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G

Divider Title: _____

Science Leadership Exchange

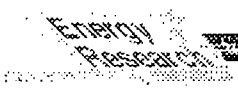
U.S. Department of Energy

Office of Energy Research

Overview

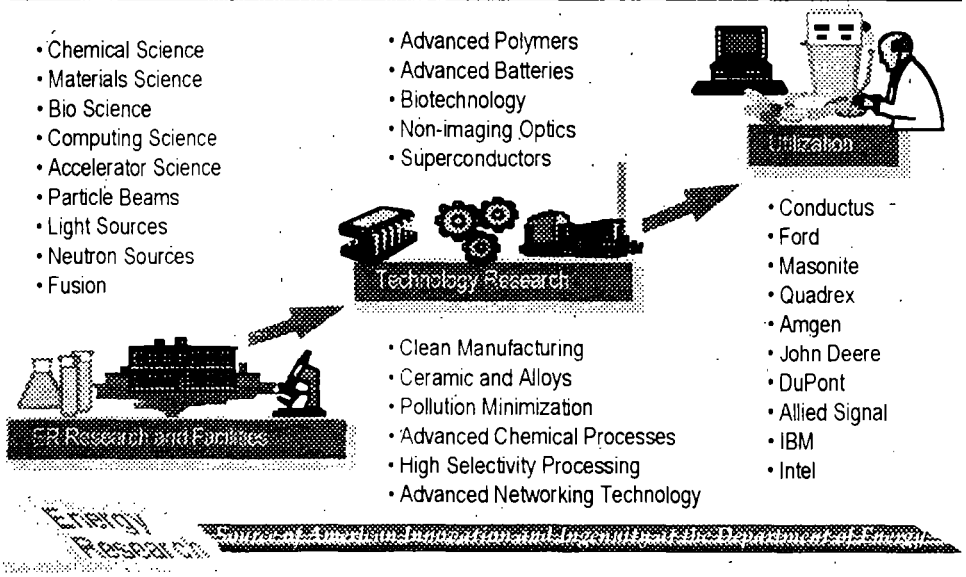
Dr. James F. Decker

March 28, 1995



For Further Information Contact Dr. P. Stone
(202) 586-9942

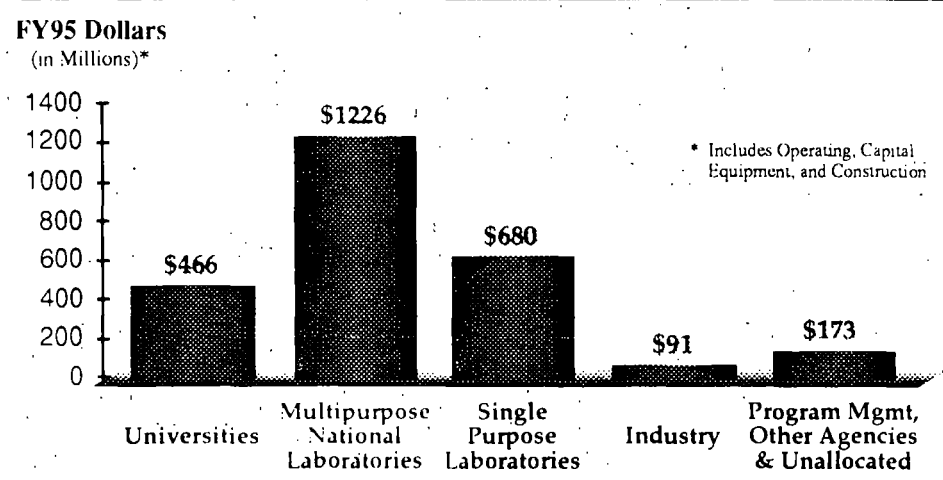
Energy Research - Making a Difference



Energy Research: *A Record of Innovation and Achievement*

- Top Quark
- Fusion Science World Records
- 1994 Nobel Prize for Physics
- Human Genome
- Global Climate Research
- High Performance Computing
- R&D 100 Awards
- Industrial Partnerships

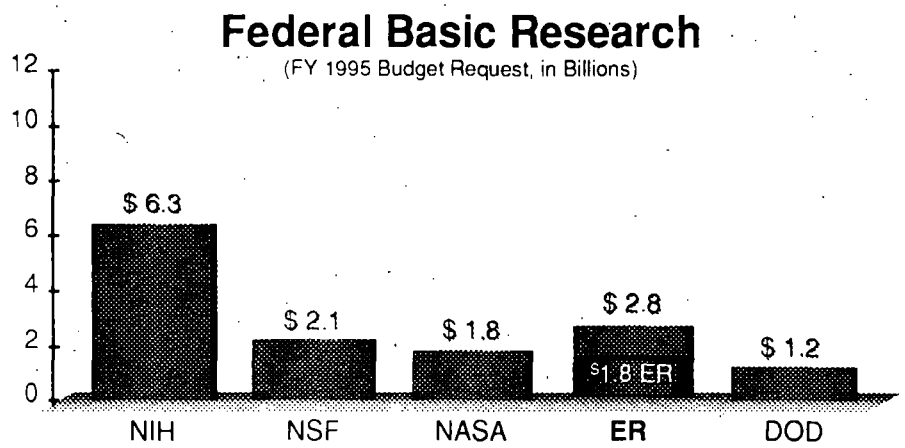
Energy Research Performers



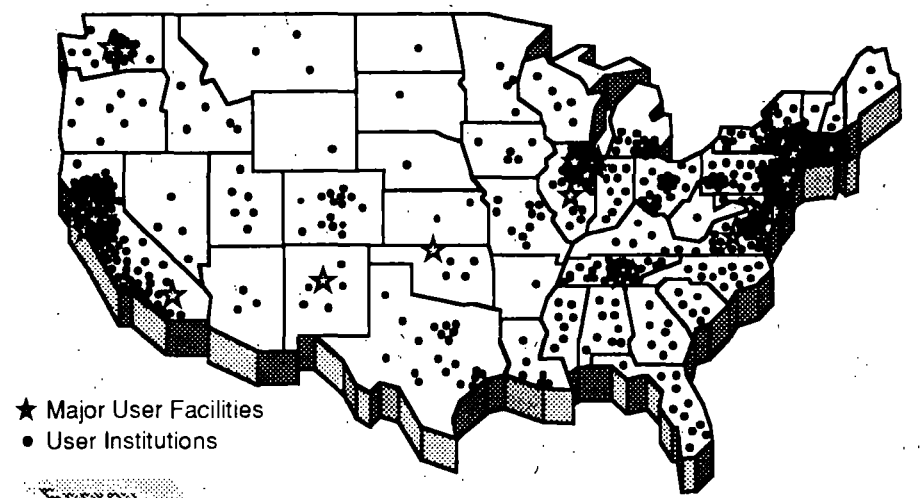
Energy Research Key Assets

- Coordinated Research on Complex National Problems
- Multi-disciplinary Teams
- Unique Large Scale Facilities
- Long Investment Horizon for Universities and the National Laboratories
- National Laboratories

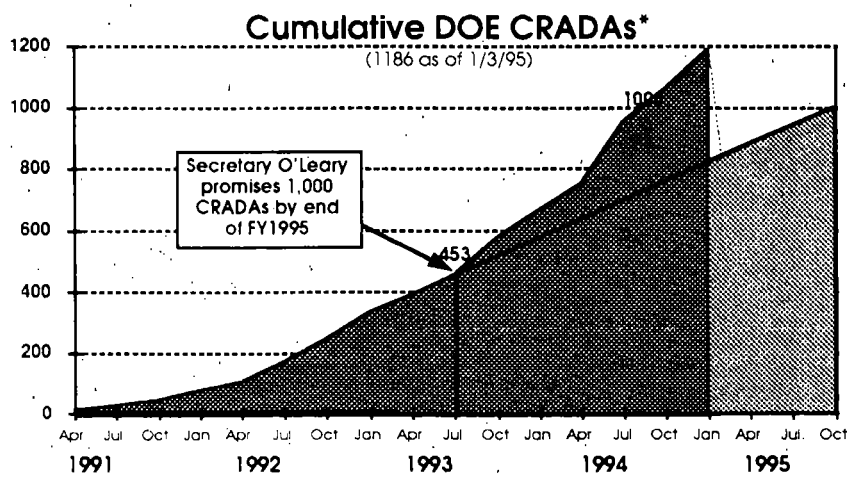
National Role of Energy Research



Major DOE User Facilities and the Institutions that Utilize Them



Partnering with Industry



* *Cooperative Research and Development Agreement (CRADA)*

Budget History

(dollars in millions)

Program	*FY93*	*FY94*	*FY95*
Basic Energy Sciences	838	758	734
Advanced Neutron Source	0	16	21
Fusion	327	329	368
Bio. and Environmental Res.	338	395	437
MEL-FS	26	40	43
High Energy Physics	588	620	642
Nuclear Physics	298	350	331
ER- Lab. Tech. Trans.	10	37	57
OTHER	23	29	10
Sub Total	2448	2574	2643
Supercond. Super Collider	513	640	0
TOTAL	2961	3214	2643

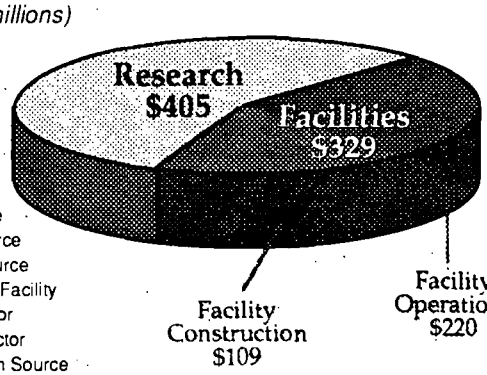
Energy Research Issues

- Alignment with National Needs
- Peer Review
- Program Balance
- Partnerships & International Cooperation
- Re-articulating The Vision For High Energy and Nuclear Physics
- New Emphasis for Environmental Clean-up
- Communication
- New Directions for The National Labs

What Types of Research We Do

Basic Energy Sciences

(FY95 dollars in millions)



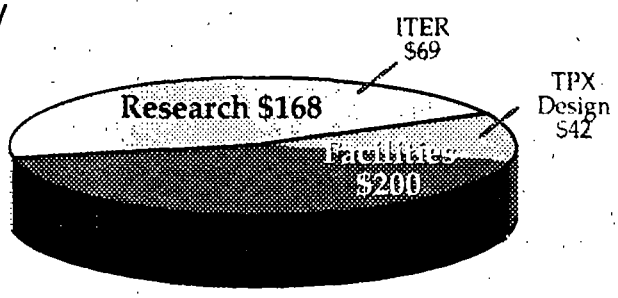
Types of Research
- Materials Sciences
- Metallurgy and Ceramics
- Solid State Physics
- Materials Chemistry
- Chemical Sciences
- Engineering
- Geosciences
- Energy Biosciences
- Scientific Computing

Facilities:
Advanced Light Source
Advanced Photon Source
Advanced Neutron Source
Combustion Research Facility
High Flux Beam Reactor
High Flux Isotope Reactor
Intense Pulsed Neutron Source
National Synchrotron Light Source
Stanford Synchrotron Radiation Laboratory

What Types of Research We Do

Fusion Energy

(FY95 dollars in millions)



Facilities:

Advanced Toroidal Facility
Alcator C Mod
Doublet III D
ITER
Princeton Beta Experiment
Tokamak Fusion Test Reactor
Tokamak Physics Experiment

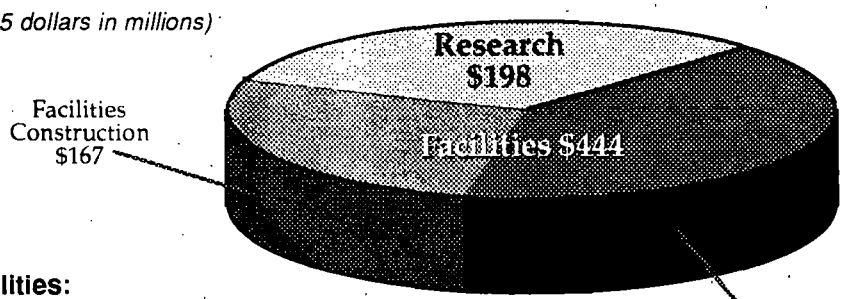
Energy Research

Source: Budget in Brief, Fiscal Year 1995, U.S. Department of Energy

What Types of Research We Do

High Energy Physics

(FY95 dollars in millions)



Facilities:

Alternating Gradient Synchrotron
B-Factory
Fermilab
Stanford Linear Accelerator Center

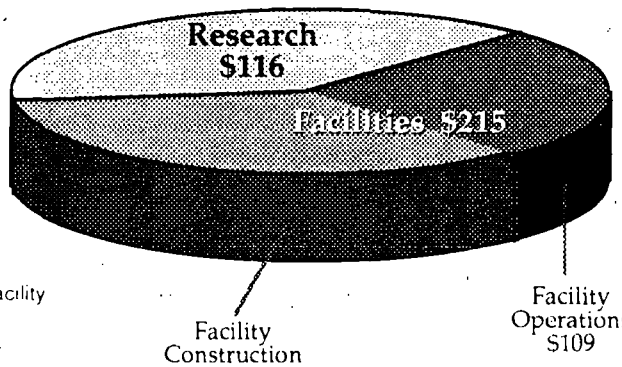
Energy Research

Source: Budget in Brief, Fiscal Year 1995, U.S. Department of Energy

What Types of Research We Do

Nuclear Physics

(FY95 dollars in millions)



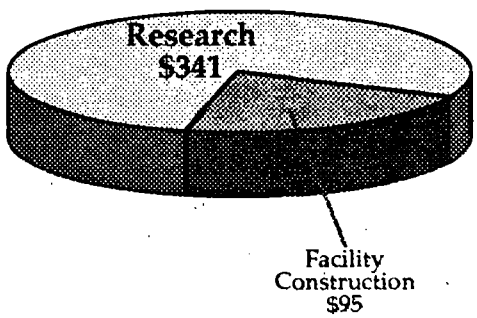
Facilities:

88-INCH Cyclotron
Atlas
Continuous Electron Beam Facility
Bates Linear Accelerator
Relativistic Heavy Ion Collider
TANDEM/ Alternating Gradient Synchrotron

What Types of Research We Do

Biological & Environmental Research

(FY95 dollars in millions)



Types of Research:

- Health Effects
- Life Sciences
  (with Human Genome)
- Medical Applications
- Biophysical Research
- Environmental Sciences

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H

Divider Title: _____

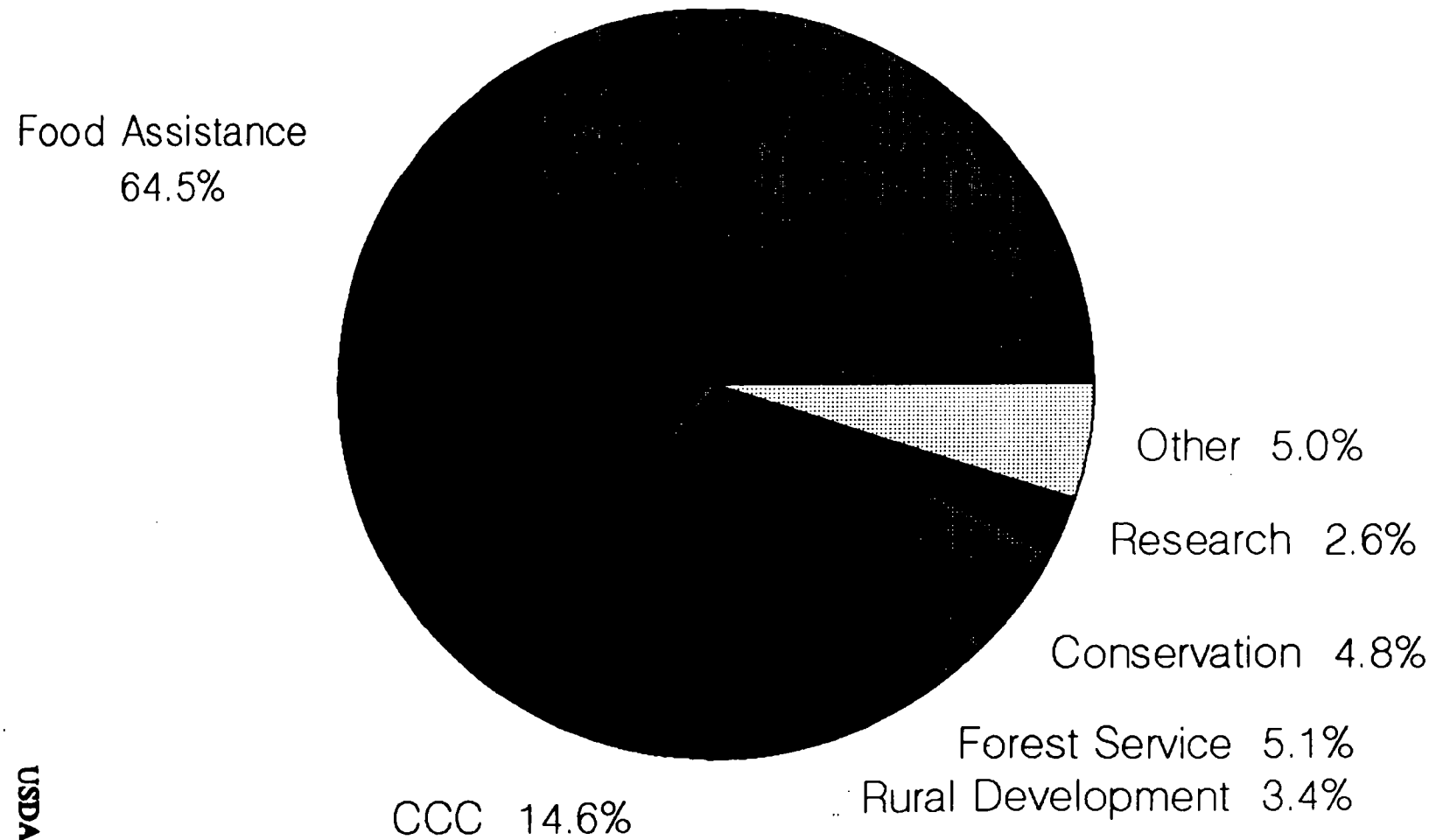
United States Department of Agriculture

RESEARCH, EDUCATION AND ECONOMICS

CONTACT: DENNIS CHILD
TELEPHONE: (202) 720-8885
FAX: (202) 690-2842

U.S. DEPARTMENT OF AGRICULTURE
Fiscal Year 1996

Total Outlays $62.3 Billion



USDA-2

UNITED STATES DEPARTMENT OF AGRICULTURE

Table 9--Appropriations for Research and Education, Fiscal Years 1987 through 1994 and Estimates for 1995 and 1996

	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
RESEARCH:										
Agricultural Research Service	518.4	552.7	578.2	602.3	640.9	681.4	680.2	706.1	707.8	704.3
Cooperative State Research, Education, and Extension Service:										
Hatch Act	148.8	155.5	155.5	155.1	162.3	168.6	168.8	171.3	171.3	171.3
Cooperative Forestry	12.4	17.5	17.5	17.3	17.8	18.5	18.5	20.8	20.8	20.8
1890 Colleges & Tuskegee	22.3	23.3	24.3	25.0	26.3	27.4	27.4	28.2	28.2	28.2
Special Research Grants a/	55.1	51.8	61.7	73.1	78.6	86.3	86.6	85.0	75.7	56.6
N.R.I. Competitive Grants	40.7	42.4	39.7	38.6	73.0	97.5	97.5	103.1	103.1	130.0
Forestry Competitive Grants	6.0	3.0	0.0	3.9	0.0	0.0	0.0	0.0	0.0	0.0
Animal Health & Disease	5.5	5.5	5.5	5.4	5.6	5.6	5.5	5.5	5.5	5.5
Direct Federal Administration	2.9	4.1	6.4	8.2	9.7	10.5	10.7	11.4	10.0	1.7
Total, CSREES	293.7	303.1	310.6	326.6	373.3	414.4	415.0	425.3	414.6	414.1
Agricultural Marketing Service	2.5	2.6	2.6	2.7	4.2	4.8	4.7	4.9	4.8	4.8
Animal & Plant Health Inspection Service	4.9	6.6	11.3	13.0	15.7	16.7	14.7	19.2	19.1	18.9
Economic Research Service	44.9	48.3	49.6	51.0	54.4	59.0	58.9	55.2	53.5	54.7
Foreign Agricultural Service	4.2	1.5	1.3	2.3	2.6	1.5	1.5	1.4	1.4	1.4
Forest Service	126.7	132.5	138.3	150.9	167.6	180.5	182.7	193.1	199.7	203.8
Grain Inspection, Packers, & Stockyards Admin.	0.8	1.0	0.4	0.3	0.7	1.5	1.8	1.8	1.8	2.8
Nat'l Agricultural Statistics Service	3.4	3.6	2.9	2.8	3.2	3.6	3.9	3.9	3.6	3.7
Rural Business & Cooperative Development Serv.	2.7	2.7	2.7	3.4	2.8	8.0	9.6	11.4	9.9	19.2
Total, Research	1,002.2	1,054.6	1,097.9	1,155.3	1,265.4	1,371.4	1,373.0	1,422.3	1,416.2	1,427.7
EDUCATION:										
Agricultural Research Service	11.1	12.2	14.3	14.7	16.8	17.8	17.7	18.2	18.4	19.6
Cooperative State Research, Education, and Extension Service:										
Extension Activities:										
Smith-Lever 3(b&c) Formula	235.9	241.6	241.6	242.3	252.6	262.7	262.7	272.6	272.6	272.6
Other Programs	96.8	109.0	110.7	118.3	136.7	145.3	155.0	151.0	153.6	167.0
Direct Federal Admin.	6.3	7.4	9.1	8.7	9.2	11.3	10.7	12.6	12.6	5.1
Total, Extension Activities	339.0	358.0	361.4	369.3	398.5	419.3	428.4	436.2	438.8	444.7
Cooperative State Research:										
Morrill Nelson Act	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	c/	0.0
Graduate Training Grants	2.9	2.9	2.9	2.8	3.5	3.5	3.5	3.5	3.5	3.5
Institution Challenge Grants	0.0	0.0	0.0	1.0	1.5	1.5	1.5	1.5	4.4	1.5
1890 Colleges	1.9	1.9	1.9	1.9	2.0	0.0	0.0	0.0	0.0	0.0
1890 Capacity Building Grants b/	0.0	0.0	0.0	5.4	8.2	10.2	10.2	9.9	9.9	10.6
Multicultural Scholars Program	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	1.0
Hispanic Education Partnership Grants	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.5
Native American Institutions Endowment Fund	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.6
Total, Cooperative Education	7.6	7.6	7.6	13.9	18.0	18.0	18.0	17.7	19.8	22.7
Total, CSREES	346.6	365.6	369.0	383.2	416.5	437.3	446.4	453.9	458.6	467.4
Total, Education	357.7	377.8	383.3	397.9	433.3	455.1	464.1	472.1	477.0	487.0
Total, Research and Education	1,359.9	1,432.4	1,481.2	1,553.2	1,698.7	1,826.5	1,837.1	1,894.4	1,893.2	1,914.7

a/ Includes program and facility grants.
b/ Includes grants for research as well as higher education.
c/ Funds previously available under Morrill Nelson were shifted to the Challenge Grants.

