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Biomedical and Environmental Sciences Program

Oak Ridge National Laboratory

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Cover: The nucleosome is the fundamental structural and functional element of the genome. This nucleoprotein complex consists of pairs of the histones H2A, H2B, H3, H4 and approximately 146 base pairs of duplex DNA. The X-ray crystal structure of the nucleosome has been solved by a group at ORNL to 8 A resolution. This figures shows a portion of the nucleosome core particle viewed along the DNA superhelical axis. The structure contains the longest segment of continuous double-stranded DNA observed at molecular resolution and is the only crystallized DNA with a highly curved path as in the genome. The upper gyre of DNA is almost entirely shown, running from base pair 73 at position zero around to the DNA end at about the 5 o'clock position. The portion of histone shown contains virtually all of the upper H3 (blue) and H4 (green) with a hint of the lower H3 and H4 also visible. H4 has a very tight contact with the DNA near position +3 and even appears to protrude between the DNA gyres. From this location, H4 extends across toward the 4 o'clock position. H3 interacts with DNA from position 0 to about +2 1/2 and extends out towards the viewer higher than the adjacent DNA. Only small portions of H2A (violet) and H2B (red) are shown. In subsequent sections, the H2B density extends from about position +5 to +3. The H2A density extends from where visible into the central region of the figure. (Courtesy of G. J. Bunick and E. C. Uberbacher)

ORNL/M--560

DE88 012148

Biomedical and Environmental Sciences Programs at the Oak Ridge National Laboratory

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February 1988

Prepared for the
Office of Health and Environmental Research
Office of Energy Research
U.S. Department of Energy

by the

OAK RIDGE NATIONAL LABORATORY
Oak Ridge, Tennessee 37831
operated by
MARTIN MARIETTA ENERGY SYSTEMS, INC.
for the
U.S. Department of Energy
under Contract No. DE-AC05-84OR21400

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Acknowledgments

We are grateful for the assistance received in preparing this document. The staff of each division contributed to the written text and provided the needed statistics. Division coordinators were Beverly Selmer and Stan Cook, Biology; Judy Trimble, Environmental Sciences; and Jewell Ellis, Health and Safety Research. The document was edited and coordinated by Jackie Miller. Our thanks go also to V. B. Isham for all budget information; to Vickie Conner for the cover design; to Virginia Norman for obtaining the publications list in Appendix B; to Sandi Lyttle for composition; to Larry Davis for makeup; to Dottie McMahan and G. A. Sweeden for graphics; to Lowell Langford, Paul Baker, and Bill West for advice and procedural assistance; and to the Photography Department for their assistance and advice.

Role

Overview

The role of the Biomedical and Environmental Sciences Program at Oak Ridge National Laboratory (ORNL) is closely linked to the mission of ORNL and the Department of Energy (DOE).

Mission of the ORNL Biomedical and Environmental Sciences Program

A primary mission of the Biomedical and Environmental Sciences Program is to identify and understand important environmental and health effects associated with the energy technologies, including (1) basic and applied biological research on genetic and somatic effects of radiation and chemical exposures; (2) relationships of primary energy effluents to global environmental issues; (3) development of human health and environmental assessments and risk analyses in these areas; and (4) development of advanced instrumentation, measurement techniques, and methodologies for applying nuclear technologies to medical diagnosis and treatment. A secondary mission is to contribute to the revitalization of American industry through a variety of associations and activities, including cooperation with industrial consortia, active promotion of user facilities, and an aggressive patenting and licensing program.

The Biomedical and Environmental Sciences Program is committed to the effective transfer of research and technological developments to the private sector, academia, and other research institutions, including, where possible, establishing joint research, education, and training programs with universities.

