology.

Outcome 4: Greater harmony between agriculture and the environment

The Physiology and Ecology of Nitrous Oxide Production and Methane Consumption by Ammonia- and Methane-oxidizing Bacteria in Agricultural Soils. Agricultural soils are a major source of the greenhouse gases, methane and nitrous oxide, due to current tillage and fertilization practices and their effects on the activities of soil microorganisms. The ecological relationships between bacteria, nutrients, and soil particles that lead to greenhouse gas production and consumption are complex and poorly understood. **Dr. Lisa Stein** of the

University of California, Riverside focuses on a small part of the soil ecosystem to understand how two specific groups of bacteria participate in the process of greenhouse gas production. The main objectives are to quantify the contributions of bacteria to the emission of greenhouse gases from agricultural soils based on nutrient availability and population structure, and to identify the metabolic mechanisms that underlie these processes. The researcher will specifically investigate the responses of pure cultures of bacteria to changes in concentrations of their most important nutrients. The interactions of each nutrient with enzymes in these bacteria are hypothesized to have significant effects on both the consumption of methane and the production of nitrous oxide. Secondly, an assessment of how nutrient concentrations affect the composition of bacterial populations in soils will identify and quantify the contributions of greenhouse gas production by specific microbial species. The results from this project will determine the environmental conditions under which particular groups of bacteria control the flux of greenhouse gases from soils, which species are most likely involved in greenhouse gas emissions, and which metabolic pathways should be targeted to ameliorate further emissions of methane and nitrous oxide from agricultural soils.

Factors Controlling Veterinary Antibiotic Sorption to Soils. Accurate fate models are required to assess the environmental impacts and risk associated with the annual discharge of up to 20 million pounds of veterinary antibiotics to soils, sediments and surface waters in the U.S. Current fate models that consider antibiotic interactions only with organic matter in soils do not completely describe all possible interactions of these polar compounds with soil components. **Drs. Allison MacKay and Dharni Vasudevan** of the **University of Connecticut** hypothesize that veterinary antibiotics are attracted to oppositely charged sites on soil organic matter and clay minerals and form complexes on the surfaces of iron and aluminum oxides. In this research, the researchers propose a broad screening approach to statistically assess the factors controlling antibiotic sorption to soils. First, agricultural soils with a wide range of characteristics (f_{oc}, clay content, oxide content) that they hypothesize as important for pharmaceutical binding will be chosen, and composition and properties of these soils will be extensively characterized. Soil-water sorption coefficients (K_d) of the high-use antibiotic ciprofloxacin will be measured for each test soil. Principal component analysis will then be used with the measured K_ds and soil properties to statistically assess the soil components that control antibiotic sorption to soils. Additional K_d measurements will be made with Enro-CO_2 and FCQA, substructures of ciprofloxacin, to probe specific mechanisms of antibiotic sorption on selected soils. Results of this study will indicate: (1) agricultural soil types in which veterinary antibiotics will be highly mobile and available to organisms and (2) soil components that require further investigations using model sorbents to develop mechanism-based predictors of pharmaceutical fates in the environment.

Fire Suppression in Ponderosa Pine/Douglas-Fir Ecosystems Causes Shifts in Soil Resource Availability. Since the early 1900's, fire exclusion and livestock grazing in the interior Northwest have changed our forests from open ponderosa pine stands to denser stands dominated by Douglas-fir. Because this gradual replacement has severe negative impacts on forest health and ecological processes, restoration efforts have commonly been employed to attempt to reverse these forests to their pre-1900 structure and function. However, the degree to which the structure and function of ponderosa pine/Douglas-fir forests of the interior northwest change as a result of fire suppression on water and nitrogen availability in unmanaged ponderosa

pine/Douglas-fir forests of wilderness areas of the interior northwest is not known. **Drs. Anna Sala and Thomas DeLuca** of the **University of Montana** will document if and how changes in forest structure resulting from long-term fire suppression cause changes in soil water and nitrogen availability. The researchers hypothesize that increases in tree density in fire excluded stands causes changes in the forest understory (increases in shrubs) and that overall changes in forest structure cause in turn a reduction in water and nitrogen available for tree uptake and growth. While these processes have often been assumed, they have never been rigorously tested in unmanaged forests subjected to different degrees of fire suppression. This project will allow the researchers to determine the importance of fire on forest structure and function and to identify baseline information on forest structure and function in reference to unmanaged stands subjected to periodical fires.