01-Mar-95

MISSION

The Research, Education, and Economics reorganization combines eight previously separate organizations and agencies into four agencies. These agencies and missions are:

- The Agricultural Research Service (ARS) includes functions previously performed by the Human Nutrition Information Service and the National Agricultural Library. The overall mission of ARS is to develop new knowledge and technology and provide access to agricultural information needed to solve technical agricultural problems of broad scope and high national priority to ensure adequate availability of high-quality, safe food and other agricultural products to meet the nutritional needs of the American consumer, to sustain a viable and competitive food and agricultural economy, to enhance quality of life and economic opportunity for rural citizens and society as a whole, and to maintain a quality environment and natural resource base.

- The Cooperative State Research, Education, and Extension Service (CSREES) was created through the merger of Cooperative State Research Service and the Extension Service. The mission is to work with university partners to advance research, extension, and higher education in the food and agricultural sciences and related environmental and human sciences to benefit people, communities, and the Nation.

- The Economic Research Service (ERS) provides economic and other social science information and analysis for public and private sector decisions on agriculture, food, natural resources, and rural America. Functions of the former Office of Energy are now part of ERS.

- The National Agricultural Statistics Service (NASS) serves the United States, its agriculture, and its rural communities by providing meaningful, accurate, and objective statistical information and services.

AGRICULTURAL RESEARCH SERVICE (ARS)

Program Level
(Dollars in Millions)

Program	1994 Actual	1995 Current Estimate	1996 Budget
Soil and Water Conservation	$88.0	$83.0	$82.1
Plant Science	250.8	244.2	237.6
Animal Science	115.1	113.9	112.4
Commodity Conversion and Delivery	135.4	141.5	139.5
Human Nutrition	60.9	62.4	71.4
Information and Library Services	17.3	17.4	18.6
Integration of Agricultural Systems	27.0	30.7	28.9
Repair and Maintenance	17.6	18.3	18.3
Contingency Research Fund	0.9	0.9	0.9
Trust Funds	11.3	14.1	14.1
Total, Research and Information	724.3	726.4	723.8
Buildings and Facilities	32.7	43.7	30.2
Total, ARS	$757.0	$770.1	$754.0

Cooperative State Research, Education, and Extension Service
Cooperative Research and Education Activities
Program Level
(Dollars in Millions)

Program	1994 Actual	1995 Current Estimate	1996 Budget
Hatch Act	$171.3	$171.3	$171.3
1890 Colleges and Tuskegee Univ.	28.2	28.2	28.2
Cooperative Forestry	20.8	20.8	20.8
Animal Health and Disease Formula	5.6	5.6	5.6
National Research Initiative:			
Natural Resources and Environment	21.8	16.7	27.0
Plants	40.3	37.0	47.0
Animals	23.0	23.1	29.5
Nutrition, Food Safety and Health	7.4	7.4	11.0
Processes and New products	6.9	6.9	9.0
Markets, Trade, and Rural Development	3.7	3.7	6.5
Earmarked Programs:			
Water Quality	- -	4.7	- -
Integrated Pest Management	- -	2.3	- -
Pesticide Impact Assessment	- -	1.3	- -
Total, NRI	103.1	103.1	130.0
Special Research Grants	60.0	51.5	15.0
Improved Pest Control	10.8	9.8	25.0
Sustainable Agriculture	7.4	8.1	9.5
Aquaculture Centers	4.0	4.0	4.3
Supplemental and Alternative Crops	1.8	1.3	2.3
Critical Agricultural Materials Act	0.5	0.5	0.0
Rangeland Research Grants	0.5	0.5	0.5
Federal Administration	11.4	10.0	1.7
Higher Education	8.8	8.9	12.1
1890 Capacity Building Grants	9.9	9.9	10.6
Total, Research and Education	444.1	433.5	436.9
Buildings and Facilities	54.0	62.7	0.0
Total, Cooperative Research and Education Activities	$498.1	$496.2	$436.9

FACTS about the USDA's
National Research Initiative Competititive Grants Program

The National Research Initiative Competitive Grants Program was established in 1991 in response to a recommendation from the National Academy of Sciences in a report, Investing in Research: A Proposal to Strengthen the Agricultural, Food and Environmental System, released in 1989. The report recommended a major increase in funding of high priority research, with a goal of $500 million per year, in order to: 1) increase competitiveness of U. S. agriculture, 2) improve human health and well-being by studies on food safety and human nutrition, and 3) enhance the environment and natural resource base upon which agriculture depends. It subsumed the former USDA Competitive Research Grants Office (CRGO), established in 1978 as the first competitive grants program of the USDA.

The purpose of the NRI is to increase the amount and quality of science applied to solve problems facing agriculture defined in the broadest sense. All U.S. scientists are eligible to compete on an equal basis for these funds, including scientists at land grant universities, nonland grant public universities, private universities and institutions, and federal laboratories. The funds go directly in support of the proposed research at the university, institution, or laboratory of the investigator(s).

The NRI in 1994 funded 833 research projects out of 3,448 proposals received by the program. The NRI in the four years since its establishment in 1991 funded 2,998 projects out of 11,967 proposals received. Including the CRGO back to 1978, this competitive grants program funded 6,768 projects out of 27,648 proposals received. The average grant awarded in 1994 was $137,256 for 2.35 years.

The NRI funds up to 80% fundamental research and at least 20% mission-linked research. Fundamental research is the quest for new knowledge and opens new opportunities and directions for applied research. Mission-linked research may be either basic or applied, as needed, and targets current problems in need of immediate solution. Fundamental and mission-linked research both are needed to help agriculture convert from a resource-based to a knowledge-based industry in the move towards sustainability.

The NRI uses merit review by scientific peers to identify the most meritorious proposals for funding each year. "Merit" includes scientific quality and relevance of the proposed research to the high-priority areas identified for funding in agriculture, food, and the environment. The nearly 3,500 proposals received in 1994 were sent for evaluation to some 15,000 ad hoc reviewers, and thirty five panels with an average of 10 scientists per panel were convened to rank the proposals based on merit within the six divisions and 31 program areas of the NRI.

The NRI approach to funding research through competitive grants provides both flexibility and outreach in meeting the needs of society in the areas of agriculture, food, and the environment. Scientists within the existing landgrant and USDA agricultural research infrastructure, when successful in competition for these funds, can pursue novel ideas and reach the goals of their programs faster with the awards made entirely based on the quality of the science proposed. In addition, the NRI attracts proposals from outstanding scientists at other public and private universities traditionally excluded from funding by the USDA.

About 10% of the funds appropriated to the NRI are used for strengthening the U.S agricultural research system. This is the highest percentage of funds for strengthening of any federal agency funding research, and at some $10 million annually, is second only to NSF in total funds available for strengthening. These funds go to new investigators, scientists at small and mid-sized institutions or institutions at states that historically have not been competitive for research funds, and for seed grants and purchase of equipment.

HIGHER EDUCATION PROGRAMS, USDA

National Needs Graduate Fellowships Grants

Competitive Grants Program Open to All Colleges and Universities to--

Stimulate development of scientists and professionals in national need areas.

Attract outstanding scholars to careers in food and agricultural sciences and business, particularly fellows with academic backgrounds in chemistry, genetics, molecular biology, medicine, computer science, business, and engineering, as well as food and agricultural disciplines.

Targeted Areas of Fellowship Support--

Plant Biotechnology; Animal Biotechnology; Food, Forest Products, and Agribusiness Management or Marketing; Food Science/Human Nutrition; Food, Forest Products, and Agricultural Engineering; and Water Science. Three of these six areas are supported annually on a rotating basis.

Awards--

Support for 2-4 fellows who must be U.S. citizens or nationals, and who are newly recruited graduate students.

2-year stipends for master's fellows at $10,000 annually. 3-year stipends for doctoral fellows at $17,000 annually. In addition, institutions receive $1,000 institutional cost-of-education allowance per year.

Higher Education Multicultural Scholars Program Grants

Competitive Grants Program Open to All Colleges and Universities to--

Increase the racial and ethnic diversity of the food and agricultural scientific and professional work force, and advance the educational achievement of minority Americans.

Targeted Areas of Support--

Agriculture, natural resources, forestry, veterinary medicine, home economics, and closely allied disciplines.

Awards--

Support for scholars, who must be U.S. citizens or nationals, undergraduate students newly recruited to a course of study leading to a baccalaureate degree in the food and agricultural sciences, and from a racial or ethnic group traditionally under-represented in the food and agricultural sciences--specifically, Blacks, Hispanics, Asians or Pacific Islanders, and American Indians or Alaskan Natives.

Students attending two-year institutions may participate in the program where an articulation or bridging agreement exists with an eligible four-year institution.

Annual stipends of approx. $6,000 per scholar, including a required 25% matching of non-Federal funds by the institution or other source; plus an institutional cost-of-education allowance of $500 per year for each scholar.

Higher Education Challenge Grants

Competitive Grants Program Open to All Colleges and Universities to--

Ameliorate national problems affecting quality of education, foster university partnerships with industry, foster partnerships among colleges and universities, and stimulate non-Federal support for higher education.

Targeted Areas of Support--

Curricula Design and Materials Development, Faculty Preparation and Enhancement, Innovative Instruction Delivery Systems, and Student Experiential Learning.

Awards--

$50,000 to $80,000 for up to 3 years. Dollar-for-dollar matching support from the institution or other non-Federal source is required.

1890 Institution Capacity Building Grants

Competitive Grants to 1890 Land-Grant Universities and Tuskegee University to--

Advance university teaching and research capabilities, foster partnerships with industry, foster partnerships with other institutions of higher learning, and stimulate non-Federal support for higher education.

Targeted Areas of Support--

Curricula design and materials development, faculty preparation and enhancement, instruction delivery systems, student experiential learning, student recruitment and retention, scientific instrumentation, and high priority research initiatives.

Awards--

Teaching projects - $50,000 to $225,000 for up to 3 years.
Research project - $50,000 to $350,000 for up to 3 years.
Matching support from the institution or other non-Federal source is strongly encouraged.

Scientific Advances in Genetics Research Applied to Agriculture

The United States during this century, with funding and leadership provided mainly by the U.S. Department of Agriculture and land grant university partners, has made enormous strides in a genetics approach to enhancing the performance of crops and livestock and solving problems for agriculture. Nearly all of the more than 150 different crops and 80 breeds of livestock used in U.S. agriculture were imported from other countries and then subjected to breeding so as to make them adapted to U.S. conditions and acceptable to U.S. consumers and now U.S. customers. Every form and scale of agriculture, from organic to conventional and small to large farms, have come to depend on these varieties of crops and breeds of livestock.

Also during this century, and also with funding and leadership provided mainly by the U.S Department of Agriculture and land grant university partners, the United States has made enormous strides in the use of biologically based technologies as the foundation of this Nation's approach to pest and disease control. "Biologically based" is used broadly to include not only breeding varieties of crop plants with resistance to pests and diseases but also the development of vaccines and release of natural enemies of pests. As examples:

- Hog cholera and screw worm, both native to North America, have been eliminated from the United States, and many other once-devastating diseases of livestock, poultry, and farm fish are controlled with vaccines;

- The U.S. corn, soybean, and small grains crops are grown with virtually no use of fungicides other than as seed treatments or the occasional emergency foliar treatment, because the varieties of these crops grown in the United States are continuously updated so as to maintain their resistance to the most important fungal leaf diseases; and

- At last count, about 850 natural enemies of insect pests and weeds have been released in the United States this century, of which about 40% have established and are providing some level of biological control.

The development of a genetic or other biologically based method of control for each of the pests and diseases important or potentially important for each of the crops and types of livestock is an enormous undertaking for two reasons: 1) this method of pest and disease control is usually more complicated than chemical control; and 2) a separate biological method must be developed for each pest or disease, one by one. The development of the sterile male approach to control screw worm took years and ranks as one of the all-time major accomplishments in the agricultural sciences, but screw worm is only one pest. The same or similar technology modified or sometimes totally redesigned must be developed for every other pest amenable to this method of control. It is mainly

because of the difficult, long-term, and painstaking nature of this work needed for each pest and each disease that U.S. agriculture continues to depend on the use of pesticides and antibiotics to control weeds and keep our crops and livestock healthy. Nevertheless, the goal remains that biologically based methods will be used to control as many pests and diseases as possible and as quickly as possible within the limits of resources available for agricultural research and education.

Virtually every biologically based solution to an agriculturally important problem developed to date, including solutions developed through plant and animal breeding, has used so-call conventional or traditional technologies. With the relatively recent development of rDNA technologies, we now have access to an almost unlimited array of useful genetic traits to further improve our food and fiber plants and animals and enhance the performance of biological control agents. After decades of fundamental, mission-linked, and applied research, carried out more or less simultaneously in the quest for new knowledge to solve problems, agriculture is now on a new threshold in this Nation's continuing efforts to assure a sustainable, healthy, and affordable supply of food and fiber for now and future generations.

The examples below illustrate some of the milestones and scientific breakthroughs in just one area of agricultural research, that of understanding and genetically improving agriculturally important plants and controlling plant diseases. It is noteworthy that each of these examples, like the examples provided on advances in human nutrition research, are from areas of research supported by the USDA's competitive grants program since first established in 1978 as the Competitive Research Grants Office (CRGO) and authorized since 1991 as the National Research Initiative Competitive Grants Program (NRI). This shows the importance of sustained support for research in targeted areas of science.

The examples fit generally into three groups: Arabidopsis thaliana as the model plant for genetic studies; engineering plants for resistance to virus diseases, following discovery of Agrobacterium as Nature's own "genetic engineer" of plants; and cloning genes for disease resistance.

Arabidopsis thaliana as the Model Plant for Genetic Studies

The rediscovery of Mendel's law of inheritance around the beginning of this century led to rapid advances and understanding of plant genetics and provided the scientific foundation for plant breeding as we know it today. However, many of the concepts applied in plant genetics research actually came from studies on model organisms outside of plant science, such as the insect Drosophila melanogaster used to demonstrate the existence if alleles, and the fungus Neurospora crassa used to demonstrate one-gene one-enzyme.

Moreover, while possibly more genetics research has been done this century on plants than on any other group of organisms, the effort has been spread over hundreds if not thousands of different species of plants.

The means by which to concentrate fundamental genetics research on one plant as a model for all plants was opened up by C. R. Somerville and W. L. Ogren in the late 1970s with their use of mutants of Arabidopsis thaliana, a little-known weed-like plant from the crucifer family, to study the genetics of photosynthesis and photorespiration in plants.

C. R. Sommerville, then from Canada, was supported by a postdoctoral fellowship from the National Research Council of Canada to work with W. L. Ogren, a scientist with the USDA's Agricultural Research Service (ARS) located at the University of Illinois, Urbana, IL. They used mutants of A. thaliana with defects in carbon dioxide assimilation and photorespiration. Until then, all understanding of photosynthesis and photorespiration were based on biochemical and physiological studies. Their first paper was published in Nature-London in 1979. Also in 1979, the USDA's Competitive Research Grants Office, in its first year of existence, made an award to W.L Ogren from the photosynthesis program that permitted Sommerville to continue with Ogren as a postdoctoral associate. Sommerville and Ogren then published a series of now classic papers starting in 1980 on photosynthesis and photorespiration using Arabidopsis mutants and based on the well-established model of one-gene one-enzyme.

Today, A. thaliana is the choice of plants for fundamental research in plant molecular genetics and related plant molecular biology and biochemistry. Its genome of approximately 100 million base-pairs is the smallest known genome among higher plants. Through joint efforts of the National Science Foundation, the Department of Energy, and the USDA, with NSF as the lead agency, work is now in progress to sequence this genome as a model for all plant genetics research.

In 1994, the NRI funded more than $11 million in competitive grants on plant genome research. About half of this was awarded through the USDA's Plant Genome Research Program established by Congress in 1991 with ARS as the lead agency and the NRI responsible for the merit review and selection of awardees. Some of the examples of scientific breakthrough out of the program are provided in the supplemental hand-out material.

Engineering Plants for Resistance to Virus Diseases--made possible by the discovery of Nature's own "genetic engineer"

For decades, scientists were puzzled by fact that the plant disease known as crown gall, evident as tumor-like growths on stems and roots and caused by the soilborne bacterium Agrobacterium tumefaciens, developed on susceptible plants whether or not the pathogen was killed after making brief contact with the plant. The brief contact was long enough for infection to occur but not long

enough for tumorigenesis. Because the galls resembled tumors on animals, the National Cancer Institute of the National Institutes of Health funded studies to determine the nature of the infections responsible for crown gall.

The answer to the mystery came starting in 1978 from research carried out by Mary-Dell Chilton and E. Nester at the University of Washington. These investigators revealed the remarkable fact that the genes in plant tumor cells were actually genes from the pathogen and not from the plant. M. Thomashow and E. Nester then reported in 1980 that genes from the pathogen are integrated into the nuclear genome of the susceptible plant.

These discoveries on how one pathogen causes disease opened the entire field of genetic engineering for plants. Science in the National Interest selected this discovery, referred to a "A Virtuous Infection," as one of 10 examples where fundamental research has led to applications that were totally unexpected.

With the mystery of crown gall solved, scientists in several laboratories immediately saw the potential for practical applications. Research was focused on the so-called "transfer" DNA (T-DNA) used by the pathogen to vector its own genes into the plant genome. There were basically two goals of the research during the early stages in the development of T-DNA as a gene vector: 1) find ways to disarm the T-DNA of its genes for production of crown gall and 2) deliver genes of choice into plants susceptible to infection by this pathogen.

Working with funding from the Monsanto Company, a research group led by Roger Beachy at Washington University, St. Louis, reported in 1986 the successful transfer of the gene from tobacco mosaic virus (TMV) into tobacco using T-DNA as the vector. The particular virus gene coded for the coat protein used to wrap the infectious RNA genome into virus particles. Two other fundamental studies were important to this work by Beachy as associates: The genome of TMV had been sequenced by Lomonasoff and associates in England, reported in 1982; and the means to develop complementary DNA (cDNA) of virus RNA, critical to development of a DNA copy of the TMV coat-protein gene, had just been developed by Paul Ahlquist at the University of Wisconsin.