Mission of Oak Ridge National Laboratory

Oak Ridge National Laboratory is the Department of Energy's largest multiprogram energy laboratory. The Laboratory's primary missions are (1) to conduct applied research and engineering development in support of DOE's programs in fusion, fission, conservation, fossil, and other energy technologies and (2) to perform basic scientific research in selected areas of the physical and life sciences. A secondary mission is to apply the Laboratory's resources to other nationally important tasks when such work is synergistic with the primary mission. Some of the issues addressed under the secondary mission include technologies related to international competitiveness, hazardous waste research and development (R&D), and selected defense technologies other than nuclear weapons. All missions include technology transfer as an integral component. In addition to the R&D missions, ORNL performs very important service roles for DOE; these roles include designing, building, and operating facilities for the benefit of university and industrial researchers and supplying radioactive and stable isotopes that are not available from private industry.

Scientific and technical efforts in support of the Laboratory's missions cover a spectrum of activities. In fusion, the emphasis is on stellarator confinement configurations, plasma heating, fueling systems, superconducting magnets, first-wall and blanket materials, and applied plasma physics. The ORNL nuclear fission activities support DOE's civilian nuclear power program through R&D on nuclear fuel reprocessing, high-temperature gas-cooled reactors, instrumentation and controls,

nuclear and chemical wastes, and materials. The Laboratory's program on conservation and renewable energy emphasizes research on high-temperature materials, electric power distribution systems, conservation technologies for buildings and industry, biomass production, and energy storage. ORNL's fossil energy work concentrates primarily on materials and on innovative research in coal conversion and utilization. Basic and applied research in the physical, social, informational, and life sciences provides the foundation for the technology development work. Biological and environmental research emphasizes the interaction of energy-related physical and chemical agents with the environment and with living organisms. Research in the social sciences includes policy analysis and technology implementation issues. The information area includes work on expert systems, simulations, and decision research. In the physical sciences, basic and applied research areas include high-temperature materials, neutron scattering, surface physics, aqueous and environmental chemistry, and heavy-ion physics. The role of providing research tools for industry and universities encompasses over a dozen major installations including the Health Physics Research Reactor (HPRR), the Oak Ridge National Environmental Research Park (NERP), the Oak Ridge Bioprocessing Research Facility (BRF), and other important user facilities related to energy technologies and the sciences.

Missions of the DOE Multiprogram National Laboratories

The main role of DOE's national laboratories is (1) to conduct basic research programs to advance the frontiers of scientific and technical knowledge in physical and energy-related life and environmental sciences that involve large multidisciplinary or major capital-intensive experimental facilities, and to provide use of those facilities to members of the scientific and technical community, including interested industry representatives or groups; (2) to conduct basic and applied research and technology development programs to explore energy technologies and related environmental factors and develop research options in areas that involve large, unpredictable, and long-term risks, costs, or payoffs, that need development before they can reach the market as competitive energy-investment options; (3) to conduct research, development, engineering, and technical and production support for nuclear weapons, associated nuclear materials, and other defense-related activities; (4) to provide research and development support, as appropriate, to other government agencies and make special capabilities available for public and private sectors on a reimbursable basis; (5) to contribute, through cooperative programs with universities, to the education of scientists and engineers in the fundamental sciences and all energy-related technologies; and (6) to provide for and encourage the transfer of technology developed at the national laboratories to the private and public sectors and facilitate an interactive climate among the laboratories and industry.

Goals of the Office of Health and Environmental Research

Goals of DOE's Office of Health and Environmental Research (OHER) Program are (1) to study the interaction to energy-related physical and chemical agents with living organisms, including their transport, chemical evolution, adverse health effects, and ultimate consequences in humans and their environment; (2) to contribute to DOE's Nuclear Medicine Program and other beneficial applications programs; and (3) to transfer research findings and technological developments outside the Laboratory.

The ORNL HAO2 Program is one of the most multidisciplinary life sciences research programs in the nation and covers a broad range of both basic and applied studies. Overall, this program is expected to experience growth in global sciences, subsurface transport studies, and radon-related research in this planning cycle.