A Geographical Information System (GIS) for Red River Watershed Management Research. Geographical Information System (GIS) technology is an important tool for watershed management research, which is a growing multidisciplinary field of study encompassing many factors important to U. S. agriculture. **Dr. Gary Hanson** of **Louisiana State University** will enhance GIS capability for the Red River Watershed Management Institute (RRWMI) to support watershed management research in the Red River Basin. The GIS project will provide an efficient system for natural resource management, public information, and outreach to stakeholders. The project will increase institutional competitiveness for future research funding and expand capacity to participate in projects significant to regional development via partnerships with local, state and federal agencies, including Natural Resource Conservation Service. State-of-the-art GIS resources will support integration of existing data sets from state and federal agencies with new field-collected data for a number of ongoing and future multidisciplinary watershed management research projects. Researchers will then be able to utilize advanced GIS data collection/analysis methodologies to analyze and display data from specific projects such as crop test plots at the Red River Education & Research Park. In addition, they will be able to address regional issues such as agricultural runoff/erosion, water quality, wetlands restoration, land use changes, resource management/planning, biodiversity, and strategies for promoting sustainable development.

Influence of Flow Augmentation of Water Quality and Quantity in the South Platte River Basin. Managed groundwater recharge is a conjunctive water management method that is becoming increasingly common in the Western United States as a means of augmenting river flows during high demand periods. The intent of managed recharge is to redistribute water in time. Pumping from an alluvial aquifer induces stream discharge to the aquifer when there is excess water available in the river under the prior appropriation doctrine. This water is pumped through pipelines to recharge ponds away from the river; it infiltrates and returns to the river as subsurface flow, augmenting the river flow during critical low-flow, high-demand periods. While the intent of these recharge systems is flow augmentation, subsurface return flows also raise the water table in the alluvium, significantly modifying the hydrology, especially at groundwater-surface water interfaces. Groundwater recharge creates floodplain wetlands and backwater sloughs that serve as waterfowl and aquatic habitat. Managed recharge systems also change the water quality of the alluvium, wetlands, backwater sloughs and river. If properly managed, groundwater recharge systems could potentially be an effective strategy to minimize salt and nitrate build-up in the alluvium, improve in-stream water quality during low flow

periods, and enhance aquatic and riparian habitat. **Drs. Deanna Durnford, William Sanford and John Stednick** of **Colorado State University** will identify the critical hydrologic and water quality variables for a managed recharge system designed for the multiple benefits of augmenting in-stream flow, while also providing or enhancing riparian and aquatic habitat.

Structurally Tailored Bioemulsifiers. **Dr. David Kaplan** at **Tufts University** is advancing the development of structurally-tailored biologically-derived emulsifiers and surfactants. This novel family of biosurfactants is based on a microbial product, emulsan, an extracellular polysaccharide produced in high yields by the Gram negative bacterium, *Aceinetobacter calcoaceticus* RAG-1. Current studies have demonstrated the use of selective feeding strategies and genetic methods to gain additional understanding of the biosynthesis pathway, to gain control over structural features of the polymers, and to further define the range of emulsification properties of these polymers. The focus of the present work is: (1) manipulation of selective genes (polymerase gene) in the biosynthetic pathway to further optimize control of structure and function, (2) exploration of organic chemical separations using the structural variants, (3) further pursuit of high yields of polymer on agricultural feedstocks, and (4) continued outreach to develop new products based on these structures in collaboration with other laboratories. The formation of a family of 'tailored' biosurfactants produced from agricultural feedstocks in high yields, biodegradable after use, and specific in the nature of their application offers new directions in the field by matching structure to function, bioderived to biodegradation, and selectivity in function to product needs while improving economics of use.