In the transfer of the TMV coat-protein gene into tobacco genome, Beachy and his associates also discovered that tobacco plants with this transgene were increasingly more resistant to TMV in direct relation to the amount of coat protein produced by the transgenic plant. H.H. McKinney, working at the Beltsville Agricultural Research Center, reported already 50 years earlier that plants inoculated first with a mild strain of a virus are then remarkably resistant to severe strains of that virus. He referred to this phenomenon as "cross protection." "Coat-protein mediated resistance" of the kind discovered by Beachy and associates is now thought to work on the same or similar principles shown for cross protection. And like cross protection, the use of transgenes to develop plants with resistance to viruses has proved to work across a wide range of viruses and crops.

In the remarkably short time of just one year--by 1987--Monsanto carried out the first field trial with tomatoes transformed to express the coat protein gene from TMV. TMV affects tomatoes throughout the world, especially tomatoes grown under greenhouse conditions for winter markets. The field trial was a success in that the transgenic tomatoes inoculated with TMV developed few or no symptoms of the disease, whereas the nonmodified check plants inoculated in the same way became severely diseased. In 1995, seed of squash developed by the Upjohn Company with coat-protein mediated resistance to a major virus disease of squash will be available to farmers.

The United States has never used cross protection as a means to control virus diseases, because of the possibility that a mild strain in one variety of a crop could cause severe disease in another variety or relative of that crop. The discovery that the same or equivalent virus disease control can be achieved by use of one just one gene from the virus offers a much safer means to control virus diseases.

Several other crops with coat-protein-mediated resistance are under development, since the method works across such a wide range of crop plants and plant viruses. In addition, research field trials are now in progress with Bt-mediated resistance to insect pests of cotton and potato. the Bt gene from the insect pathogen Bacillus thuringiensis codes for production of a protein toxic to certain species of insect pests. As with other biologically based approaches to pest and disease control, however, each use is specific to that pest (insect or virus) on that crop.

Cloning Disease Resistance Genes from Plants

Plants employ many different mechanisms of defense against their pests and diseases. Many of these mechanisms are controlled by many genes and are biochemically and physiologically very complex. Others are controlled by single genes and have been more amenable to genetic and molecular analysis. It is this later category of resistance genes that have been the object of intense research during the past 15-20 years, supported heavily by both the USDA's competitive grants program (CRGO and the NRI) and the National Science Foundation. The particular genes for resistance are of the kind known today by Flor's gene-for-gene model.

Dr. H.H. Flor was employed by the U.S. Department of Agriculture, Bureau of Plant Industry (later ARS) and stationed at North Dakota State University, Fargo, ND. His job was to work on flax rust, a problem in the northcentral states. Plant geneticists had shown already by 1910 that resistance in wheat to any given biotype (race) of the wheat stem rust fungus was controlled by single dominant genes. Flor found the same situation in his early studies of resistance in flax to the flax rust fungus.

However, Flor also examined the genetics of virulence in the pathogen. He crossed different races of the fungus and analyzed ability of the progeny to cause rust on different genetic lines (genotypes)

of flax. He developed a method whereby a segregating population of the pathogen could be interacted with a segregating population of the plant, in all possible combinations. From the results of these sometimes enormous experiments, carried out over several years, he proposed his now classic "gene-for-gene" model to explain his mountains of data. His hypothesis was first proposed in 1942 but was not fully developed until a paper published in 1955.

Flor proposed that for every gene for resistance in the plant, there is a corresponding and complementary gene that conditions virulence in the pathogen. Resistance is dominant over susceptibility in the plant, and avirulence is dominant over virulence in the pathogen. The resistance phenotype (incompatible host/pathogen interaction for any given race x variety combination) resulted with those genotypes of the host that are either homozygous or heterozygous for resistance interacted with those genotypes of the pathogen that were either homozygous or heterozygous for avirulence. Different alleles for resistance in the host match up with different alleles for avirulence in the pathogen.

Flor's gene-for-gene model has been validated for a wide range of fungal, virus, and bacterial diseases of plants. It represents one of the major contributions to genetics of this century.

Subsequent work proposed for host-plant resistance of the gene-for-gene type that the product of any given resistance gene in the plant somehow helps the plant recognize the invading pathogen, either directly, through recognition of the product of the corresponding avirulence gene, or indirectly, through recognition of an event or process elicited by the corresponding avirulence gene. Scientists succeeded first in cloning avirulence genes, in the 1980s, and then succeeded in cloning resistance genes, in the 1990s.

Research groups at the University of California, led by Dr. Noel Keen at Riverside and Brian Staskawicz at Berkeley, cloned several genes for avirulence from strains (pathovars) of the bacterial plant pathogen, P. syringae. The first such accomplishment was reported in 1984. In 1992, the group led by Staskawicz cloned the avirulence gene from Pseudomonas syringae pathovar tomato that corresponds with the pto gene for resistance to this pathogen in tomato. One year later, in 1993, a research group led by Steve Tanksley at Cornell University and supported by the USDA's Plant Genome Research Program cloned the pto gene. This was the first plant gene for disease resistance to be cloned, a discovery selected as a cover-article in Science provided as part of the hand-out with this report. This is also the first gene-for-gene system where both the avirulence gene in the pathogen and the corresponding resistance gene in the plant have been cloned.

Four more plant genes for recognition and defense against pathogens were cloned in 1993/94. Three of these genes are from respectively, tobacco for resistance to tobacco mosaic virus, flax for resistance to the flax rust fungus, and Arabidopsis thaliana for resistance to Pseudomonas syringae. Surprisingly, these three genes from such different plants for recognitions and defense against such

different kinds of pathogens--a virus, fungus, and bacterium--all are basically the same gene or members of the same family of genes. The gene from tobacco for resistance to TMV was cloned by Barbara Baker and associates at the USDA's Plant Gene Expression Center at the University of California, Berkeley. The gene from A. thaliana for resistance to the bacterial pathogen was cloned simultaneously by the research group led by Staskawicz and a group led by F. M. Ausubel, at Massachusetts General Hospital, Boston. The gene for resistance in flax to flax rust was cloned by Jeff Ellison in Australia.

From the practical standpoint, it will soon be possible to transfer genes for resistance of the gene-for-gene type precisely into the genome of susceptible plant lines, including across traditional barriers of sexual compatibility. This will make it easier and faster for plant breeders to update varieties of crop plants needed to stay ahead of the always changing pathogen. Scientifically, this accomplishment matches similar accomplishments in medical research on cloning human genes for susceptibility to genetic diseases.

Scientists working on agriculturally important plants have exploited most of the genetically useful variation within the range of normal sexual compatibility in the development of crop plants. Work is now well along in the development of new varieties of crop plants based on transfer of so-called "alien" genes from wild relatives using the wide cross, embryo rescue, and chromosome substitution and manipulation. These developments have been made possible following decades of fundamental research in plant cytogenetics as well as plant genetics.

The next phase in the application of genetics in agriculture is already here with commercial production in 1994 of the Flavr Savr tomato and in 1995 the virus-resistant squash. In addition to our ability to access still more sources of useful genetic variation, plant breeding can be made more efficient and precise. The new molecular techniques will also make it possible to update varieties for disease or pest resistance without changing their familiar appearance or quality features so important to consumer preference. With all of these methods, integrated and packaged with the traditional technologies, the goals of genetics research applied to agriculture remain: Develop ever better varieties of crop plants and breeds of livestock adapted to U.S. conditions, resistant to U.S. pests and diseases, and suitable to U.S. consumers and customers.

HUMAN DIETARY MINERAL REQUIREMENTS

Bone Health

Osteoporosis is the loss of bone density during aging and is more common in women due to the rapid loss of bone which follows menopause, however, adult bone loss due to aging contributes significantly to the osteoporosis seen in elderly men as well as women. The HNRC has developed considerable evidence that inadequate dietary calcium intake and low vitamin D intake in the Northern U.S., can result in a failure to reach optimal peak bone density during early adulthood and accelerated bone loss afterwards. In recent years researchers have identified genetic links to a number of chronic diseases, and osteoporosis is no exception.

While studies with twin pairs had previously suggested a strong genetic contribution to bone density, a genetic marker for prediction of low bone density has only recently been identified at the HNRCA. This marker, which is a restriction fragment length polymorphism (RFLP) in the vitamin D receptor gene, allows the separation of the population into three distinct groups; a low bone density group (12-20% of adult white women), a high bone density group (35-45% of adult white women), and an intermediate bone density group (45-50% of adult white women). Preliminary studies have predicted that women with the low bone density genotype will reach the fracture threshold (the bone density where mechanical strength is insufficient to resist fracture due to trauma) at an earlier age than either of the other groups. Thus, osteoporosis, and all of its associated medical costs, is expected to be greater in these women. Currently, there is no indication how to prevent the development of osteoporosis in these women. It is possible, given the importance of adequate calcium and vitamin D intake in attaining and maintaining optimal bone health, that women with the low bone density genotype are particularly susceptible to inadequate intake of these nutrients. In addition, some research suggests that the regulation of calcium metabolism may be altered in women with the low bone density genotype. As a result, unique requirements for calcium and vitamin D intake may be needed for this population group if prevention efforts are to be optimally effective.

In the United States is excess of $20 million are spent on calcium supplements in the hopes of preventing osteoporosis. This occurs although the U.S. has one of the highest per capita intakes of calcium and one of the highest incidence rates of osteoporosis. Thus, other nutrients probably are of equal importance to calcium in maintaining healthy bones. Research at the GFHNRC has revealed that boron, magnesium, copper and perhaps silicon nutriture affects the absorption, retention and excretion of calcium. Moreover, although absorption and retention of calcium increased in response to bone mineral loss, total body bone mineral significantly decreased with a weight loss program of reduced calorie intake and exercise. In parallel with the bone loss, copper and magnesium were lost in amounts exceeding intake, which were set at accepted requirement levels, as was calcium. The findings indicate that boron, copper and magnesium are of more practical concern with regard to osteoporosis than currently acknowledged, and efforts are underway to change this.

The findings with calcium and bone were accomplished by the use of advance technology including a dual x-ray absorptiometer to measure bone density in humans; light, scanning and electron microscopy to characterize morphological changes in bone; a human whole body gamma counter to follow radiocalcium

in the body; a robotic centrifugal analyzer for biochemical measurement, and a nephrometer for immunological measurement, of blood and urine metabolites involved in calcium and bone metabolism.

Copper

Human and animal studies at the Grand Forks Human Nutrition Research Center (GFHNRC) have revealed that an inadequate copper intake results in biochemical and physiological changes that result in an increased risk of heart attacks, decreased blood-clot forming and dissolving abilities, impaired ability to cope with stressors which can lead to high blood pressure, impaired ability to maintain body temperature when exposed to cold, impaired ability to defend against a variety of chemicals present in the diet which are cancer-causing or toxic in other ways, and reduced quality of sleep.

These findings have been achieved through the use of molecular biological techniques of immunoblotting, gene expression and transgenic mice; stable isotopes and mass spectrometry; live-in human volunteers in a 14-bed metabolic ward, and equipment such as atomic absorption and inductively coupled plasma mass spectrometers, high pressure liquid and gas chromatographs, fluorometer, enzyme immunoassay analyzer, and cell/hematology analyzer. Mineral nutrient effects on brain function were determined by measuring brain electrical activity using the electroencephalograph, using sophisticated computer algorithms to spectrally analyze brain electrical activity, and measuring performance on computerized tasks.

Boron

Neuropsychological and behavior studies at the GFHNRC have found that low boron intakes are associated with reduced short-term memory and motor performance; marginal intakes of magnesium similar to those consumed by many Americans results in changes in brain electrical activity which are indicative of emotional and sleep disturbances; calcium supplementation provides relief of some menstrual symptoms (for example, mood swings, water retention and pain); and copper, iron, selenium and zinc have important roles affecting mood states, sleep behavior, pain perception and menstrual and menopausal symptoms.

Selenium

Although selenium is an essential nutrient for man, it has never been included in national nutrition examination surveys because of the tedious and expensive procedures required. The only functional biochemical indicator of selenium status is the selenium-dependent enzyme, glutathione peroxidase, an important part of the body's antioxidant system which protects against oxidative (free radical) damage associated with degenerative diseases such as cancer and eye cataracts. The traditional assay method for the enzyme is labor intensive and costs from $0.50 to $1.00 per sample for materials. The WHNRC has developed an entirely new chemical method for assaying glutathione peroxidase that lends itself to automation on commonly available clinical analyzers. This automated assay has a throughput of 30 samples per hour at a cost of less than $0.50 per sample, making it a practical method for use in large-scale surveys. The antioxidant health of the U.S. population has not been surveyed, largely because of inadequate methodology and lack of interpretive guidelines for tests of oxidative damage and defense. The availability of this automated assay fills an important part of this gap, and should also speed the process of developing improved dietary recommendations for selenium nutriture.

DIET AND IMMUNOLOGICAL FUNCTION

Few strategies have been effective in reversing or delaying the onset of age-related immunological decline. Nutritional insufficiencies contribute to the decline of the immune response in the aged and nutritional intervention represents the most practical and economical means to reverse and/or delay age-associated decline of the immune response. Along these lines, HNRCA scientists showed that supplementation with vitamin E will significantly improve the immune response in the elderly. Vitamin E supplementation enhanced antibody production in response to vaccine. Clinical significance of an immuno-stimulatory effect of vitamin E is supported by animal studies that showed vitamin E supplementation significantly decreased viral titer in lungs of old mice infected with influenza virus. Studies to determine the mechanism of immuno-stimulatory effect of vitamin E have led to the observation that aging is associated with increased activity of two key enzymes (cyclooxygenase and 5-lipooxygenase) in production of important immuno-regulatory compounds, prostaglandins and leukotrienes. The effect of vitamin E seems to be mediated through genetic control of the enzyme cyclooxygenase.

Studies are needed to determine the mechanism of nutrients' effect on immune response and prevention of immune-associated diseases. Such studies will help in designing better dietary interventions as well as in understanding the molecular and biochemical basis of the age-associated deterioration of the immune response.

Results from studies conducted at the WHNRC showed that the amount and type of dietary fat influence the activity of the human immune system. Immune response was increased by a lower total fat intake and decreased by a higher fat intake. In two separate studies conducted with men and women, the ability of white blood cells to mobilize to fight disease was increased when the fat intake was reduced from 40% of calories (levels typical of U.S. diets) to 25%. The reduction in fat intake was also accompanied by an increase in the number of infection fighting white cells. Intake of n-6 type polyunsaturated fat (PUFA), found in common vegetable seed oils such as soybean, corn, safflower, and sunflower oils, was also varied and was found to have no effect on the several indices of immune response tested. Thus a moderate increase in the consumption of such oils to improve cardiovascular health by lowering blood cholesterol does not appear to have an adverse effect on immune response when the total fat content of the diet is below 25% of calories.

In another study conducted with male soldiers, an increased intake of highly unsaturated fat of the n-3 type, found in flaxseed and fish oils, was found to significantly reduce the immune response when flaxseed oil was fed, but not when salmon was fed daily. These results indicate that periodic fish consumption would have no adverse effect on immune response but prolonged supplementation with fish oils or oils rich in the n-3 type fatty acids may not be altogether safe.

HOMOCYSTEINE, FOLATE, AND THE DIET-GENE-DISEASE INTERACTION

Homocysteine, a sulfur amino acid whose metabolism is closely linked to that of folic acid and certain other vitamins (B6 and B12), usually a normal blood constituent, becomes an independent risk factor for coronary

heart disease, occlusive vascular disease, and stroke when the level is elevated. These links between folate, homocysteine and vascular disease are particularly demonstrated in Jean Meyer Human Nutrition Research Center on Aging (HNRC) studies which showed that individuals with inadequate folate intake have a two-fold elevated risk of stenosis of their carotid arteries. This link between folate and homocysteine metabolism provided a tool to use plasma homocysteine level as a functional indicator for the assessment of folate status. Close to 40% of the population over age 65 in the original Framingham Heart Study cohort have inadequate folate status and close to 30% of this population were considered to be hyperhomocysteinemic. This was reflected in the higher incidence of carotid artery thickening.

Studies are progressing in the evaluation of the interaction between a common gene defect in folate metabolism and nutritional folate requirements. Methylenetetrahydrofolate reductase (MTFR) catalyses the synthesis of 5-methyltetrahydrofolate which is required for homocysteine methylation. Dr. Rima Rozen, a collaborator, has isolated the cDNA of this gene and identified a polymorphic site with an allelic mutation frequency of about 35% and homozygosity frequency of about 12%. The MTFR in homozygotes has both reduced activity and heat instability, hence the name thermolabile MTFR. Using plasma homocysteine as a functional indicator, preliminary studies implied that the phenotypic expression of homozygosity for MTFR thermolability depends largely on folate nutritional status. When folate status is above the marginal state, plasma homocysteine concentration was low and was the same as that seen in individuals with similar folate status and normal (i.e. thermostable) MTFR genotype. However, when the folate status is low, homozygotes for MTFR thermolability exhibit a plasma homocysteine concentration which is twice as high as that seen in individuals with the same genotype but higher folate status and 50% higher than that seen in individuals with the normal genotype but same marginal folate status. This nutrient - gene - disease interaction is now at the forefront of research on diet and the prevention of heart disease, the number one cause of death in this country.

Folic acid is found in leafy green vegetables and some fruits. Scientists at the Western Human Nutrition Research Center (WHNRC) in San Francisco and at the UCLA School of Public Health, conducted a controlled study in which dietary folate equivalent to 12%, 100%, and 220% of the current Recommended Dietary Allowance (RDA) was fed to ten healthy men to determine the folate intake that would prevent elevated homocysteine. The study was carried out over 15 weeks on the live-in nutrition research unit at the WHNRC. Blood homocysteine and other analyses were performed at UCLA.

Nearly half of the men developed high homocysteine levels after four weeks on the low folate intake. Some high levels persisted even after two weeks on the 100% RDA intake, but all decreased to normal within nine days when the high intake was fed. The results show that elevated blood homocysteine levels can provide a sensitive measure of even moderate folate deficiency. The results also indicate that the current RDA for folic acid may not be sufficient to prevent elevated homocysteine levels that increase the risk of thrombotic type heart disease in the U.S. population. The RDA for folate was lowered in the last edition (1989) of the RDAs, from 400 to 200 micrograms per day. This research supports the position of some scientists that the current RDA for folate should be increased back to the previous level, and that increased folate supplementation of the U.S. diet should be considered (folate is now supplemented into some breakfast cereals).

DEVELOPMENT OF STABLE ISOTOPES FOR NUTRITION RESEARCH

Few discoveries in nature have enhanced scientific progress as have the stable isotopes. Examples of their utility can be found in all of the basic and biomedical sciences including the exponential growth of their use in basic NMR studies in chemistry and biochemistry. While the scarcity of heavy isotopes in nature is the distinctive feature that makes them valuable as tracers in biomedical research, the difficult and costly physical processes of separation of such scarce isotopes limited the availability of stable isotopes to biomedical scientists for several decades.

Foods Intrinsically labelled with Stable Isotope Tracers

The CNRC mission to study nutrient requirements in children not only involves a determination of absolute daily requirements, but also how these requirements can be supplied by the foods commonly consumed by US children. Food is a complex matrix, and our ability to absorb various nutrients in foods, as commonly consumed, is in great part dependent on the nature of that matrix. We know for instance that the degree to which certain minerals are absorbed in the gut (i.e. their bioavailability) can be decreased by various inhibitory compounds in that food. The ability to determine the percent of a nutrient requirement which can be provided by a particular food can be best achieved through studies involving foods which have labeled nutrients directly incorporated into them. The CNRC, therefore has developed a unique hydroponic facility for growing and labeling plants with stable isotopes. The recirculating hydroponic system enables a very efficient and controlled procedure for the root uptake of specific mineral elements and subsequent transport within the plant to an edible plant structure; the recirculating nature of this system also minimizes isotope use and thus provides labeled plant material as economically as possible. The generated food products are identical in nature and quality to field grown grains and vegetables, and are a safe and effective tool for determining nutrient bioavailabilities and for studying nutrient metabolism in children.

Soybeans have been labeled with a nitrogen isotope and the seeds processed into soy protein isolate. This will be incorporated into infant formula to provide a labeled protein source for the determination of amino acid requirements. Green beans have been labeled with a calcium and magnesium isotope and spinach and broccoli are being labeled with a calcium isotope; these have been and will be used to study the absorption of these minerals in teenagers. Plant culture methodology to incorporate iron isotopes into cereal grains and certain vegetables is being developed.