ORNL/OHER Facilities and Resources

The administration and management of the Biomedical and Environmental Sciences Program are the responsibility of the Associate Laboratory Director for Biomedical and Environmental Sciences (ADBES), who reports directly to the ORNL Director. ORNL is a government-owned facility operated by Martin Marietta Energy Systems, Inc., for DOE. The DOE OHER provides the largest funding source for ORNL's Biomedical and Environmental Sciences Program (Fig. 1). Biomedical and environmental sciences research is carried out primarily by three divisions: Biology, Environmental Sciences, and Health and Safety Research. Organizational structures are shown in Figs. 2–5. Changes in Biomedical and Environmental Sciences professional personnel for FY 1987 and anticipated changes for FY 1988 are summarized in Table 1. A table showing current personnel totals, categorized by principal investigator, scientific support personnel, and others, is given in the Resource Quantitation section (Table 12). Other ORNL divisions that contribute to the ORNL BES multidisciplinary projects are Analytical

Table 1. Changes in Biomedical and Environmental Sciences Program professional personnel

	FY 1987	FY 1988[a]
Arrivals	20	10
Departures	27	15
Status changes	−7	−5

[a]Anticipated changes in personnel.

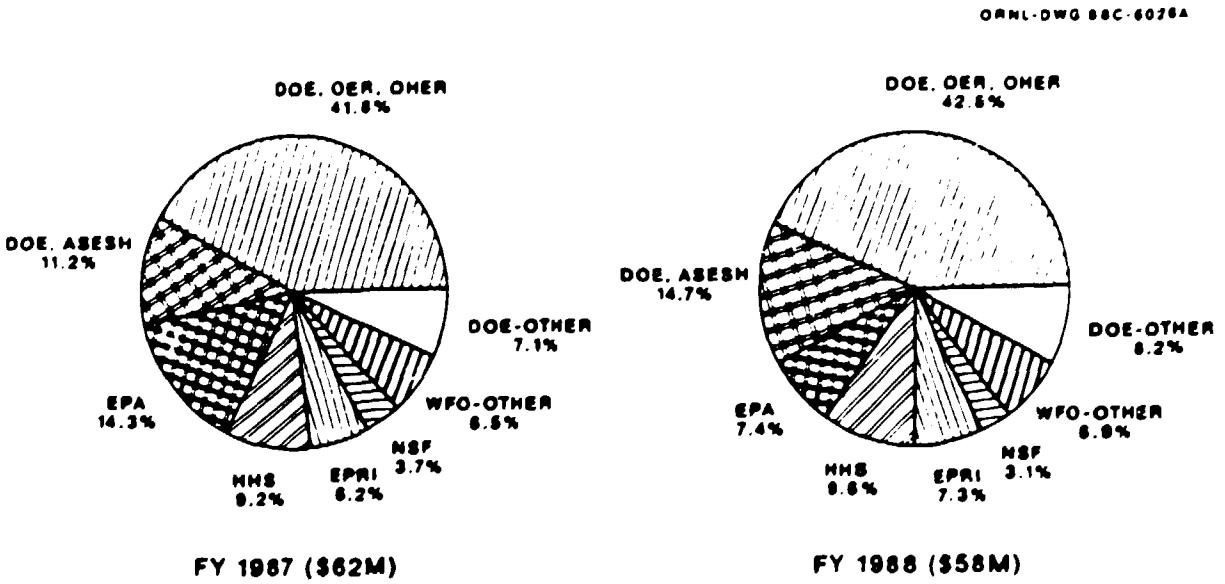

Fig. 1. Sponsors of the Biomedical and Environmental Sciences Program at Oak Ridge National Laboratory (total budget is operating BO).