Nanobio-Plastics and Composites from Linseed Oil and Saccharidic Source Materials. **Drs. David Boyles, Jon Kellar** and **William Cross** at the **South Dakota School of Mines and Technology** are researching the use of agricultural materials to produce plastics and composites. Structural materials that incorporate agriculturally-derived biomass are advantageous from the standpoint of renewability and compatibility with the environment. This proposal investigates two major classes of biobased materials: plastics and polymer matrix composites. Each class will rely on flaxseed oil which is the highest known natural source of linolenic acid. Linolenic acid will be chemically reacted with starch based compounds to give esters which are highly polymerizable. The esters will be polymerized directly by themselves, and the materials made from the polymerization of these esters will be tested for their mechanical properties. Also, polymer matrix composites will be made in which the esters serve as filler materials embedded in and polymerized with commercial monomers. The molecular geometry of the esters and their solubility in the monomers of the matrix is anticipated to afford unique properties unlike current filler materials, allowing creation of molecular-level, biobased additives for polymer matrix composites. The project will provide proof-of-principle for a new commercial niche for oilseed and saccharidic materials as alternatives to current inorganic fiber reinforcements, and as useful plastic materials. This project will investigate the effectiveness and properties of agriculturally-derived materials as precursors to plastics and as nanofiller materials in polymer matrix systems

Chemically Inducible Expression of Bt Genes: An Advanced Strategy for Resistance Management. Development and deployment of crops expressing proteins of *Bacillus thuringiensis* (Bt) is revolutionizing agriculture. These crops resist pests without application of chemical insecticides, thereby avoiding the hazards and costs of pesticide use. To prolong the durability of the valuable crops, it is essential to prevent or delay development of insects

resistant to the Bt proteins. The current U. S. practice combines constitutive overexpression (continuous high expression) of Bt protein with a refuge (plants not producing Bt protein) on which susceptible insects can survive. Mating of these susceptible insects with rare Bt-resistant insects reduces frequency of resistance in the insect population. Another proposed resistance management strategy is engineering plants to produce multiple insecticidal proteins. However, alternate resistance strategies should also be assessed. One such strategy is inducible (control production of proteins) rather than constitutive expression of proteins. This may permit more targeted insect control by limiting induction to particular parts of the plants, time periods, or situations when an economic threshold is reached. **Drs. Elizabeth Earle and Anthony Shelton** of **Cornell University** have created broccoli lines that produce Bt protein production and control the diamond back moth only when treated with non-insecticidal chemical. The researchers will analyze the time course of Bt protein production and insect control after induction in leaves and whole plants. They will compare chemically inducible plants with plants continually expressing Bt proteins in green house cage tests that measure how rapidly insect resistance develops in each treatment. This approach will identify benefits or pitfalls of chemically-inducible expression of Bt proteins and will guide further research and regulations.

Disruption of Germ Cell Development in Insects by RNA Interferance Using Somatic and Germline Transformation. Control programs for agricultural pest insects are changing because of an increased public concern for food safety and environmental quality. As a consequence, the use of pesticides has been reduced, necessitating an immediate need to develop pest management practices that are economical and efficacious, yet environmentally benign. Sterile insect technique has been used successfully to control some flies and could be applied to other insect pests if an alternative procedure for sterilization can be developed. One approach would be through genetic sterilization by gene silencing or RNA interference (RNAi) of genes that are critical for germ cell development. **Dr. Paul Shirk** of the **USDA-ARS** will utilize the features of both somatic transformation vectors (*Jc*DNV) and germline transformation vectors (*piggyBac*) for stable and controlled *in situ* production of RNAi sequences. The objectives are (1) to establish activities of genetic promoters in *Diptera* and *Lepidoptera* that can control RNAi products using both somatic and germline transformation vectors; (2) to determine the silencing efficiency of RNAi products produced *in situ* from either somatic or germline transformed RNAi constructs; and (3) to assess the efficacy of the RNAi mediated genetic sterilization by silencing the *Drosophila* "vasa" gene from which is critical for germ cell development. This should result in the production of sterile adults.