The Noninvasive Determination of Essential Dietary Amino Acids

The direct determination of dietary amino acid essentially has not been feasible in normal infants and children because the method used in animals requires the arrest of growth by a deficient diet before quantitative refeeding with individual amino acids. The dietary amino acids essentially is demonstrated by the return of normal growth. This approach distorts the normal requirement by superimposing the adaptive mechanisms of starvation. The use of foods uniformly labeled with a stable isotope of carbon has allowed studies of amino acid essentiality in normal infants. An edible alga was uniformly labeled by growth in an

atmosphere of pure $^{13}CO_2$. As a preliminary experiment, the labeled biomass was incorporated into a diet for a laying hen. As measured by mass spectrometry, the eggs and hen came to steady state isotope enrichment after 27 days of feeding the 99% ^{13}C labeled alga. The proteins from the eggs and the tissues of the hen were hydrolyzed and the ^{13}C enrichment of individual amino acids determined by gas chromatography/mass spectrometry.

The amino acids from the eggs and chicken showed two enrichment patterns, either complete preservation of the intact algal amino carbon skeleton or extensive degradation and resynthesis with unlabeled carbon. Similar distinct patterns were seen in tissue proteins. These patterns clearly distinguished the intact essential amino acids (e.g., phenylalanine) required in the diet from the random labeled unessential amino acids (e.g., glutamate) synthesized by the hen. This uniformly labeled algal protein has been used to determine the essential amino acid requirements of premature infants. When then applied to human infants, the approach showed that immature infants require dietary proline, an amino acid for building bone and tendons, which is not essential in the diet of normal adults

Use of Uniformly Labeled Metabolic Substrates in Neonatal Nutrition

The availability of substrates labeled uniformly with stable isotopes has made it possible to study directly a number of issues related to the status of metabolic pathways in human subjects, including human neonates. The ability to probe metabolic pathways in the latter population is particularly noteworthy since a number of important metabolic pathways are thought to be poorly developed in neonates, particularly prematurely born neonates. Examples of suspected metabolic delays that may influence the nutrient requirements of this population include low or absent activities of enzymes necessary for conversion of classically essential amino acids to classically non-essential amino acids (e.g., methionine to cysteine, phenylalanine to tyrosine), endogenous synthesis of classically non-essential amino acids (e.g., histidine, proline, arginine), and conversion of linoleic (18:2n-6) and linolenic acids (18:3n-3) to longer chain more unsaturated fatty acids (e.g., arachidonic acid (20:4n-6); eicosapentaenoic acid (20:5n-3); docosahexaenoic acid (22:6003). CNRC has addressed the last two issues and studies addressing the first issue are underway.

The principal underlying the studies of endogenous synthesis of classically non-essential amino acids is that these amino acids are derived from metabolites of glucose. Thus, glucose, uniformly labeled with ^{13}C and having a mass of 186 (i.e., m + 6), rather than mass 180, the mass of ^{12}C-glucose, when infused, mixes with the glucose pool and is metabolized resulting in metabolites with masses of m + 1, m + 2 and m + 3, all of which contribute to the carbon skeleton of endogenously synthesized amino acids. Thus, the presence of plasma of an amino acid with masses of m + 1, m + 2 and/or m + 3 indicates that the particular amino acid has been synthesized endogenously. Conversely, absence of ability to detect an amino acid with these masses suggests lack of endogenous synthesis.

Investigators at the CNRC have found that preterm infants cannot synthesis proline or cysteine (i.e., that proline and cysteine with masses other than m + 0 are not present in plasma following infusion of uniformly labeled ^{13}C-glucose). This suggests that these amino acids, which are considered "non-essential" for adults, are "essential" or "conditionally essential" for preterm infants. This finding with respect to cyst(e)ine is not surprising since the hepatic activity of cystathionase, a key enzyme in conversion of methionine to crysteine, is very low throughout gestation and for several weeks following term birth. However, this is the first direct

demonstration that this amino acid, which on the basis of the hepatic enzyme data is considered essential during infancy, cannot be synthesized endogenously (e.g., via cystathionase activity in other tissues). The finding that proline also may be an essential amino acid is new and has important implications for nutritional management of preterm infants, particularly the sizable percentage of this group who require parenteral nutrition for the first several days to weeks of life.

Another important issue in infant nutrition concerns the need to supplement infant formulas with long chain polyunsaturated n-6 and/or n-3 fatty acids. Because human milk contains these fatty acids, which are deposited in sizable amounts in the central nervous system and retina during development, whereas formulas contain only the parent 18-C fatty acids of each family and because breast-fed infants or infants fed human milk have more long chain polyunsaturated fatty acids in plasma and erythrocyte lipids than formula-fed infants, it has been argued that infants cannot effectively desaturate and elongate the parent fatty acids and, therefore, that formulas should be supplemented with long chain polyunsaturated fatty acids. This argument is supported by observations that human milk and formulas supplemented with marine oil (long chain polyunsaturated n-3 fatty acids) appear to confer at least transient benefits with respect to visual development and, perhaps, neurodevelopmental outcome of preterm infants. However, the need for supplementation of formulas is far from clear and the type and/or amount of supplementation needed, if any, is even less clear. Further, virtually no information is available concerning the need to supplement term infants whose plasma lipid fatty acid patterns resemble those of preterm infants.

The principal of this method is that the uniformly labeled precursors with a mass of m + 18, if desaturated and elongated to 20 and 22 carbon fatty acids, will result in 20 and 22 carbon fatty acids with a mass of m + 18. These 20 and 22 carbon fatty acids are synthesized by infants from the parent fatty acids. As the enrichment of the uniformly labeled ^{13}C-18:2n-6 and C-18:3n-3 decrease, the enrichments of both m + 18 arachidonic acid (20:4n-6) and m + 18 docosahexaenoic acid increase. This is the first conclusive, direct demonstration that infants can convert 18:2n-6 and 18:3n-3, respectively, to 20:4n-6 and 22:6n-3.

Additional information derived from these studies include:

(1) both preterm and term infants can desaturate and elongate 18:2n-6 and 18:3n-3 to longer chain more unsaturated fatty acids;

(2) conversion ability does not increase as the infants become older; and

(3) a dietary 18:3n-3 intake of 4% vs. 1% inhibits conversion of 18:2n-6 to 20:4n-6 and results in formation of more 22:6n-3

It should be noted that the pathway by which 20:4n-6 and 22:6n-3 are synthesized endogenously is complex. In animals and cell systems, it is characterized by precursor competition for desaturation and elongation as well as by product inhibition. Clearly, a number of these issues must be further clarified in the human infant. The availability of uniquely labeled precursors and products, as described above, will be invaluable in unraveling the details of pathway and defining how best to supplement infant formulas with these potentially important fatty acids.

FOOD COMPOSITION RESEARCH AND NEW NUTRIENTS

In order to correctly ascertain the nutrient intake of individuals as well as subgroups within the general population, an accurate database of the nutrients that are found in foods is necessary. Having such information is essential in meeting the requirements for nutrition labeling which necessitates reliable methods for the rapid and accurate analysis of food. In addition, the information obtained from such analyses is needed to make decisions regarding dietary recommendations, to provide information regarding nutrition education, and eventually, decisions regarding agricultural production and food processing.

The Food Composition Laboratory of the BHNRC is a unique facility that develops new and improved methods of food analyses as well as improved instrumentation that aids in the analysis of nutrients. Scientists in the laboratory have developed a graphite furnace atomic absorption spectroscopy instrument that allows the sensitive determination of very low levels of trace elements. At the request of the food industry, a method was developed for the determination of lead in sweeteners, a measurement for which adequate methods did not exist previously. The method that was developed has been adopted as the official method for this type of analysis. It is very sensitive and can measure lead at the level of 100 parts per billion of food.

Additional experimental work by scientists in the lab have extended the usefulness of the graphite furnace technique by making changes in instrumentation that allow for the simultaneous analysis of up to eight different trace elements in a single sample of food. This allows for the rapid and reliable analysis of a large number of nutrients in a short period of time. This technology has been licensed to the Perkin-Elmer Corporation who continues to work with ARS scientists under a Cooperative Research and Development Agreement.

In addition to the refinement of methods of analysis of known nutrients, the Food Composition Laboratory is actively engaged in the development of analytical methods for the analysis of so called "new nutrients". This term refers to components in foods whose biological role is yet to be determined. Scientists in the Food Composition Laboratory have developed the methods to measure over twenty different carotenoids. The carotenoids are a class of pigmented chemicals that are found in fruits and vegetables. Many of the carotenoids function as antioxidants and several serve as a dietary precursor to vitamin A. There is increasing evidence to suggest that these compounds may be important dietary components that are needed in the diet. Using the methods they have developed, scientists in the Food Composition Laboratory have published the only available database of the carotenoid content of foods. Scientists can now study the relationship between carotenoid intake and risk factors for diseases such as heart disease and cancer. The Food Composition Laboratory is actively collaborating with the National Cancer Institute and the National Heart, Lung, and Blood Institute to continue to develop methods for the analysis of additional carotenoids. Scientists at other laboratories within the BHNRC have started human studies to evaluate the dietary importance of the carotenoids. Elsewhere in ARS, scientists have developed new varieties of carrots and tomatoes that have increased content of carotenoid and if the carotenoids are found to be beneficial in terms of nutrition, these varieties can be made available to the consumer who can benefit from the increased nutritional value.

Recent work has suggested that some carotenoids, such as beta-carotene, provide antioxidant protection because they can neutralize reactive oxygen species that cause damage associated with initiation of cancer, heart disease and cataracts. The WHNRC conducted a carotenoid depletion study in healthy women to determine the effects on measures of body oxidative (free radical) damage. Nine young adult women were fed a low carotenoid diet (containing little or no colored fruits and vegetables) over 3-1/2 months on the WHNRC metabolic unit. Beta-carotene was added back into the diet during the last month. Sophisticated measures of oxidative damage and defense were made in blood plasma and red cells, in collaboration with scientists at the University of California at Davis, the UCLA School of Public Health, the University of Nevada at Reno, and the Centers for Disease Control and Prevention in Atlanta. Measures of antioxidant protection were diminished during carotenoid depletion while oxidative damage measures, such as oxidation of cell membrane fatty acids, increased. Supplementation with beta-carotene during the last month reversed these trends. These results suggest that dietary carotenoids provide benefits beyond their role as vitamin A precursors. This research provides the first evidence from a well-controlled human nutrition experiment that carotenoids are utilized for antioxidant protection and that oxidative damage is increased when they are not included in the diet. This observation may help to explain the strong associations of increased fruit and vegetable intakes with decreased incidence of chronic degenerative diseases.

Food components also act to detoxify harmful materials consumed. The effects of dietary broccoli on the body's ability to detoxify were studied in 18 adult males by measuring the major urinary conjugation products, mercapturates, sulfoconjugates, glucuronides, and amino acid conjugates. After several days of consuming a semisynthetic diet to establish baseline endogenous levels, subjects continued receiving the semisynthetic diet with added broccoli at 250 g/d for three days followed by 500 g/d for another three days. A significant increase in urinary mercapturates and sulfoconjugates was observed with added broccoli, but no significant influence was noted for glucuronides or amino acid conjugates. A significant linear trend for mercapturate excretion was dose-dependent. Although an unexplained decrease in sulfoconjugates was observed the first day of consuming broccoli, within the six day broccoli dietary treatment a continuous increase was noted. The sulfoconjugate excretion did appear to be dose-dependent. Overall, of the four detoxification pathways studied, the level of urinary mercapturates is the most responsive to dietary broccoli and, consequently, mercapturate excretion would appear to more closely reflect exogenous rather than endogenous compounds.

THE NONINVASIVE DETERMINATION OF ENERGY COST OF NORMAL GROWTH

Atwater (1844-1907), the first director of the USDA Office of Experiment Stations built the first US human calorimeter in order to measure human carbon oxidation. In 1899 he calculated the energy conversion factors used today: 4,8.9, and 4 kcal per gm of dietary protein, fat and carbohydrate. His methodology required the experimental subject to dwell in a 4 by 8 foot room for many days. Although it is of extreme programmatic importance to know the energy requirement for normal growth, it is not feasible to do this type of space constrained study with infants and young children. The development of an alternate unenclosed method of measuring carbon oxidation has allowed CNRC scientists to determine the energy expenditure of free-living subjects and to calculate the energetic cost of normal growth. The procedure uses water labeled with the stable isotopes of hydrogen (^2H, deuterium) and oxygen (^{18}O). The labeled water is administered in a precise dose and breath vapor or urine samples taken at timed intervals. After equilibration with body water, the deuterium label declines only as a function of water intake and dilution. The oxygen

isotope label declines at a faster rate as a function of water intake and dilution and of the transfer of ^{18}O from body water to $C^{18}O_2$ through the action of the enzyme carbonic anhydrase. Thus, the difference in rate of loss of consumption (*i.e.*, energy expenditure) through the respiratory quotient (R.Q). The method has been validated in adolescents and adults using CNRC room calorimeters (in general concept identical to but using instrumentation a century advanced over the Atwater calorimeter.) Using the isotope method CNRC has firmly documented that it requires 23 kCal for every gm of weight gained. This is three times the kCal stored as new tissue. We have also determined that a 27% greater intake of energy by formula fed infants is not associated with the cost of growth or increased fatness. This apparent violation of Lavoisier's 200 year old law of chemical equivalence by formula fed infants is explained by increased total energy expenditure and not by body mass growth. The CNRC is now studying the energy cost of adolescent growth using the double isotope methodology. The unique diet and activity patterns of normal US teenagers make it almost impossible to otherwise assess the energy expenditure and growth of adolescents. The center is in the early stages of extending these investigations to the energy cost of superimposed fetal growth in pregnant growing adolescents.

NUCLEAR PROPERTIES AS A BASIS FOR DETERMINING BODY COMPOSITION IN HUMANS

The successful transfer of nuclear technologies developed in the last two decades into the life sciences has allowed us to develop accurate assessment of human body composition at the most fundamental chemical level. These are direct in vivo (nondestructive) analytical chemical assays for the body content of potassium, calcium, sodium, chlorine, phosphorus, nitrogen, hydrogen, carbon, and oxygen (which added together represent more than 99% of body weight). Development and improvement of these basic physics techniques, especially for nitrogen, carbon and oxygen, as accurate tools for nutritional assessment in the individual are part of the CNRC effort.

These techniques take advantage of the unique physics or characteristics of each element, whether a natural property as in the case of potassium (^{40}K),
or induced when the body is placed in a very weak x-ray or neutron beam.
The x-rays are used to determine the absorptiometric or mass attenuation properties of the tissues, while the nuclear capture, excitation and decay properties of the natural stable isotopes of an element are the basis for the neutron activation measurements. In parallel, CNRC is examining the changes in bioelectrical properties of the body during growth as a function of these chemical compositional mappings. While not stable isotope methods, these techniques complement the dynamic data obtained using the non-radioactive tracers of different nuclear mass with information on the body's elemental metabolic milieu obtained using the non-radioactive tracers of different nuclear mass with information on the body's elemented metabolic milieu obtained by use of the activity properties of the nucleus.

There are several models of human body composition; the one that partitions the body into its water, protein, mineral, and fat compartments is probably the most often used for nutritional studies. Previously, the most basic knowledge of body composition was based, in large part, on the chemical composition of these tissues. Prior reference data for humans, nevertheless, was very limited. For example, information is available from about 20 fetuses and pre-term infants and only eight adult cadavers dating back to more than 80 years. Similar information has been reported for only one child, age 4 1/2 years. Although these fundamental data are invaluable in establishing nutritional requirements, especially for growth and aging, the nature of

classical wet chemistry techniques makes them difficult to perform with any reasonable analytical precision and required the complete destruction of the body, both of which will preclude any future attempts.

The non-invasive nuclear methods, however, have now permitted study of both cross-sectional and longitudinal changes in body composition in children to provide, for the first time, accurate assessment of the relationships between lean tissues (skeletal muscle and visceral development), mineral accretion (bone growth) and fat accumulation during growth for boys and girls of white, black, and Hispanic populations. To date, CNRC has measured body composition in more than 400 children.

Other methods for the evaluation of body composition including fat-free body mass, fat mass, percent body fat, and body fluid volumes have been validated by scientists at the Western Human Nutrition Research Center (WHNRC). One technique is that of total body electrical conductivity (TOBEC). TOBEC is an easy, rapid, and reliable method that has been validated against standard laboratory procedures for individuals ranging in age from 9 to 90 years including lean and obese people. In addition to the TOBEC research, scientists also have been involved in the validation of a portable instrument, bioelectrical impedance analysis (BIA), for the rapid estimation of fat and fat-free mass. This particular technique has been added to the procedures included in the National Health and Nutrition Examination Survey (NHANES) III for body composition assessment. The most recent advances, however, have taken place with multiple frequency bioelectrical impedance spectroscopy (BIS). Scientist at the WHNRC in conjunction with Xitron Technologies, worked on the validation of this method. It allows for the rapid non-invasive measurement of both intra- and extracellular fluid compartments. Cooperative research done by WHNRC researchers and scientists at the University of California at Berkeley and the CNRC documented the successful use of this technique for monitoring fluid changes in women during pregnancy. This method has potential for widespread application in the clinical sphere, such as in edema, hemodialysis, ascites, and liver disease, where decisions about treatment may depend upon rapid and accurate assessment of changes in fluid balance.

CHANGES IN DIET AND METABOLIC PROCESSES DUE TO CHANGES IN THE FOOD SUPPLY

Within the Diet and Human Performance Laboratory of the Beltsville Human Nutrition Research Center (BHNRC), scientists are studying a substitute for fat called Oatrim. This high fiber material was developed within ARS at the National Center for Agricultural Utilization Research in Peoria, Illinois. Oatrim consists of amylodextrins, which are short fragments of starch and beta glucans, the principal fiber in oats. It has been licensed to several food companies and has been used in a number of commercially available low fat foods.

A study of 24 volunteers was conducted to test the effects of the replacement of fat in foods with Oatrim. Over the 11 week period of the study, the participants lost an average of 4.5 pounds even though the calorie content of the Oatrim diet was the same as the control diet. The Oatrim seemed to add bulk to the diet and this resulted in a greater sense of satiety in the volunteers. In addition, the cholesterol and LDL levels of the Oatrim fed group decreased significantly while the level of the beneficial HDL did not change. Such changes might have been expected since oat fiber is known to sequester bile acids in the lumen of the intestine and thereby remove cholesterol from the enterohepatic circulation. Advantageous changes were also noted in the level of blood glucose and the body's response to insulin. The mechanism of this effect is

not known at this time and is under further study at the Beltsville Human Nutrition Research Center. Thus, Oatrim as a substitute for fat in food recipes appears to be a very desirable change.

The greater use of vegetable oils has been advised by nutritionists for years. The processing of vegetable oils often involves hydrogenation, a chemical process that causes physical changes in oils and enhances their use in a wide variety of foods. During hydrogenation, a portion of the fatty acids is converted to "trans isomers" where the special arrangement of the atoms around the double bond differs from that of the native fat. Until recently, most nutritionists believed that the trans fatty acids did not have detrimental effects.

With the partial support of the Institute of Shortening and Edible Oils, Inc., the Diet and Human Performance Laboratory of the BHNRC fed 58 subjects diets of various fatty acid composition for 6 weeks per diet. It was found that trans fatty acids caused an elevation of total and LDL cholesterol while the level of HDL cholesterol did not change at the level of trans fatty acid intake approximating the average daily intake in the U.S. diet. This rise in the level of cholesterol was lower than what was observed for the feeding of an equivalent amount of saturated fatty acids, or fats of predominantly animal origin, in the diet. Thus, the trans fatty acids were intermediate between naturally occurring vegetable oils and saturated fats in terms of risk factors for heart disease. The mechanism of these effects is unknown. Possible mechanisms include the incorporation of the trans isomers into cellular membranes that results in a change in the signal transduction mechanism that is responsible for hormone action or alternatively, there may be differing abilities of the cis and trans isomers to act as substrates for the enzymatic pathways that are responsible for the metabolism of the fatty acids. These results suggest that additional studies on the effect of trans fatty acid are needed. The understanding of their effects is important to the edible oil industry, soybean and oil seed producers, regulatory agencies, nutritionists and consumers.