ORNL DWG 88M-6275

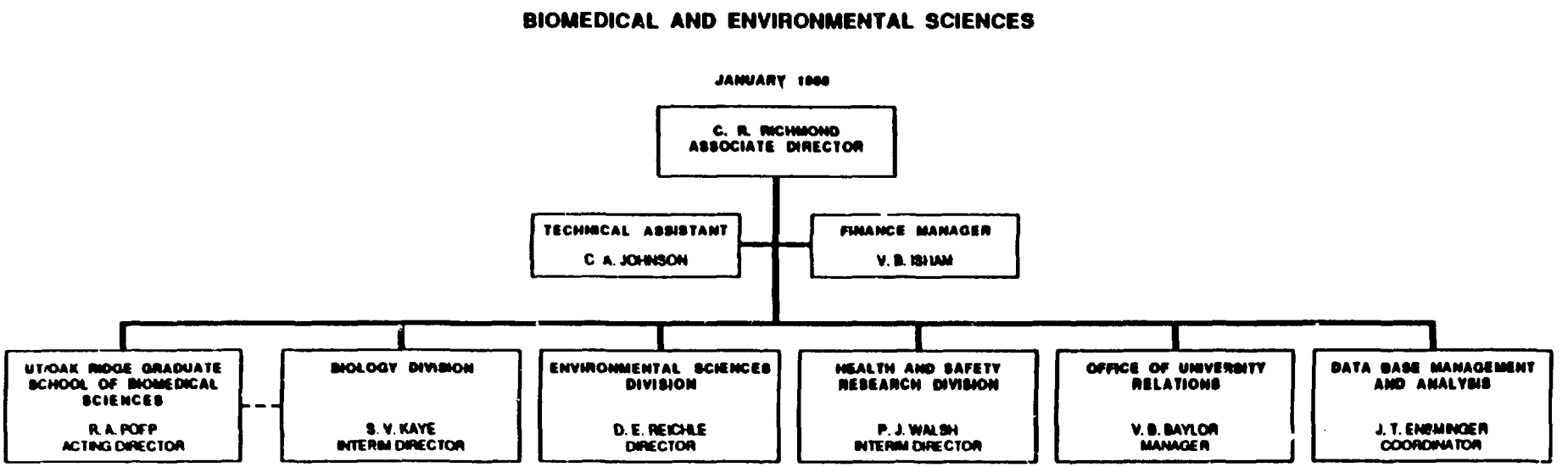

Fig. 2. Organization chart for the Office of the Associate Director for Biomedical and Environmental Sciences.