Allelism of Root-Knot Nematode Resistance in Grape. Root-knot nematodes (*Meloidogyne* species) are a principal limiting factor in viticulture. Production losses of up to 20% are attributed to the damage caused by the feeding of these tiny worms on grape roots. Grafting susceptible wine, table, raisin, and juice grape varieties onto resistant rootstocks is an environmentally sound method to reduce damage from root-knot nematodes and provides an alternative to nematode control with methyl bromide and other toxic chemicals. Breeding improved grape rootstock varieties requires understanding the genetic control of nematode resistance. Several different sources of nematode resistance have been identified in rootstocks and wild grape species, but the relationship of these different sources to one another has not been described. **Dr. Peter Cousins** of **New York State Agricultural Experiment Station** will investigate the relationship of five sources of nematode resistance. The different models of

genetic control impact the strategies used to breed new nematode resistant rootstocks. Understanding the relationship between the different sources of nematode resistance will facilitate the development of new grape rootstock varieties with enhanced nematode resistance.

Outcome 5: Enhanced opportunities for farmers, ranchers, and rural people and communities

Can the Small Dairy Farm be Competitive in U.S. Agriculture? A large number of small dairy farms have ceased operation in traditional dairy areas, and many wonder how many more small dairy farms will be lost. In a competitive market like milk, the survival of the small dairy farm hinges upon whether those farms are competitive with large dairy farms. Since low cost of production is critical for dairy farm survival, **Dr. Loren Tauer** at **Cornell University** will estimate the cost of milk production by farm size, but for two separate cost components. The first component is the lowest cost for the given technology available at that farm size, called the frontier cost. The second component cost is how efficient that individual farm is in using the techniques utilized at that given farm size. The analysis will estimate both frontier and efficiency components by farm size. Whether high cost for small farms is due to a higher cost frontier or to inefficiency has implications for government policy addressing the small farm. If high cost of production on smaller farms is due to a higher frontier cost of production, then to make small farms competitive requires research to devise and design new technology that is suitable for small farms. If instead high cost is due to inefficiency, and not to a high frontier cost, then current technology exists to allow small farms to be competitive with larger farms. Educational programs are necessary to ensure that small dairy farms more efficiently use the technology currently available to them at their respective size.

The Role of 1890's in Building Human Capital Among Rural People: Methods and Case Studies. Teaching, research, and extension programs federally funded at historically black land grant institutions (1890s) build human capital of rural people in traditionally under-served areas. Investments in human capital help people improve themselves economically, increase farm and business profitability, enhance family well-being, and strengthen civic activities leading to stronger and more economically stable communities. There has been, however, no research that systemically quantifies the results of public investments in 1890s in terms of benefits to the 1890s unique clientele. **Drs. Winfrey Clarke, Nicole Ballenger, Albert Essel and Abebayehu Tegene** at **Virginia State University** propose to build the analytical base for assessing and further enhancing the role of the 1890 institutions in building human capital. Specific objectives of the project include (1) Building an integrated data base describing public and other investments in 1890 programs, numbers and characteristics of 1890 students and external clientele, 1890 programs accomplishments, and impacts; (2) Developing methodological approaches for analyzing the contributions of the 1890s teaching, research and extension programs to rural people and economies through human capital development; and transferring an understanding of these approaches to 1890 institution researchers and others who can benefit from applying them; (3) Using several case studies to empirically apply the methods developed in (2) and quantifying where possible the private and social returns to human capital development; and (4) Exploring conceptually and empirically the connections between human capital impacts and the economic development of rural communities. Project results will be used to enhance understanding and decision-making regarding public investments in 1890 programs.