Additional insight into the mechanisms may be related to regulation of fatty acid traffic. It has been known for over 20 years that intestinal epithelial cells contain high levels of two related but distinct fatty acid binding proteins (FABP), called I-FABP and L-FABP (the former is found only in the intestine, the latter is also found in the liver). The precise functions of these proteins are not known, nor is it known why epithelial cells contain two separate FABP. Using purified I-FABP and L-FABP, researchers in New Jersey identified large differences in the mechanism by which these two proteins transport fatty acids to membranes. Although both FABP bind fatty acids similarly, the rate of transport of the fatty acids to a membrane acceptor is 2 to 5-fold faster for the I-FABP than the L-FABP. Moreover, transfer of fatty acids from I-FABP appears to occur during direct collisional interaction of the protein with the membrane, whereas transfer of fatty acid from L-FABP occurs by dissociation of the fatty acids and diffusion through the aqueous phase to the acceptor membrane. These results suggest two very different functions for these related proteins. L-FABP may serve as a reservoir for fatty acids in the intestinal cell, providing precursors for triglyceride synthesis and preventing the potentially toxic buildup of unbound fatty acids. I-FABP, on the other hand, may serve as a more specific role in the targeted delivery of fatty acids to sites of metabolic utilization on membranes.

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I

Divider Title: _____

Research and Development at EPA: A New Beginning

Presentation to the

Science Leadership Exchange

Office of Science and Technology Policy

Robert J. Huggett, Ph.D.
Assistant Administrator for Research and Development
U.S. Environmental Protection Agency

March 28, 1995

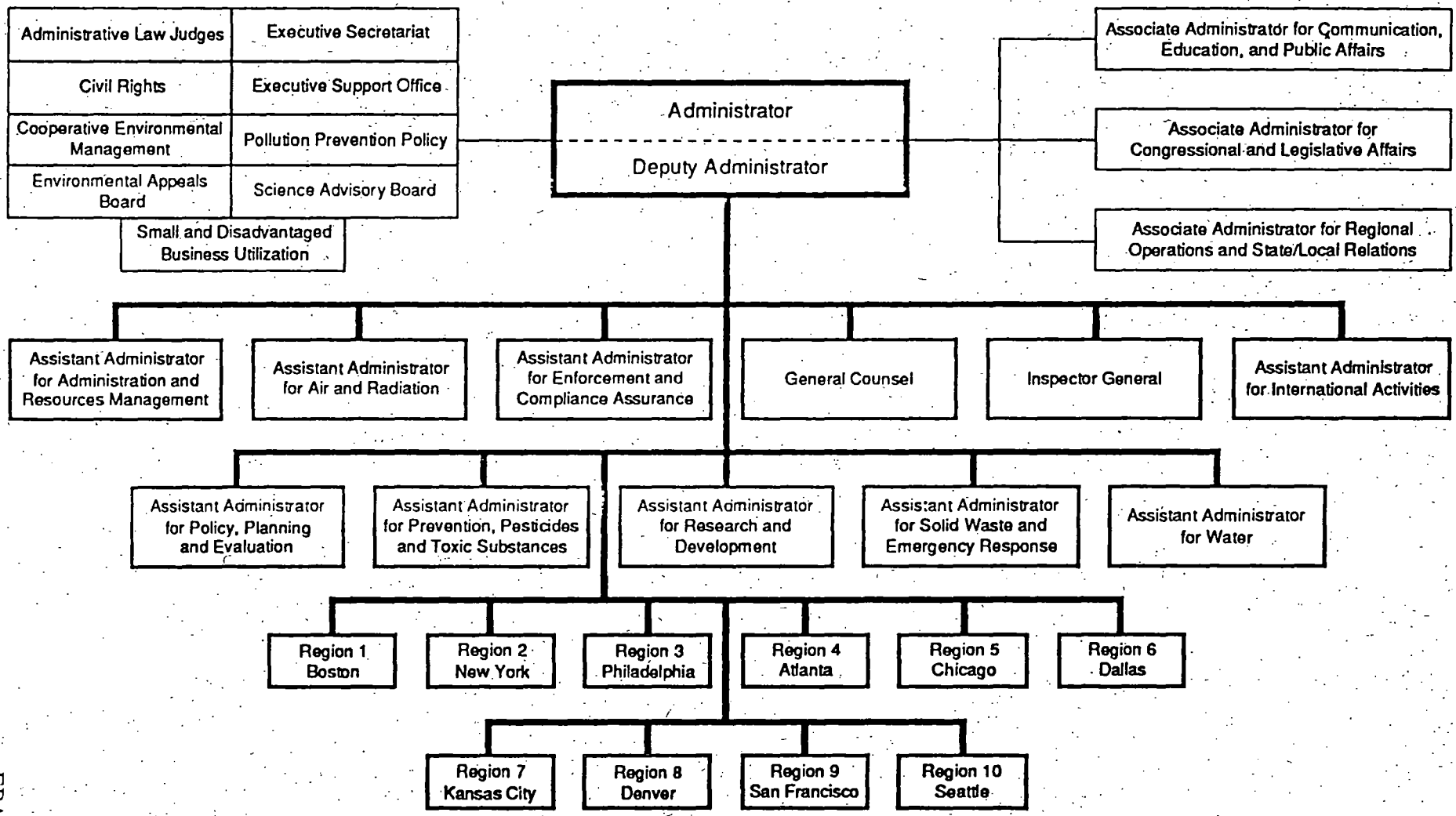
Context for Research at EPA

- **EPA mission**
  - Improving and preserving the environment in the U.S. and around the globe
  - Working with partners to protect human health, ecosystems, and the beauty of the environment, using the best available science
  - Promoting innovative solutions to environmental problems
  - Protecting and sustaining the productivity of natural resources

- **Research coordination/cooperation with other federal agencies**
  - e.g., through NSTC Committee on Environment and Natural Resources

Mission statement from "The New Generation of Environmental Protection: A Summary of EPA's Five-Year Strategic Plan"

U.S. Environmental Protection Agency



EPA Strategic Directions

- **Ecosystem Protection**
  - EPA will focus on an ecological approach to environmental protection that takes into account economic development issues and environmental sustainability.
- **Environmental Justice**
  - EPA will work to assure that individuals and communities are treated equitably under environmental laws, policies and regulations, and that the benefits of environmental protection are shared by everyone in the society.
- **Pollution Prevention**
  - EPA will prevent pollution by incorporating prevention into all of the Agency's environmental programs. EPA will work to anticipate and address future environmental issues before they become problems.
- **Strong Science and Data**
  - EPA will employ the best possible science, invest strategically in research and development for the future, and foster a productive dialogue with the public about science and risk. To be credible and effective, EPA policies, programs and actions will be based on sound data and research from both the traditional sciences and the social sciences, such as economics and sociology.

EPA Strategic Directions (cont'd)

- **Partnerships**
  - EPA will work in partnership with its stakeholders -- federal, state, and local agencies, tribes, private industry, public interest groups and citizens -- to develop the technology and capacity for carrying out environmental programs and policies, using common sense, innovation and flexibility.
- **Reinventing EPA Management**
  - EPA will strive to make itself known as the best managed agency in the federal government. EPA will seek to: manage for better results; streamline its programs; and use savings to strengthen existing programs and invest in emerging high risk issues. Employee development, empowerment, and diversity will be emphasized.
- **Environmental Accountability**
  - EPA will develop integrated enforcement and compliance strategies for targeting non-complying sectors of the regulated community. Compliance assistance approaches, emphasizing provision of information and education, will be coupled with a strong deterrence-based enforcement program.

• The Administrator is also emphasizing the need for new policy frameworks, such as a place-based approach to ecological protection and an industry sector approach to environmental regulation.

ORD Mission & Organization

Mission

As the primary scientific arm of EPA, which is the only federal agency with a broad environmental charter, ORD's mission has three components:

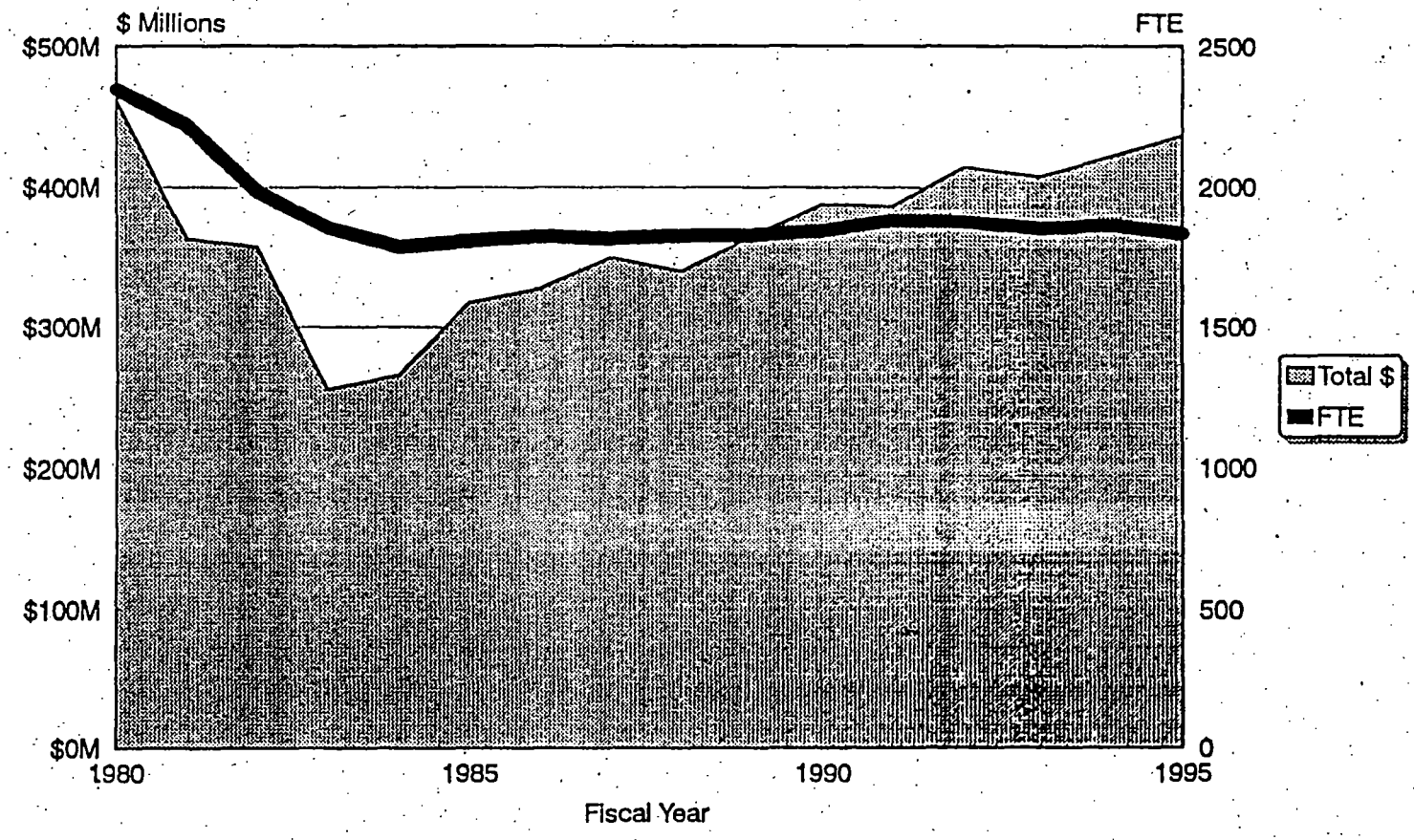
- Conducting research in support of effective policies and regulations for environmental protection;
- Integrating technical and scientific knowledge to provide scientifically sound advice for EPA's programs; and
- Providing national leadership for environmental science and research.

(still under discussion as part of restructuring)

Current Organization

- Twelve laboratories and four assessment offices
- 2137 intramural personnel
- President's FY 1996 budget request of $386 million in extramural resources (total budget, including salaries, etc., is $629 million)

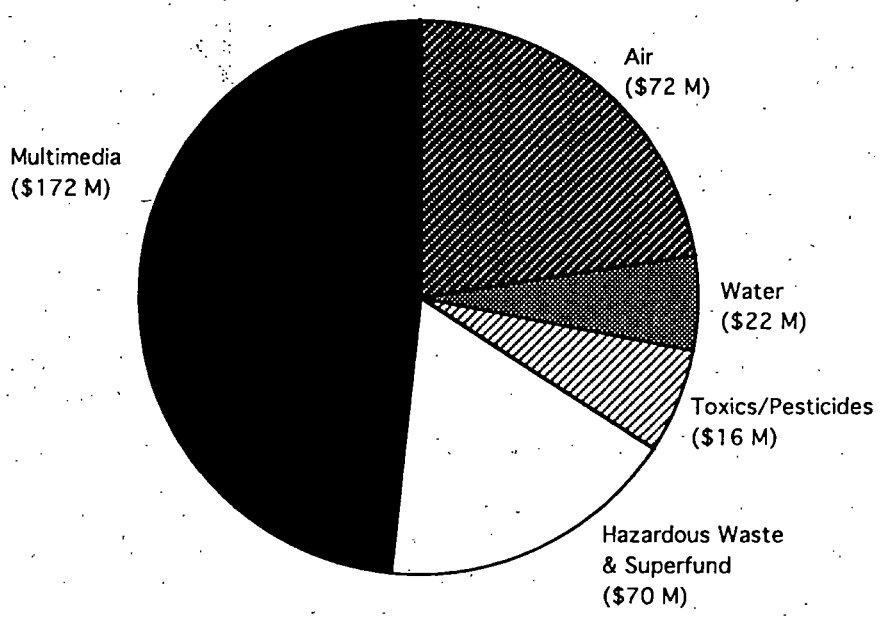
ORD Budget History
(Total Resources)



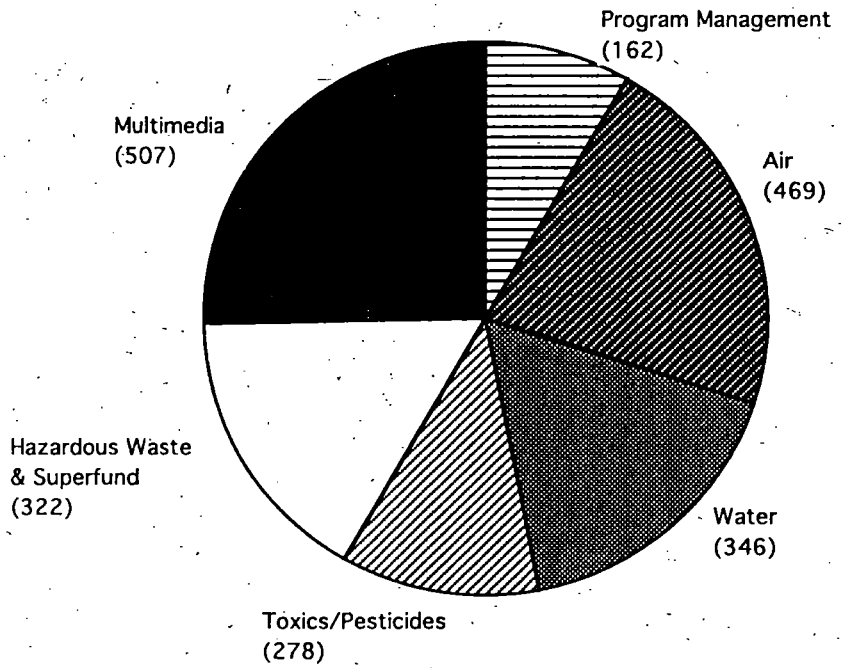
Resources shown in constant 1987 dollars

ORD FY 1995 Budget (Current Estimate)
(Breakdown by Media)

Extramural Resources ($351 M)



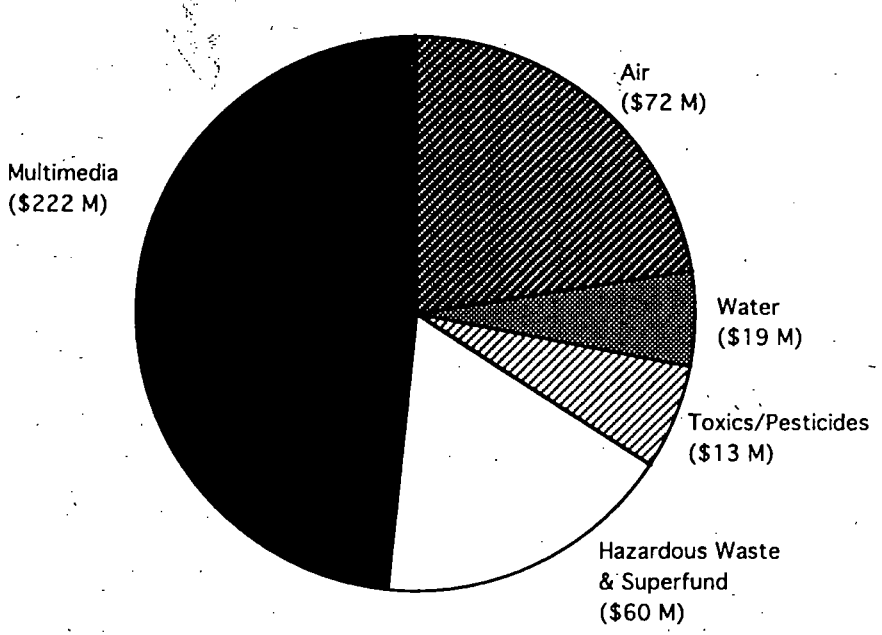
Personnel (2142 FTE)*



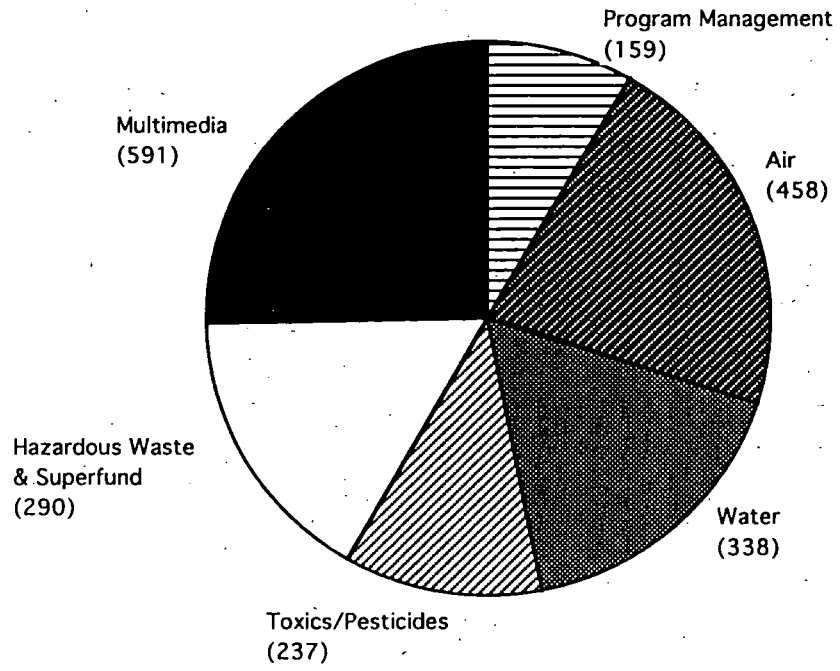
* *Includes 59 Reimbursable FTE*

ORD President's Budget for FY 1996
(Breakdown by Media)

Extramural Resources ($386 M)