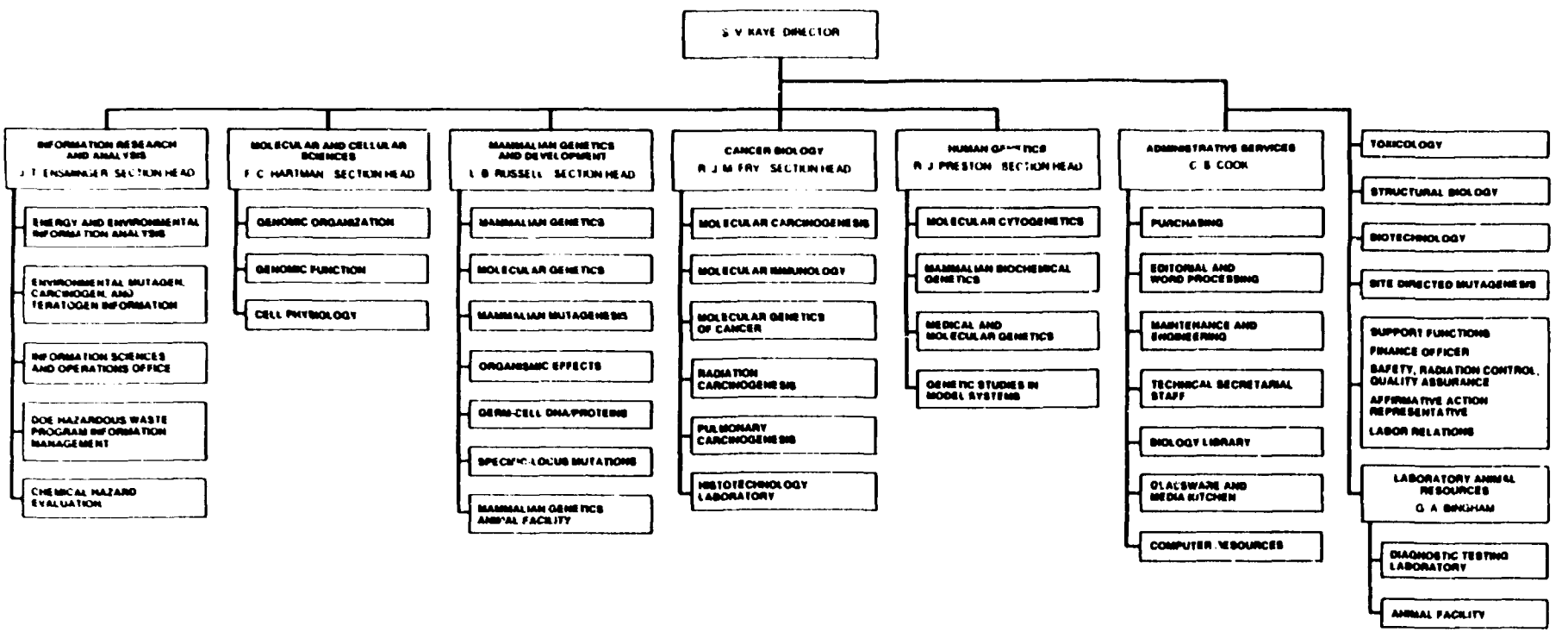

Fig. 3. Organization chart for the Biology Division.