Rural Civic Community and Population Stability: Linking Civic Structure and Individual Migration Behavior. Many rural communities are losing population, tax bases, essential services, and businesses. But some rural communities are more likely to retain people than other communities. Researchers will evaluate both community and individual factors that encourage rural citizens to remain in rural areas. **Dr. Michael Irwin** at **Duquesne University** and **Dr. Troy Blanchard** at **Mississippi State University** focus on the role that civic organizations, such as churches, local businesses and local associations, have upon individuals' likelihood of staying in rural communities. Using limited access U.S. Census data, they will re-allocate the 1990 and 2000 individuals into their communities of origin in 1985 and in 1995. Then, using community variables from special access Economic Census data, they will develop statistical models, which capture the effects of individual characteristics and community context upon individual probabilities of staying in their communities. The study will identify which factors are most important in embedding rural populations in their communities. Results of this work may greatly aid rural policy makers in sustaining and enhancing their communities.

Celebrating Minority Professionals in Forestry and Natural Resources. A Symposium to Strengthen Research into Graduate Production Efforts. Recruiting, retaining and graduating minorities in Forestry and Natural Resources Conservation (FNRC) have always been very difficult. Subsequently there are limited numbers of minority professionals in the Forestry and Natural Resources Conservation professions, thus negatively impacting workforce diversity in Forestry and Natural Resources Conservation. **Drs. Oghenekome Onokpise and Dreamel Worthen** of **Florida Agricultural & Mechanical University** will focus on this four day symposium to highlight the program and its contribution to increasing minority professionals in Forestry and Natural Resources Conservation. The symposium also offers an opportunity for FNRC professionals, especially minorities from public and private industry, to interact and educate future professionals.

Scientists Complete Advanced Draft Sequence of the Rice Genome in 2002

Rice is the most important food crop in the world and feeds half the human population. It is that half of the population that is projected to double over the next half century, so it is of critical importance that we learn as much as possible about rice to be able to improve yield and quality on less land and with less water. Rice is also considered an important model organism to study plant biology and shares a common ancestor with many other important cereals like corn, wheat, barley and sorghum.

The U.S. Department of Agriculture (USDA), the National Science Foundation (NSF) and the U.S. Department of Energy (DOE) joined together to initiate the United States Rice Genome Sequencing Project. Launched in 1998, the project is a multinational effort to map the

rice genome's 12 chromosomes. USDA, NSF and DOE have provided a total of $14.4 million. The U.S. research is based at The Institute for Genomic Research in Maryland, Clemson University in South Carolina, Cold Spring Harbor Laboratory in New York, Washington University in Missouri, the University of Arizona and the University of Wisconsin.

In December 2002, officials at the USDA, NSF and DOE announced completion of an advanced draft of the rice genome. This milestone concludes the second phase of the rice genome sequencing effort which was initiated under the coordination of the Japanese Rice Genome Program. The goal of the Japanese Rice Genome Program was to improve the quality and increase yields of a staple consumed by over half of mankind. In addition to the United States and Japan, participating countries included Brazil, China, France, India, South Korea, Taiwan, Thailand and the United Kingdom. It was agreed at the outset to work on a single cultivar, to share materials, to use a clone-by-clone approach, and to accept the policy of immediate sequence release. "Decoding the rice genome is an important scientific achievement that can lead to improved nutrition and aid in efforts to eliminate hunger throughout the world. This scientific partnership between the United States and Japan continues to demonstrate our commitment to advancing research and science" said Agricultural Secretary Ann M. Veneman.

The draft rice sequence provides early access to the majority of genes in rice as well as their position along the 12 rice chromosomes. It also incorporates sequence data from two privately held data sets from Monsanto and Syngenta and therefore represents the highest quality sequence of rice to date. Efforts in 2003-2004 are now focused on generating "finished" sequence, filling gaps in the genomic sequence, increasing accuracy of the sequence data to no more than one error per 10,000 bases and annotation. All sequence data are deposited in a central repository and are available for use by the public. Sequencing of the rice genome has created a revolution in plant biology that will lead the future of agriculture toward a safe, secure and nutritious food supply.