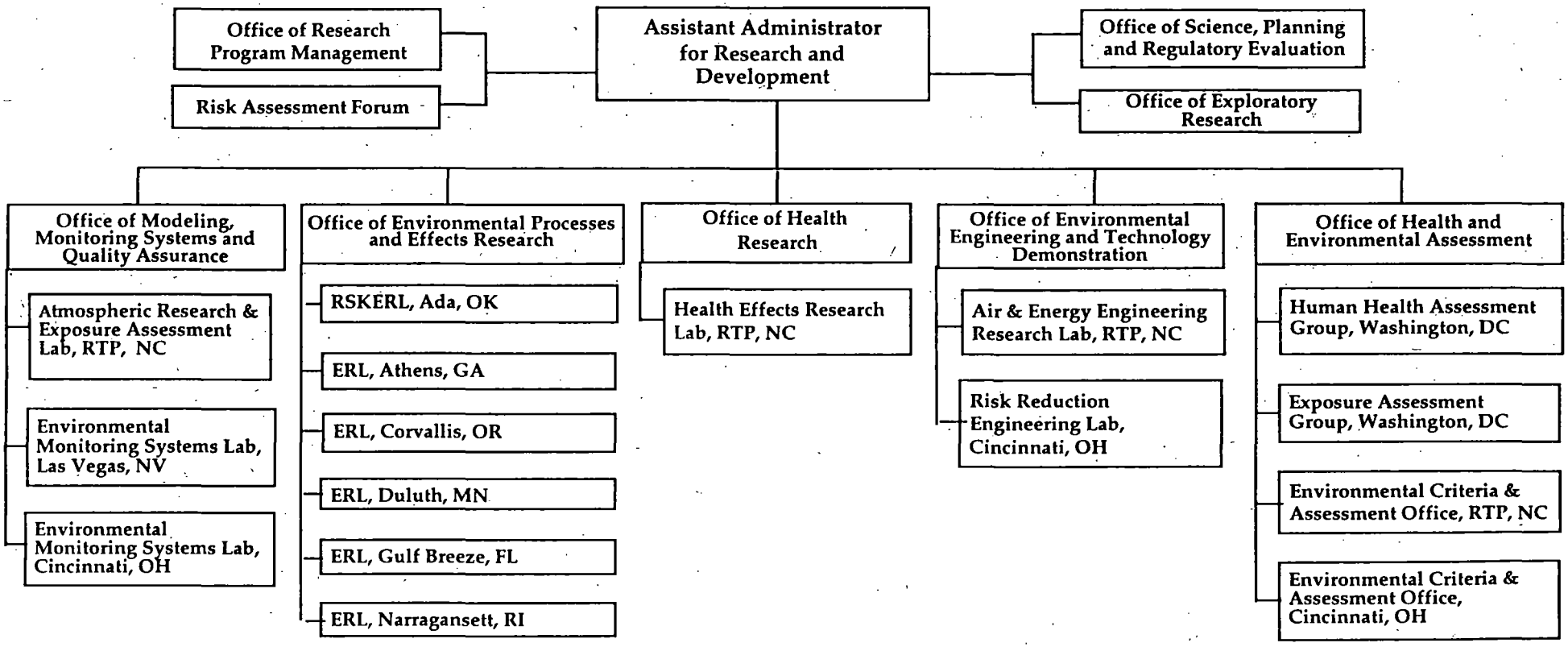


Personnel (2137 FTE)*



* *Includes 59 Reimbursable FTE*

Current Office of Research and Development Organization Chart



New Directions: Restructuring and Streamlining

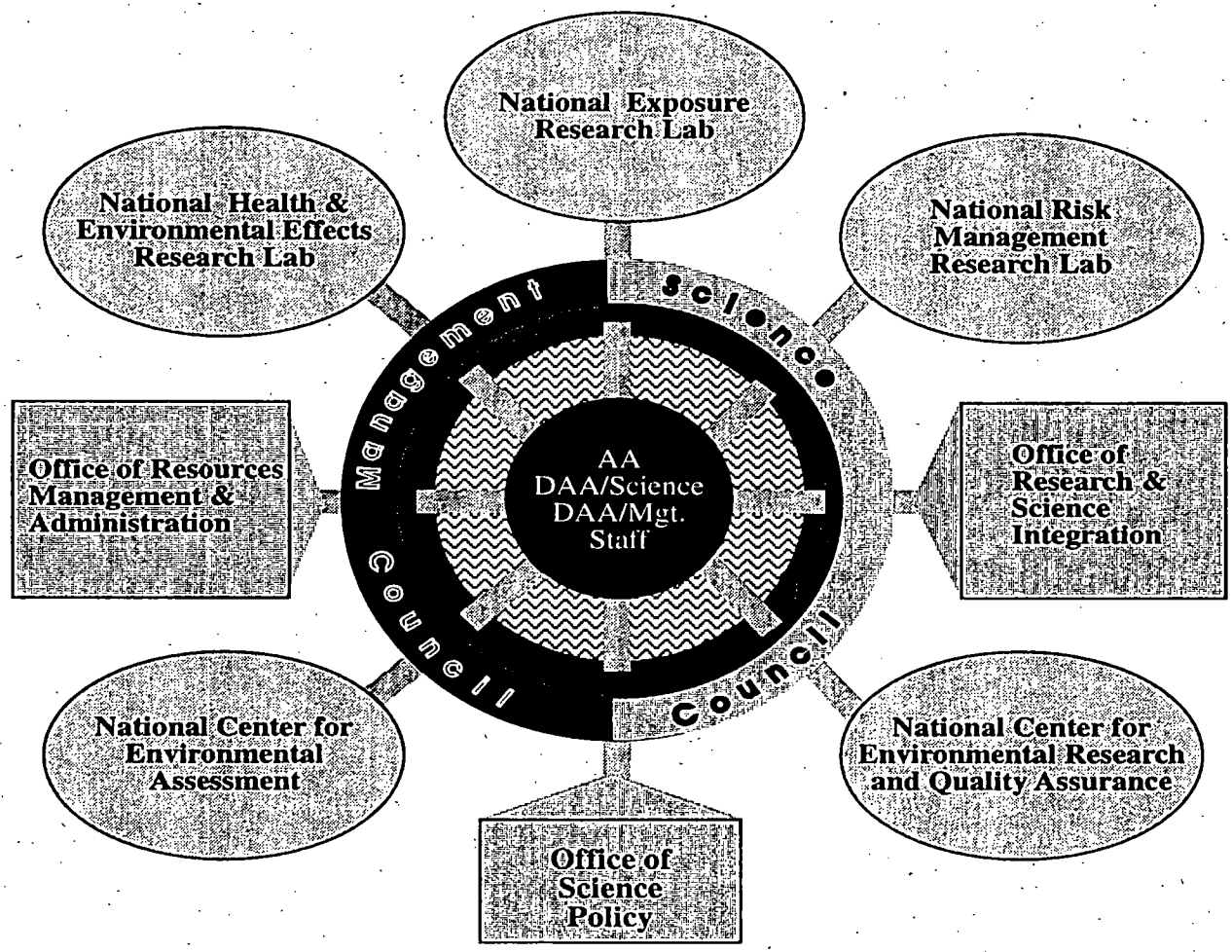
- **Reorganizing current laboratories based on the risk assessment/ risk management paradigm:**
  - National Health and Environmental Effects Research Laboratory
  - National Exposure Research Laboratory
  - National Risk Management Laboratory

  - National Center for Environmental Research and Quality Assurance
  - National Center for Environmental Assessment

- **Decentralizing research management and administration and streamlining headquarters**

- **Strong client office participation in priority-setting and planning**

Proposed ORD Reorganization



New Directions:
Science to Achieve Results (STAR) Program

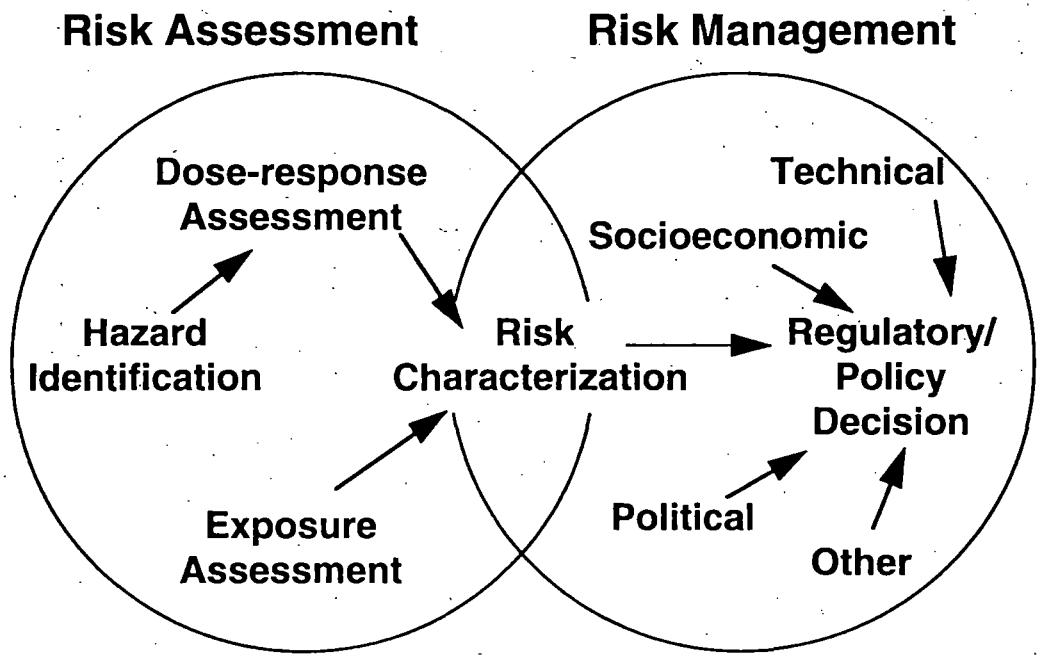
- **Vigorous research grants program**
  - To support the Nation's best environmental scientists
  - Grants program doubling in FY 1995
    - » working with EPA program offices to target key areas
  - Goal is to reach an annual $100 million funding level by 1997
  - Partnership with NSF

- **Graduate student fellowship program**
  - To train next generation of scientists and engineers
  - Solicitation issued for graduate fellowships available to students nationwide, through a competitive process
  - 100 awards in FY 1995, with goal of 300 fellowships in 1997

New Directions:
Strengthening ORD Lab Research Programs

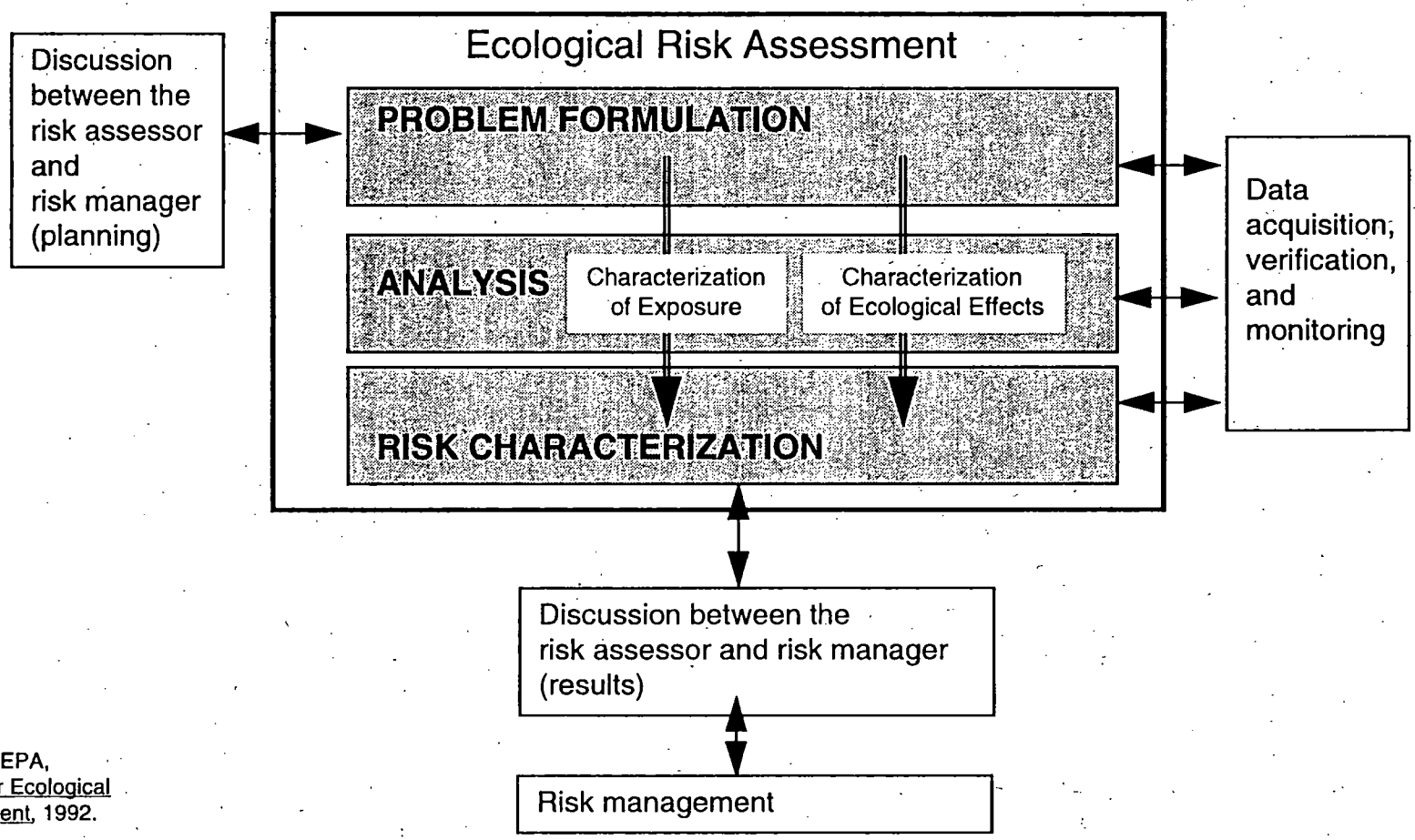
- **Various management initiatives to get more scientists doing science**
  - strengthen in-house science, spend less time on administrative tasks
- **Developing intramural "grants" program**
  - ORD scientists to develop proposals and compete for funding
  - Peer review process same as for extramural grants
- **Balancing long-term/short-term research**
  - Change research balance to 50% long-term, 50% short-term
  - Focus short-term research on clearly supporting applied research and implementation needs of the media programs and regions
- **Strengthening and expanding use of peer review**
  - Grant program peer review with NSF
  - Revised product peer review procedures
  - Strengthening peer review throughout ORD, e.g., lab site reviews

New Directions:
Using the Risk Framework



- **ORD will give priority to research that will have the greatest impact on reducing uncertainties in risk assessment, and facilitating risk management.**

New Directions:
Ecological Risk Assessment Framework
(some changes from original health effects paradigm)



Adapted from EPA, Framework for Ecological Risk Assessment, 1992.

Example research priorities*
with potential for reducing uncertainties in risk assessment

- Hazard assessment
  - biological basis for toxicity
  - non-cancer effects of toxic materials
  - individual and interspecies variability in susceptibility
- Exposure assessment
  - contaminant release rates from sources
  - abiotic processes that control transport, persistence and bioavailability
  - diagnostic methods and biomarkers for exposure
- Risk characterization
  - integration of hazard, dose-response, and exposure in complex cases (e.g., ecological assessments, mixtures, cumulative exposures)
  - methods for both qualitative and quantitative aspects of uncertainty analysis need to be applied to risk assessment, and included in risk characterizations

*Excerpted from CENR Toxics Substances and Hazardous and Solid Waste Research and Development Strategy

Example research priorities*
with potential for facilitating risk management

- Pollution prevention
  - pollution prevention options and clean technologies
  - life cycle analysis tools
- Control research
  - Low cost, innovative control technologies for air pollution control, water and wastewater treatment
  - Watershed management approaches for sewage sludge, stormwater discharges, nonpoint source pollution
- Remediation and restoration
  - Field evaluations of performance and cost of remediation technologies
  - Bioremediation and in-situ remediation technologies
- Monitoring methods
  - Rapid, cost-effective field screening techniques for contaminants
  - Innovative subsurface characterization and monitoring methods

*Excerpted from CENR Toxics Substances and Hazardous and Solid Waste Research and Development Strategy

Research Program Example 1:
Drinking Water Research

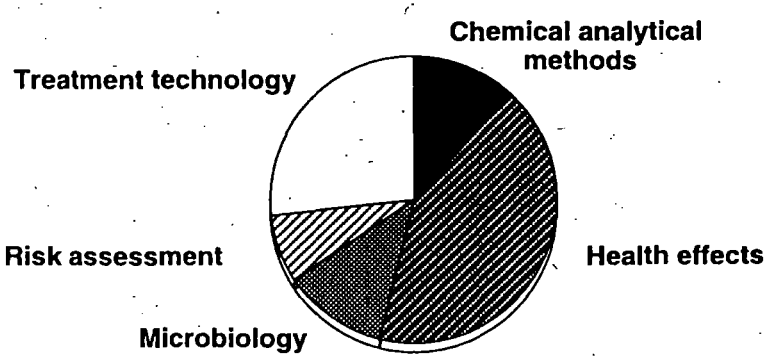
Providing the scientific and technical basis for :

- Phase VIb Chemical Contaminants Rule
- Disinfection/Disinfection By-Products Rule
- Ground Water Disinfection Rule

Research Objectives

- Provide methods for identification and measurement of pollutants --chemicals and disinfection by-products
- Develop data on hazards and risks associated with exposure to alternative disinfectants and disinfectant by-products
- Conduct research and quantitative comparative assessments of the risks associated with exposure to chemicals
- Reduce or minimize risks through control technology and alternative treatment
- Develop innovative cost-effective methods to screen for potential new hazards and pollutants

ORD Program



$5.2M in FY 94

Research Program Example 2:
Indoor Air Pollution Research

Three Major Goals

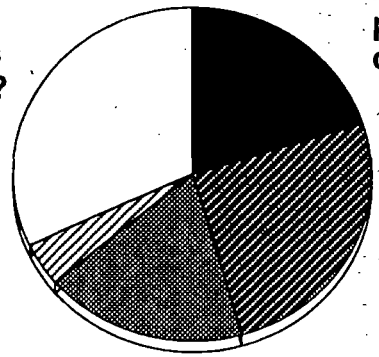
- Improve scientific understanding of indoor air health risks and the effectiveness of risk reduction strategies
- Provide scientific information to EPA program offices and regions
- Promote private sector involvement in addressing indoor air problems

Source Characterization

What are the emissions from indoor air pollutant sources, and how do they contribute to human exposures?

Solutions

What are the most cost effective strategies to prevent or control indoor pollution?



Exposure Assessment

How many people are exposed to what levels of indoor pollution?

Risk Assessment

What are the likelihood and magnitude of health risks associated with indoor air pollution?

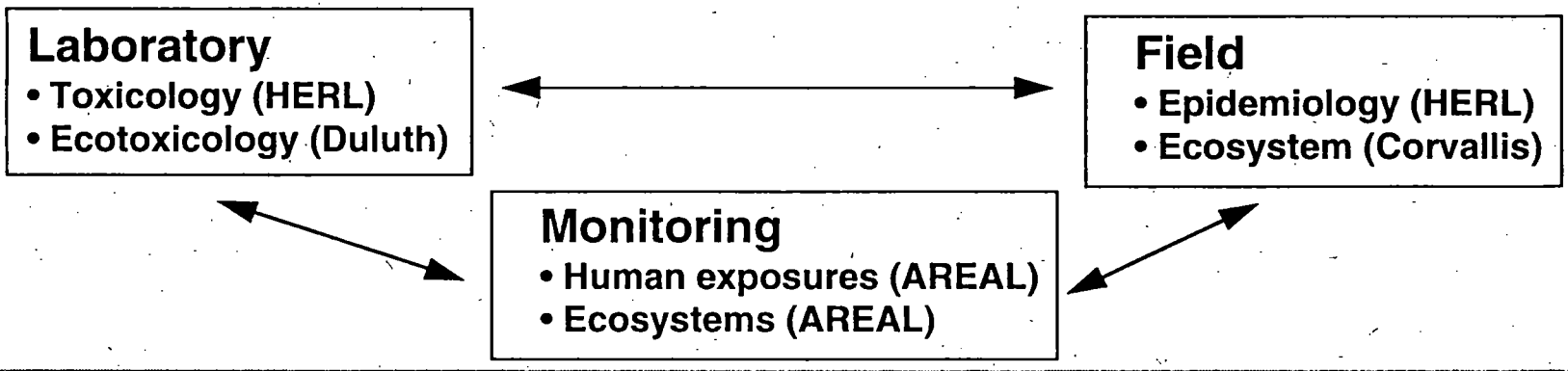
Health Effects

What is the relationship between indoor exposure and adverse health effects?