ORNL-DWG 87M-18791

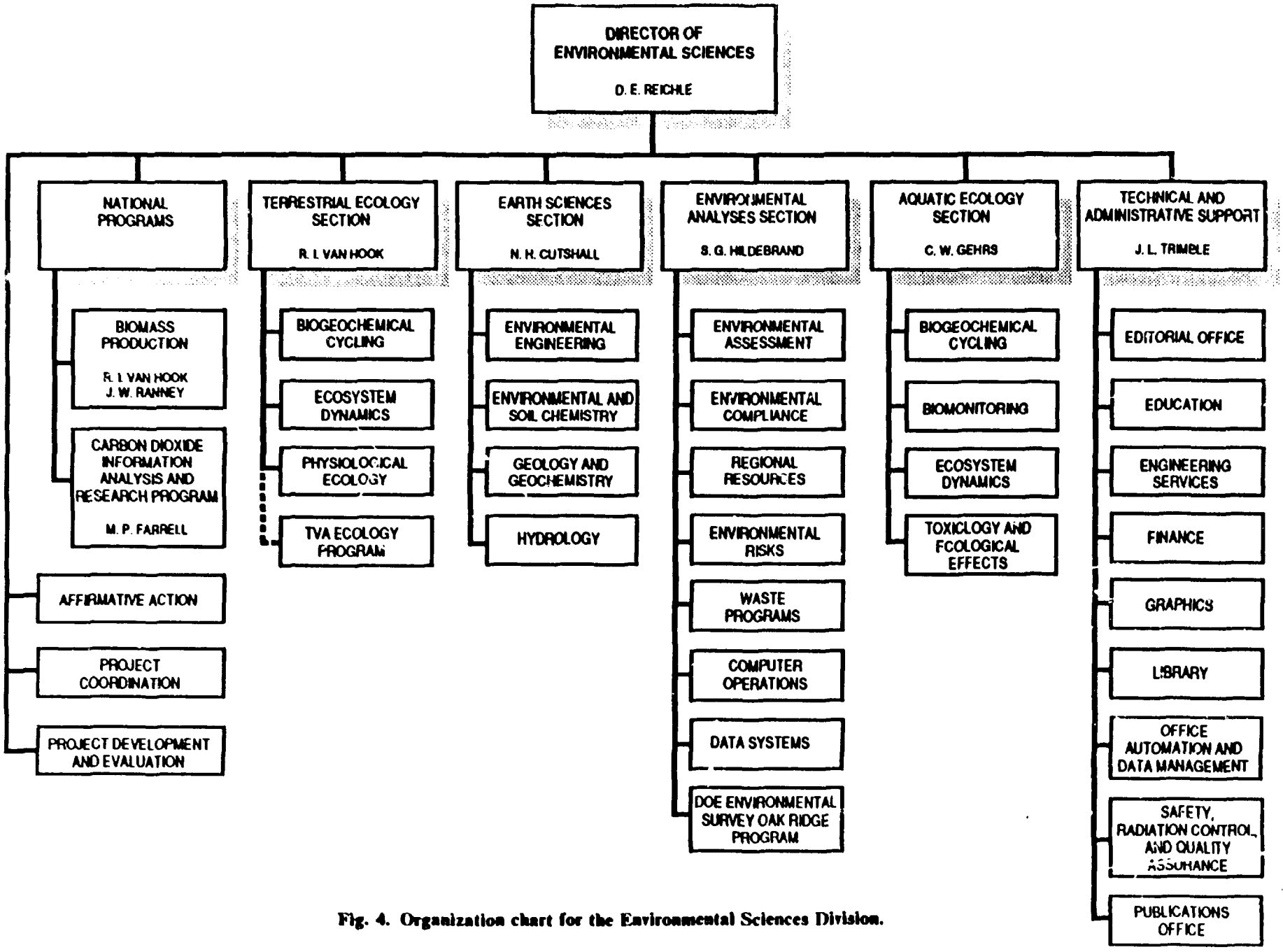

Fig. 4. Organization chart for the Environmental Sciences Division.