Presidential Early Career Award for Scientists and Engineers (PECASE*)*

Dr. Mahfuzur Sarker of **Oregon State University**, Corvallis, Oregon, was the FY 2002 recipient of the Presidential Early Career Award for Scientists and Engineers. He was nominated by the NRI for his current and potential future excellence of his research. He received funding for a problem of great national and international interest, the "Determination of the Molecular Basis for Heat Resistance in the Spores of *Clostridium perfringens* Isolates that Causes Foodborne Illness." As a result of the PECASE award, Dr. Sarker will be able to concentrate fully on his research program during this critical phase of his career. The results of his work will be useful in developing processing methods to prevent *C. perfringens* type A food poisoning, which currently ranks as one of the most commonly reported foodborne diseases in the United States.

From Discovery to Practice: A Success Story from the Competitive Grants Program (CRGO/NRI)

The National Research Initiative supports a wide array of fundamental scientific research. Over time the scientific findings produced serve as a starting point that can lead to concrete products that support and advance U.S. agriculture. Described below is a case study on how this process works.

During the period 1983-88, the USDA Competitive Grants Office supported **Dr. Willbur H. Campbell's** academic research on higher plant nitrate reductase. The objectives of the research were to develop antibody-based tools for quantifying the synthesis of nitrate reductase protein in the extracts of leaves. He was successful in those efforts and published two papers in the journal *Plant Physiology*. At the same time, he moved his laboratory to **Michigan Technological University,** Houghton, Michigan. He produced murine hybridomas to generate monoclonal antibodies for corn leaf and squash cotyledon NADH: nitrate reductases. Again he was successful and published the results on monoclonal antibodies for nitrate reductase in the journal *Plant Molecular Biology*. A key aspect of the monoclonal antibodies was that several could be used to purify nitrate reductase. Basically, the monoclonal antibody-based purification method for corn leaf NADH:nitrate reductase made it possible to study the properties of this enzyme form which had been extremely difficult to purify prior to this advance in methodology.

Subsequently, Dr. Campbell became interested in commercial production of corn leaf nitrate reductase, and Michigan Technological University granted him an exclusive license, royalty free, for utilizing the hybridoma cell lines for production of monoclonal antibodies. A few years later in 1993, he and his wife, **Ellen R. Campbell**, started **The Nitrate Elimination Co., Inc**. **(NECi**), and developed the monoclonal antibody-based immunoaffinity chromatographic method for purification of corn leaf NADH: nitrate reductase for production of a commercial grade of this enzyme. NECi corn leaf NADH: nitrate reductase was sold to Sigma Chemical Company in 1994, and put on the NECi website (nitrate.com) for sale in 1995. This was the first time that a plant nitrate reductase was commercially available and assisted many researchers who needed this enzyme for their studies. NECi also sells both polyclonal and monoclonal antibodies for nitrate reductases, which have benefited many academic research projects worldwide. NECi nitrate reductase has been adopted by several companies which produce nitric oxide analytical test kits for biomedical research.

In FY 1996, NECi was awarded USDA SBIR grants for development of nitrate test kits based on purified corn leaf nitrate reductase. The first NECi Nitrate Test Kits were produced and marketed in 1998. A key aspect of this advance was the method to stabilize the nitrate reductase so that it could be shipped at room temperature, which was achieved at NECi in the 1990's. NECi now has a line of four different Nitrate Test Kits versions for applications from consumer/farm nitrate test needs to laboratory Nitrate Test Kits in both test tube and microplate formats. A central feature of NECi Nitrate Test Kits is its environmental and user friendliness, which results from using biological based testing with an enzyme as compared to the widely

used chemical methods for determining nitrate. Thus, NECi Nitrate Test Kits are used in many schools and for many field studies in remote locations such as Amazon rain forests. Today, NECi has two SBIR grants for further development of NECi Nitrate Test Kits for applications in analysis of farm runoff and actual nitrate testing in crops. Thus, the original USDA competitive grants for basic research on nitrate reductase have assisted NECi in developing enzyme-based nitrate testing as a commercial reality in today's market.

APPENDIX

Current Information about the National Research Initiative Competitive Grants Program and Points of Contact

The current information about the National Research Initiative Competitive Grants Program and the Points of Contact are available on the CSREES home page (*http:// www.csrees.usda.gov/funding/nri/nri.html*).