$7.5M in FY 94

Emerging Issue Example:
Endocrine Disruptors

- Research questions
  - Are persistent environmental pollutants responsible for endocrine-related effects reported in wildlife and humans?
  - What is the extent of the problem?
- Research strategy being developed
  - involving other federal agencies (e.g., NIEHS) and private sector researchers (e.g., CMA)
  - coordinating with EPA programs (Air, Water, Pesticides/Toxics)
  - coordinating with Canada and U.K. efforts
- Multi-disciplinary approach
  - with linkages within and between study components



Strategic Vision
(3 -year transition)

ORD Program	94	95	96	97	Goal
Fellowships	1	+5	+5	+5	$15M program 300 fellowships
Extramural Grants	22	+22	+42	+14	$100M program
Intramural Competition for L-T Research Projects	0	+	++	+++	All L-T research conducted at ORD labs competed
New Research Focus	*Examples:* *endocrine disruptors* *risk assessment methods* *drinking water*				Shift program to high risk/high uncertainty
Long-term Research	30-35%			50%	50% L-T / 50% S-T balance achieved
Short-term Research	65-70%			50%	

Summary of New Directions

- Organizational restructuring and streamlining
- Greater extramural science participation
- Expanded use of peer review
- Responsive to program and regional office needs, with appropriate balance of long-term and short-term research
- Risk as the framework for priority-setting

Issues for EPA R&D Programs

- **Strengthening role of science at EPA**
  - Peer review
  - Analysis of costs and benefits
  - Science in development of regulations (e.g., risk characterization)

- **Redesign of research programs**
  - Tension in providing support to specific programs and R&D on underlying science questions
  - Balance between health and ecology R&D
  - Appropriate mission for "risk management" research

- **Strategic planning**
  - Will complete a new strategic plan by late Summer 1995
  - Have worked closely with EPA programs to identify needs
  - Using National Research Council Task Force to help guide ORD

NATIONAL RESEARCH COUNCIL

NEWS

NATIONAL ACADEMY OF SCIENCES NATIONAL ACADEMY OF ENGINEERING INSTITUTE OF MEDICINE

Office of News and Public Information • 2101 Constitution Avenue, N.W., Washington, D.C. 20418 • (202) 334-2138

Date: March 16, 1995
Contacts: Lee Tune, Media Relations Associate
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FOR IMMEDIATE RELEASE

CHANGES WILL PUT EPA RESEARCH PROGRAM ON RIGHT TRACK

WASHINGTON — Substantial changes under way in the U.S. Environmental Protection Agency's (EPA) research program will improve it in many ways, concludes an interim report* by a committee of the National Research Council.

An assessment of EPA's research program and peer review process was requested by Congress last year when it approved EPA's $378 million research budget for fiscal year 1995. The legislation prohibits the agency from spending 75 percent of this budget until it receives the interim report and begins to implement the committee's recommendations.

"In the 25 years since EPA was created, its research programs and scientific credibility have been assessed by several independent groups," said committee chair Paul G. Risser, president of Miami University, Oxford, Ohio. "EPA has made many positive changes in its research program in response to recomendations from these groups. The changes currently underway amount to the most dramatic reforms in the history of the agency's research program."

The committee applauded EPA's efforts to improve strategic planning for its research and development activities. It endorsed the agency's decision to increase its emphasis on long-term, fundamental research. Because this approach will lead to cutbacks in some short-term programs, the

(MORE)

*Limited quantities of the ***Interim Report of the Committee on Research and Peer Review in EPA*** are available from the Board on Environmental Studies and Toxicology at the mailing address in the letterhead; tel. (202) 334-3060. Reporters may obtain copies from the Office of News and Public Information at the letterhead address (contacts listed above).

committee called for safeguards to ensure that the important scientific needs of the agency's regulatory and regional offices are not compromised.

In this preliminary assessment, the committee evaluated and endorsed several changes that the agency is making to improve its research program and peer review practices:

- resources for long-term fundamental research are being increased, with corresponding reductions in applied projects and technical services for the agency's regulatory and regional offices;
- EPA laboratories and assessment centers are being consolidated, and research management authority is being decentralized from headquarters to the laboratories;
- annual funding is being increased from $20 million to $100 million for grants to independent researchers and research centers;
- peer-review practices are being strengthened and expanded; and
- a national program of 300 graduate fellowships is being created.

EPA's research program includes investigations that advance knowledge about pollution, the environment, and human health, as well as studies that address solutions to environmental problems. It also offers technical assistance to other programs within the agency.

The committee's final report, containing an assessment of EPA's scientific practices, is scheduled for completion in 1996. It will address in detail the structure, funding, and long-term plans for EPA's research and development program, as well as procedures for laboratory site review and research staff evaluation.

The National Research Council is the principal operating agency of the National Academy of Sciences and the National Academy of Engineering. It is a private, non-profit institution that provides science and technology advice under a congressional charter. A committee roster is attached.

# # #

[Internet availability: This news release is available on the WorldWide Web at http://www.nas.edu, via Gopher at gopher.nas.edu, and via FTP at ftp.nas.edu/pub/]

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NATIONAL RESEARCH COUNCIL

Commission on Geosciences, Environment, and Resources
Board on Environmental Studies and Toxicology

Committee on Research and Peer Review in EPA

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Principal Staff Officer

Raymond A. Wassel, M.S.
Senior Staff Officer

[1] Member, National Academy of Sciences
[2] Member, National Academy of Engineering
[3] Member, Institute of Medicine

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Divider Title: _____

The Department of Commerce

10 Agencies, 2 of which have significant research operations

National Oceanic and Atmospheric Administration (NOAA)

Technology Administration
- Office of Technology Policy (OTP)
- National Institute for Standards and Technology (NIST)
- National Technical Information Service (NTIS)

International Trade Administration (ITA)

Bureau of Export Administration (BXA)

Economics and Statistics Administration
- Bureau of the Census
- Bureau of Economic Analysis

National Telecommunications and Information Service (NTIS)

Patent and Trademark Office (PTO)

Economic Development Administration (EDA)

Minority Business Development Agency (MBDA)

U.S. Travel and Tourism Administration (USTTA)

Research Vision

NOAA: To provide the nation with a robust research and technical foundation in oceanic and atmospheric sciences, so that society, now and in the future, can base decisions involving or affected by these environments upon continually improving knowledge, understanding and predictive capabilities.

NIST: To assist industry in the development of technology...needed to improve product quality, to modernize manufacturing processes, to ensure product reliability...and to facilitate rapid commercialization ...of products based on new scientific discoveries.

Achieving NOAA's Vision for 2005

NOAA's Strategic Plan for 1995-2005 describes the goals and objectives that have been established to fulfill its vision. The strategy consists of seven interrelated goals. Each goal is a coherent unit, but there also are important crosscutting relationships which enable the implementation and advancement of national, Department of Commerce, and NOAA objectives. The goals are grouped within the two primary missions of *Environmental Assessment and Prediction* and *Environmental Stewardship*.

Environmental Assessment and Prediction Mission

- Advance Short-Term Warning and Forecast Services
- Implement Seasonal to Interannual Climate Forecasts
- Predict and Assess Decadal to Centennial Change
- Promote Safe Navigation

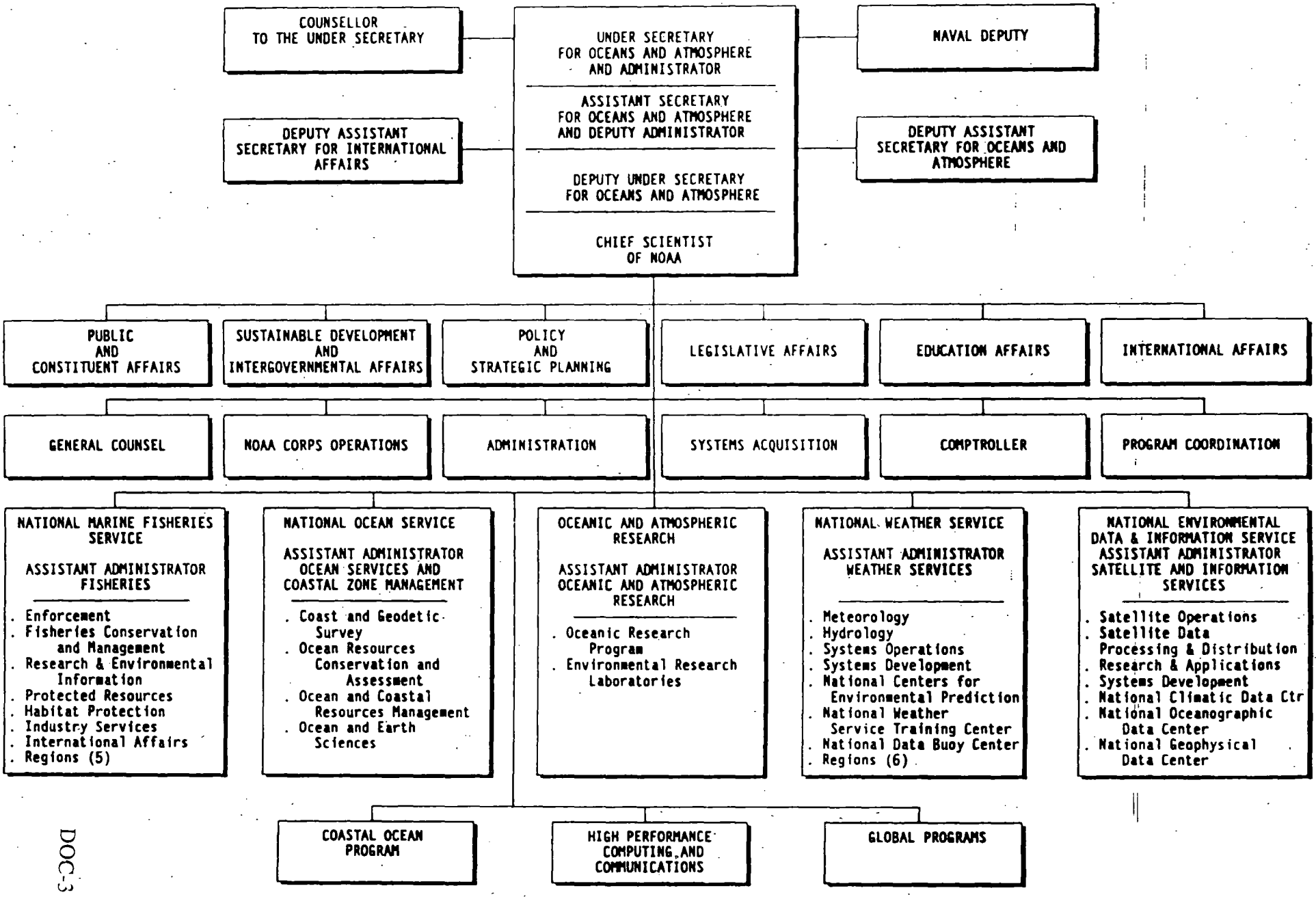
Environmental Stewardship Mission

- Build Sustainable Fisheries
- Recover Protected Species
- Sustain Healthy Coastal Ecosystems

The execution of NOAA's goal-based strategy depends strongly on a stable infrastructure and administrative and human resources, as well as on the underlying capabilities of the agency as a national resource for research, observing systems, and environmental data and information services.

Each mission, the seven strategic goals, and NOAA's national capabilities are summarized in the following pages.

U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION



NOAA Research Activities: Environmental Stewardship Mission

- **Build Sustainable Fisheries**
  - Collection and analysis of harvesting and survey data to assess the status and trends of more than 231 commercially valuable marine fish, shellfish and crustacean stocks;
  - Development of new observational technologies, a new nationwide computerized statistical system, and improved analysis techniques for stock assessment;
  - Studies of fisheries and fisheries oceanography, aimed at understanding marine ecosystems;
  - In collaboration with other agencies, states, and academia, expansion of collection and analysis of data on the value of the catch and the economic characteristics of fishing vessels, to support decisions on the use of market-based regulation;
  - Joint studies with industry, including harvesting methods and fishing gear to reduce wasteful by-catch, and seafood science research to handle or prevent microbial or chemical contamination of seafood

- **Recover Protected Species**
  - Research on population trends, takes and removals, critical habitat and resource requirements for endangered and threatened marine species such as northern right whales, northwest salmon runs, and sea turtles;
  - Establishment of social and economic implications of management alternatives, and characterization of uncertainty and risk;
  - Identification of genetic markers for stock identification of protected species;
  - Adaptation of technologies such as low frequency acoustics, lidars, and satellite radio tags to supplement and improve traditional line transit techniques.

- **Sustain Healthy Coastal Ecosystems**
  - Determination, evaluation, and prediction of the quality of and changes in U.S. estuaries and coastal waters;
  - Compilation of inventories of coastal data;
  - Scientific support for management of coastal oil and chemical spills;
  - Geographically targeted research programs in the National Estuarine Research Reserves, Marine Sanctuaries, and other important coastal water bodies;
  - Research on status and functioning of coastal habitats, implications of change to coastal habitat, and appropriate responses to habitat change.

NOAA Research Activities:
Environmental Assessment and Prediction Mission

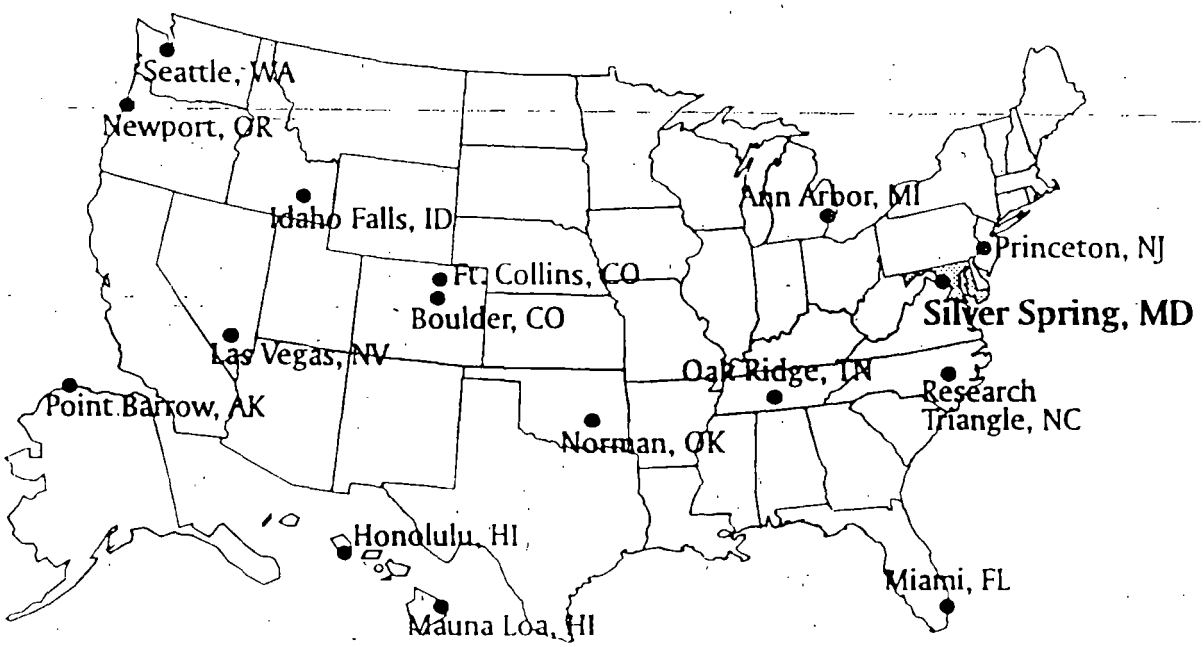
- **Advance Short Term Warning and Forecast Services**
  - Research to improve the understanding of the structure of severe storms, to develop new algorithms, models and forecasting techniques, and to improve the accuracy and lead-time of forecasts and warnings;
  - Exploration of new atmospheric observing capabilities, such as wind profilers and lidars, and applications of new technologies being fielded under the National Weather Service Modernization;
  - Hydrological research to develop numerical and physical models that incorporate measurements of rainfall and soil moisture attained with the modernized Weather Service observing systems;
  - Research to extend the range of the weather forecast to a week or more;
  - Development of a coastal forecast system;
  - Research to improve forecasts of solar disturbances that can cause fluctuations in ground- and space-based power and communications systems, done in conjunction with military and academic efforts;
  - Research to define a new upper air observing system, including characterization and assessment of candidate measuring systems.

- **Implement Seasonal to Interannual Climate Forecasts**
  - In conjunction with academic researchers, translate present capacity to forecast El-Niño-Southern Oscillation (ENSO) events into operational forecasts that are sufficiently reliable to allow economically significant decisions to be based on them; research prerequisites include understanding key climatic processes, improving forecast skill, improving observing systems, and assessing social and economic impacts of the forecasts.

- **Predict and Assess Decadal-to-Centennial Change**
  - In conjunction with USGCRP, research on atmospheric and oceanic processes that contribute to long term climate variation;
  - Research on the chemistry of stratospheric ozone;
  - Research aimed at understanding the processes that govern long term regional variation in ground level ozone, particularly in rural areas; done in conjunction with EPA.

- **Promote Safe Navigation**
  - Research in geodesy, hydrographic and photogrammetric technology, and marine coastal forecasting aimed at integrating Geographic Information Systems (GIS) and the Global Positioning System (GPS), into NOAA navigation and positioning missions.

ENVIRONMENTAL RESEARCH LABORATORIES



Environmental Research Laboratories Headquarters

The mission of the Environmental Research Laboratories (ERL) is to conduct an integrated program of fundamental research, related technology development, and services to improve understanding and prediction of the geophysical environment comprising the oceans and inland waters, the lower and upper atmosphere, the space environment, and the Earth.

ERL is the research base for NOAA's contribution to major national environmental programs including Climate and Global Change, Coastal Oceans, and Severe Weather. Users of ERL research results include the atmospheric, marine, and space research communities; the National Weather Service; the National Ocean Service; the National Environmental Satellite, Data, and Information Service; the National Marine Fisheries Service; and other Federal, State, local, and private entities.

Environmental Research Laboratories Headquarters — Silver Spring, Maryland

The Environmental Research Laboratories is composed of 11 Laboratories and 7 Joint Institutes located across the U.S. The headquarters for ERL is Silver Spring where 11 Federal employees are located, including Dr. Alan R. Thomas, the Director of the laboratories.

Examples of Environmental Research Laboratories research results and applications are:

- ✔ Doppler radar technology to improve tornado detection and warnings
- ✔ Mathematical models to predict climate and ocean variations and to improve hurricane forecasting
- ✔ Cooperative fisheries and oceanography studies to improve prediction and management of fisheries stocks
- ✔ Ocean current forecasts to minimize ship operation costs
- ✔ Solar activity forecasts to protect astronauts and aircraft crews and to preserve communications efficiency.

NOAA ENVIRONMENTAL RESEARCH LABORATORIES

Lab/Director	Location/phone	Research specialization
Aeronomy Laboratory Dr. Daniel Albritton	Boulder, CO (303)497-5785	Atmospheric chemistry, physics, and dynamics, focusing on air quality, stratospheric ozone depletion, and climate change
Air Resources Laboratory Dr. Bruce Hicks	Silver Spring, MD (301)713-0684	Transport, dispersion, air surface exchange and transformation of pollutants and aerosols; relation to air quality, emergency preparedness and response, and climate trends
Atlantic Oceanographic and Meteorological Lab Dr. Hugo Bezdek	Miami, FL (305)361-4300	Atmospheric chemistry; observations related to climate change, hurricane research, fisheries recruitment, and nutrient enrichment
Climate Diagnostics Center	Boulder, CO	Diagnostic studies of climate variability; data management systems for observational and model-generated data
Climate Monitoring and Diagnostics Laboratory Dr. Eldon Ferguson	Boulder, CO (303)497-6966	Long-term measurement and analysis of greenhouse gases, aerosols and ozone, related to climate change and stratospheric ozone depletion.
Environmental Technology Lab Dr. Steven Clifford	Boulder, CO (303)497-6291	Development, demonstration, and transfer of cost-effective remote measurement systems for weather, climate, and coastal applications.
Geophysical Fluid Dynamics Laboratory Dr. Jerry Mahlman	Princeton, NJ (609)452-6502	Develop numerical models related to weather, climate and ocean predictability.
Great Lakes Environmental Research Laboratory Dr. Alfred Beeton	Ann Arbor, MI (313)741-2244	Integrated, interdisciplinary research on coastal, estuarine, and Great Lakes environments, in support of management
National Severe Storms Laboratory Dr. Robert Maddox	Norman, OK (405)366-0427	Numerical and conceptual models of storms and studies of mesoscale weather processes
Pacific Marine Environmental Lab Dr. Eddie Bernard	Seattle, WA (206)526-6800	Observation and process studies in oceanography, marine meteorology, and related subjects
Space Environment Laboratory Dr. Ernest Hildner	Boulder, CO (303)497-3311	Research, monitoring, assessment, and forecasting of near-earth space environment, to mitigate economic loss and promote public safety.

NOAA JOINT INSTITUTES

Institute	University	Research Areas
Cooperative Inst. for Research in Environmental Sciences (CIRES)	Univ. of Colorado, Boulder, CO	Atmospheric and climate dynamics, cryospheric and polar processes, environmental chemistry and biology
Coop. Inst. for Research in the Atmosphere (CIRA)	Colorado State Univ., Fort Collins, CO	Local weather forecasting, air quality, economic and social aspects of weather forecasting, satellite applications
Coop. Inst. for Mesoscale Meteorological Research (CIMMS)	Univ. of Oklahoma, Norman, OK	Convective and mesoscale research, forecast improvements, socio-economic effects of weather and climate
Coop. Inst. for Limnology and Ecosystems Research (CILER)	Univ. of Michigan, Ann Arbor, MI	Coastal and nearshore processes, climate and large lake dynamics, large lake ecosystem structure and function
Coop. Inst. for Marine and Atmospheric Studies (CIMAS)	Univ. of Miami, Miami, FL	Climate variability; marine gases, aerosols and climate; fisheries ecology and ecosystem dynamics
Joint Inst. for the Study of the Atmosphere and Ocean (JISAO)	Univ. of Washington, Seattle, WA	Climate, environmental chemistry, estuaries, and fisheries oceanography
Joint Inst. for Marine and Atmospheric Research (JIMAR)	Univ. of Hawaii, Honolulu, HI	Equatorial and fisheries oceanography, tsunamis, climate, tropical meteorology
Cooperative Institute for Meteorological Satellite Studies (CIMSS)	Univ. of Wisconsin, Madison, WI	Meteorological research using satellite technology
Coop Inst. for Arctic Research (CIFAR)	Univ. of Alaska, Fairbanks, AK	Arctic research

NOAA Fishery Science Centers

Research at NOAA's Fishery Science Centers provides resource managers in NOAA and other agencies with the scientific basis for informed marine fishery management decisions. The five regional Centers, composed of about thirty facilities nationwide and more than a thousand scientific personnel, conduct a comprehensive, interdisciplinary fishery science program. The scope of their work is broad in time, space, and discipline. Their activities include the collection of harvesting statistics and associated economic data; resource surveys; biological and ecological studies; technology development; and assessments and models of the impacts and benefits of alternative stewardship decisions. The Fishery Science Centers work in cooperation with other federal and state agencies, academia, and the private sector including the fishing industry.

Center/Director	Location/phone
Northeast Fisheries Science Center Dr. Allen Peterson	Woods Hole, Mass. (508)548-5123
Southeast Fisheries Science Center Dr. Bradford Brown	Miami, Fla. (305)361-4284
Southwest Fisheries Science Center Dr. Michael Tillman	La Jolla, Calif. (619)546-7067
Alaska Fisheries Science Center Dr. William Aron	Seattle, Wash. (206)526-4000
Northwest Fisheries Science Center Dr. Usha Varanasi	Seattle, Wash. (206)860-3200

NOAA Partnership and Extramural Research Programs

Office of Global Programs (OGP)
NOAA's Office of Global Programs develops and coordinates national and international research programs aimed at those components of the US Global Change Research Program (USGCRP) that are of top priority and of most relevance to NOAA's missions. These collaborative scientific efforts have proven extremely effective in advancing the nation's capability to predict seasonal climate variations up to one year in advance. The program awards competitive, peer-reviewed grants to academic and NOAA researchers.

Coastal Ocean Program (COP)
NOAA's Coastal Ocean Program develops and supports research activities to improve understanding of coastal processes and management of coastal resources. Under this program, government and academic research partners jointly develop research plans and priorities. COP then funds the recommended research through competitive, peer-reviewed grants to both academic and internal scientists. The program pursues three main research foci: coastal fisheries ecosystems, coastal environmental quality and coastal hazards.

National Sea Grant College Program (NSGCP)
The NSGCP is an important partnership of the federal government, state governments, and the private sector, combining university-based research, education and technology transfer. The program comprises a network of over 300 institutions nationwide, operating through a core leadership of 29 Sea Grant Colleges and Institutions. Through Sea Grant, NOAA can access academic expertise throughout the nation and support public outreach and education efforts. The Sea Grant program awards competitive, peer-reviewed grants to academic researchers to address urgent environmental and economic problems faced by the public, industry and government in coastal and Great Lakes states. Sea Grant is notable for its outreach program, which fosters transfer of research into effective resource management.

National Undersea Research Program (NURP)
The NURP provides access for the U.S. research community to civilian, military, and international undersea platforms. The research it supports relies upon submersibles, underwater laboratories, and diving to enable scientists to perform in-situ studies, and on remotely operated vehicles (ROVs) and observatories for indirect access. The program is directed by a national office and carried out by six university-based National Undersea Research Centers. Primary research emphases in NURP are fisheries, coastal processes, ecosystem health, marine lithospheric processes, undersea technology, and diving safety and physiology.

NOAA FY 1996 Budget Request (in millions)

Build Sustainable Fisheries	$339.4
Recover Protected Species	$64.6
Sustain Healthy Coastal Ecosystems	$206.1
Advance Short-term Warning	$1281.4
Implement Seasonal to Interannual Climate Forecasts	$125.9
Predict & Assess Decadal-to-Centennial Climate Change	$121.5

Total R&D Portion of NOAA FY 1996 Request

$597.4 million (28%)

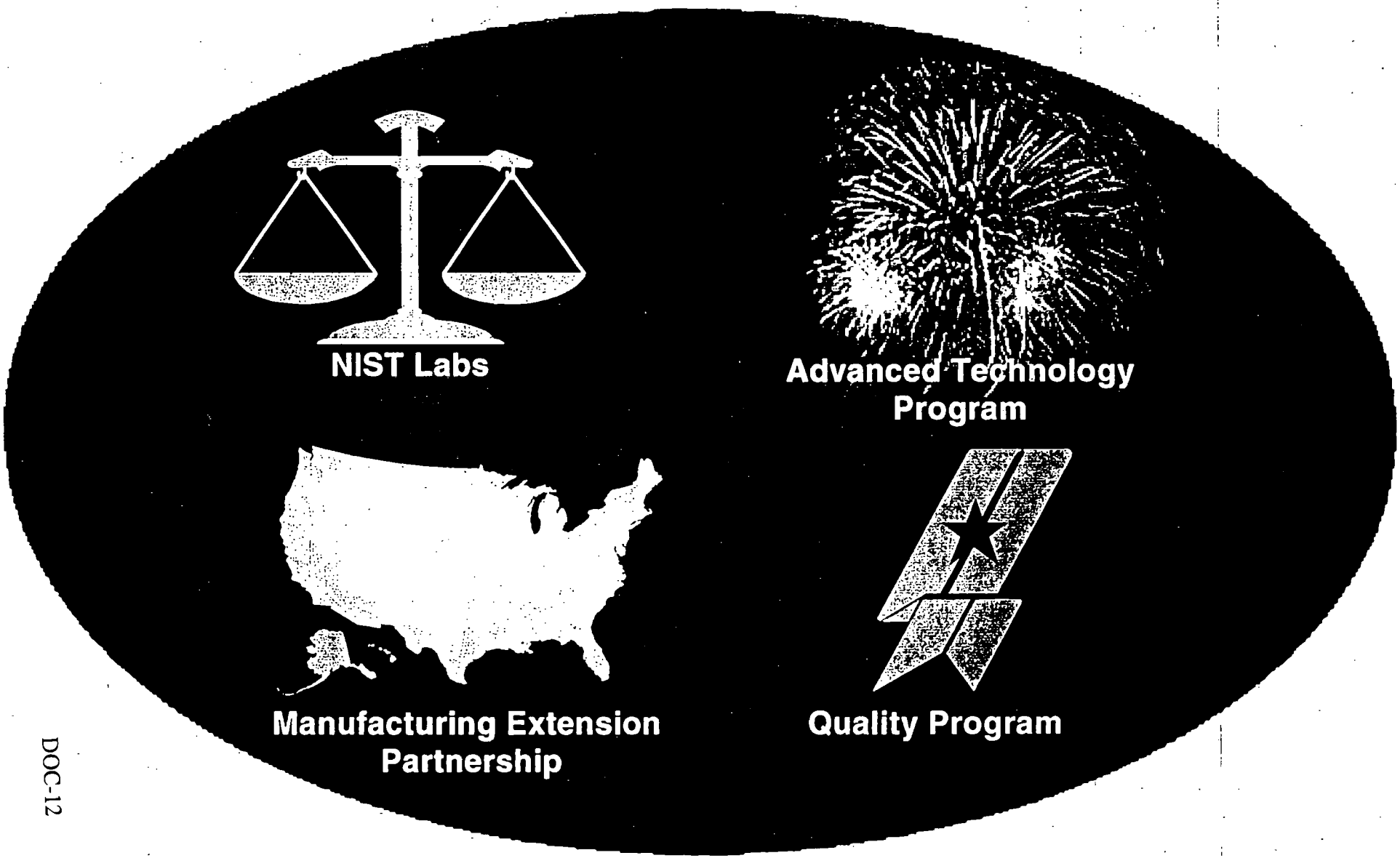
Technology Administration

Office of Technology Policy

National Institute of Standards and Technology

National Technical Information Service

National Institute of Standards and Technology



Advanced Technology Program

Mission Stimulate U.S. economic growth by promoting the development of high-risk, enabling technologies through programs and projects proposed and cost shared by industry

Strategy Work with U.S. industry to plan, execute, and cofund development programs for high-risk technologies that are:

Enabling – provide technical bases for process- and product-specific applications.

High-Value – offer large and/or strategic long-term benefits to the U.S. economy.

Unique Features

- Focus on high-risk generic technologies
- Direct funding of companies only
- R&D priorities set by industry
- Cost sharing required for all projects
- Selection based on **both** technical and business merit
- Automatic sunset provisions -- funding limit on single-company projects
- Broad scope
- Promotes cooperative research and strategic business alliances
- Substantial support to small businesses (including startups)
- Intellectual property rights assigned to awardees
- Proprietary information protected

ATP Focused Programs

April 1994

- Tools for DNA Diagnostics
- Information Infrastructure for Healthcare
- Manufacturing Composite Structures
- Component Based Software
- Computer Integrated Manufacturing for Electronics

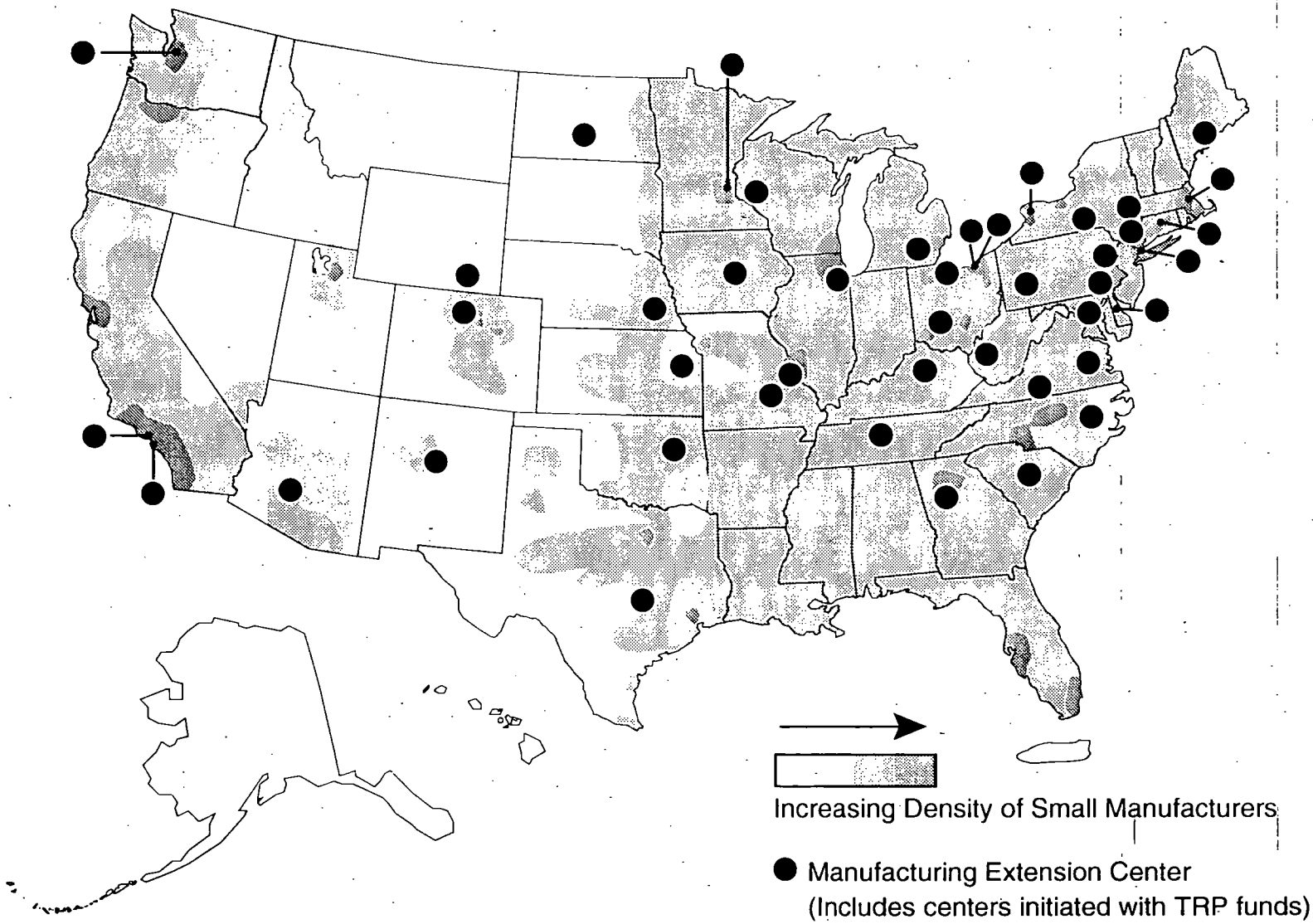
November 1994

- Catalysis and Biocatalysis Technology
- Motor Vehicle Manufacturing Technology
- Digital Data Storage
- Digital Video in Information Networks
- Materials Processing for Heavy Manufacturing
- Advanced Vapor Compression Refrigeration Systems

MANUFACTURING EXTENSION PARTNERSHIP

- Grassroots effort to improve competitiveness of smaller manufacturers
  - 500 employees or fewer (370,000 companies, 98% of all U.S. manufacturers)
  - Assist with modern manufacturing processes
  - Apply appropriate technologies and techniques
  - On-site assistance
- Industry driven, market defined
- Rigorous, merit-based selection of centers
- Builds on existing state and local resources and services
- Centers run by local and state non-profit organizations
- State and local matching funds
- Work with companies that are committed to investing in themselves
- Thorough evaluation based on bottom-line company results

NIST Manufacturing Extension Partnership



Baldrige National Quality Program

NIST Administers Malcolm Baldrige National Quality Award

- Highest National Recognition for a U.S. Company

Award Criteria Support Dual, Results-oriented Goals

- Delivery of Ever-improving Value to Customers
- Improvement of Overall Company Performance and Capabilities

The Award Promotes

- Understanding of Quality Excellence
- Awareness of Quality as Crucial Competitive Element
- Sharing of Quality Information and Strategies

NIST Laboratories

Focus on infrastructural technologies such as:
- measurements
- standards
- evaluated data
- test methods

Provide common language for all stages of commerce:
- research
- development
- production
- marketing

Benefits spread across entire industries, usually not embodied in specific products.

Improve quality and productivity, ensure reliability, assure compatibility

Programs and priorities determined in cooperation with U.S. industry.

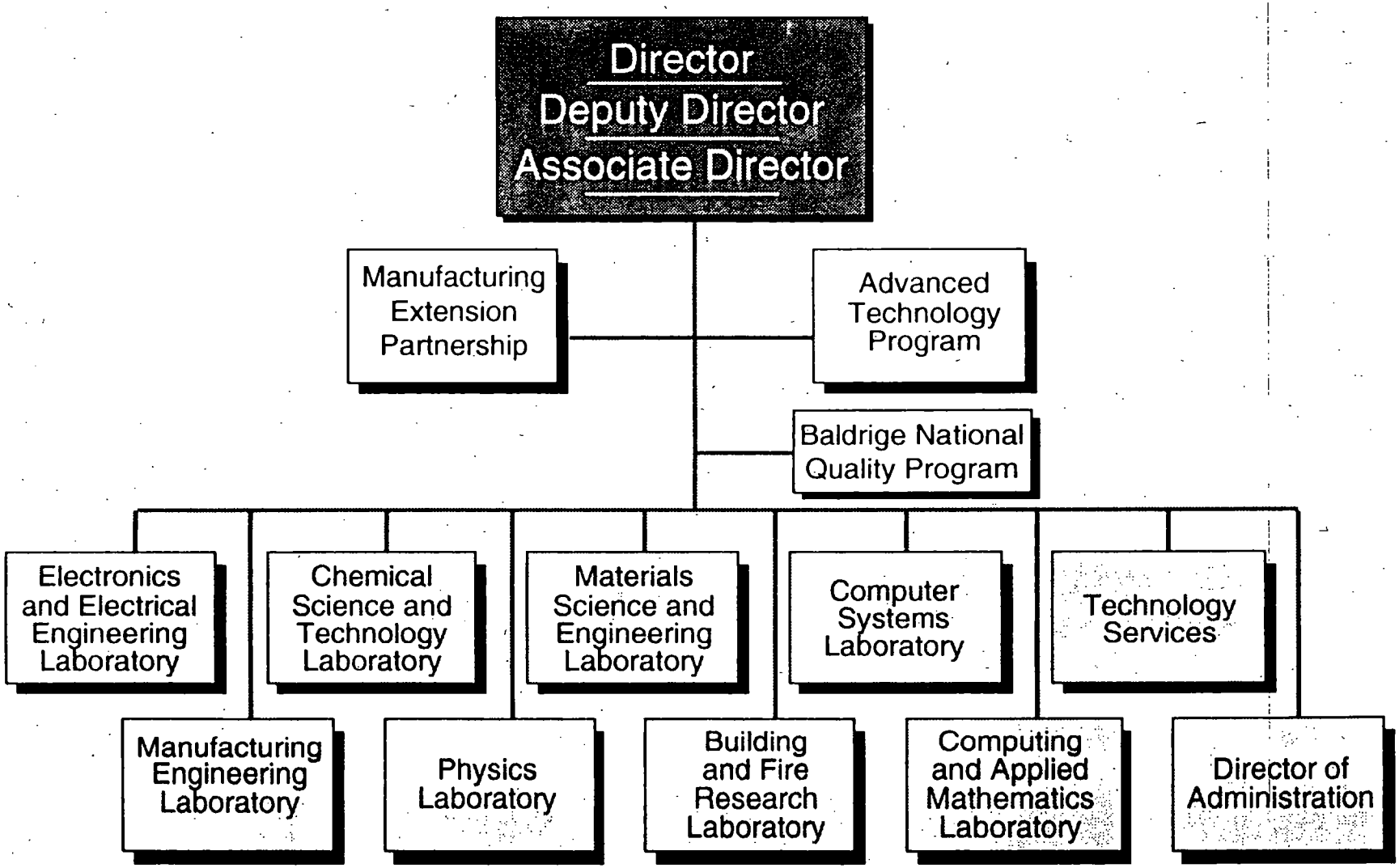
Address current U.S. infrastructural needs for measurements and standards in rapidly developing emerging technologies such as biotechnology and information technology.

Anticipate future U.S. needs through long-term research in fundamental measurement science.

Actively participate in state, national, and international standards communities.

National Institute of Standards and Technology

Organizational Chart



NIST FY 1996 Budget Request

Advanced Technology Program	$490.9M
Manufacturing Extension Partnership	$146.6M
Laboratory Programs	$310.7M
Malcolm Baldrige National Quality Program	$4.9M

NIST Laboratory FY 1996 Initiatives

Semiconductor metrology

Health care measurements

Biotechnology

Environmental technologies

Advanced materials and processing

- Information technology
- Construction technologies
- Measurements and standards for emerging instrumentation industries

NIST Partnerships with Universities

- Center for Advanced Research in Biotechnology

  - joint research with the University of Maryland

- JILA

  - joint research with the University of Colorado

NIST Major User Facilities for Science and Engineering

Cold Neutron Research Facility

Synchrotron Ultraviolet Radiation Facility

Large-Scale Structures Testing Facility

NSTC Committees
Participation by NIST and Technology Administration

Civilian Industrial Technology
- Materials Technology (chair)
- Construction and Building (co-chair)
- Partnership for a New Generation of Vehicles (chair)
- Environmental Technology (joint with ENR committee)
- Advanced Manufacturing

Information and Communication R&D
- High Performance Computing, Communications, and Information Technology
- Scientific and Engineering Computing
- Information Infrastructure Technology and Applications
- Federal Networking Council

Fundamental Science
- Biotechnology (chair)
- Research
- Budget Priorities (Working Group)

Transportation R&D
- Physical Infrastructure for Transportation
- Aeronautics Materials and Manufacturing Technology (Working Group)

Environment and Natural Resources (ENR) Research
- Toxic Substances and Hazards in Solid Waste

Health, Safety, and Food R&D
- Human Subjects Research

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