ORNL-DWG 87 6815R

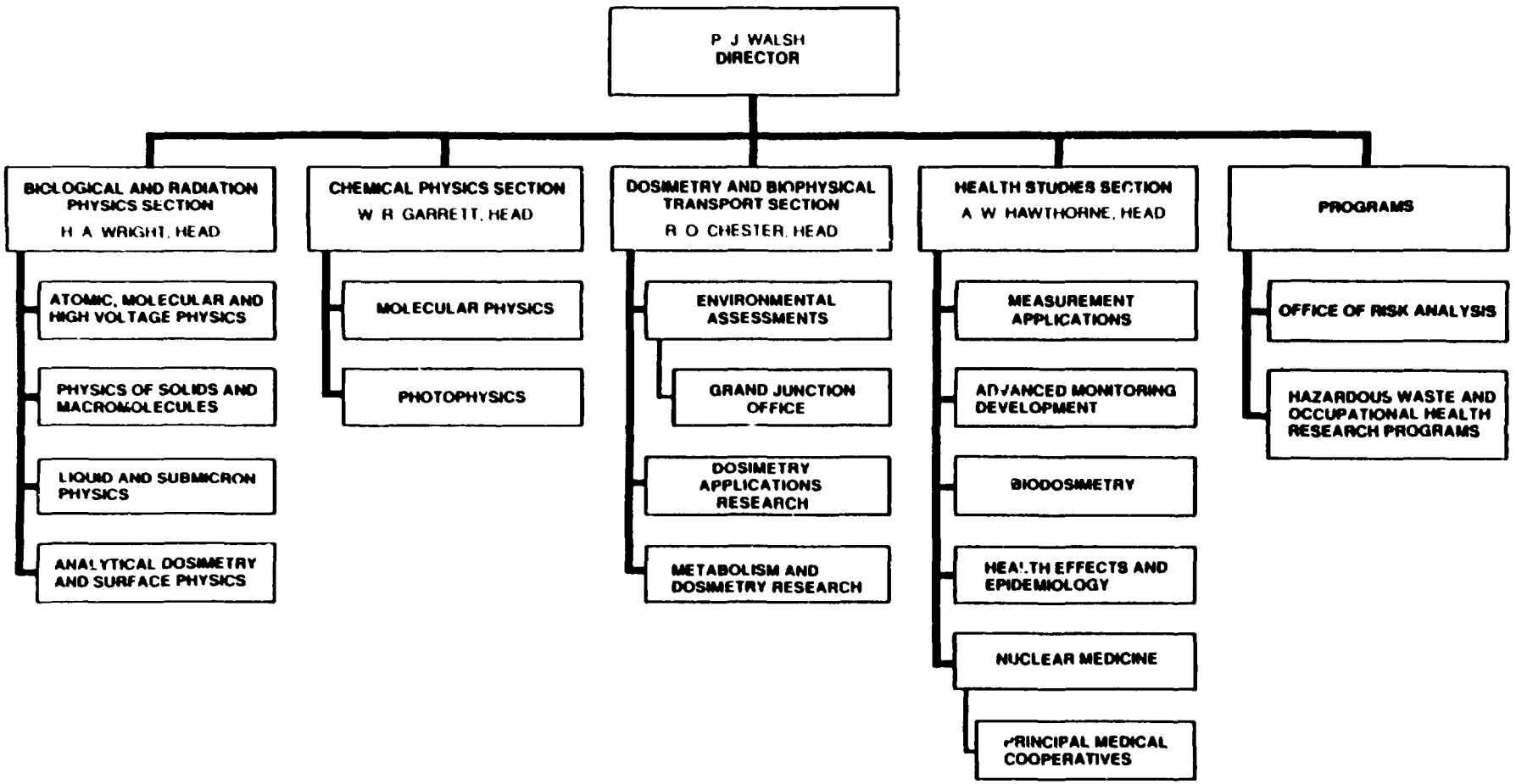

Fig. 5. Organization chart for the Health and Safety Research Division.

Chemistry, Chemical Technology, Energy, Engineering Physics and Mathematics, Instrumentation and Controls, Operations, and the Computing and Telecommunications Division of Energy Systems. In addition, the ADBES is responsible for the ORNL University Relations Program.

The University of Tennessee–Oak Ridge Graduate School for Biomedical Sciences is located in the Biology Division. The school offers a multidisciplinary program designed for training toward the M.S. and Ph.D. degrees. The division provides four full-time faculty members as well as a major portion of the teaching and research training. In addition, The University of Tennessee (UT) in conjunction with the Biology Division offers an M.S. degree program in biotechnology. The first students entered this unique program in 1986. The Environmental Sciences Division also collaborates with UT to provide graduate education and training in ecology.

Three unique user facilities are supported by the DOE OHER: the Health Physics Research Reactor (HPRR), the 5500-ha (13,585-acre) Oak Ridge National Environmental Research Park (NERP), and the Bioprocessing Research Facility User Resource. The NERP Program coordinates all environmental research activities with other land uses and serves as the repository of data on long-term preservation research. The bioprocessing facility integrates physical resources from the Biology and Chemical Technology divisions to include bioreactors, a flow cytometry laboratory, large-volume fermenters, and centrifugal analyzers. Users of these facilities include staff of national laboratories and industry and students and staff from universities.

Research Management Practices

Research projects under the auspices of the ADBES continually undergo review procedures to ensure quality, productivity, and efficiency. To help accomplish the desired results, appropriate management measures are applied at various levels of the organization.

Staff

Formal yearly reviews are conducted for each staff member according to the Performance Planning and Review (PPR) System. Figure 6 illustrates the organizational performance planning process and the progression from the company's strategic plan to performance plans for individual salaried employees. The reviews are augmented by informal reviews that occur several times during the year. The PPR System has recently undergone comprehensive review and revision using input from outside consultants and ORNL staff. Career development reviews take place at years two and five.

ORNL-DWG 88-7107

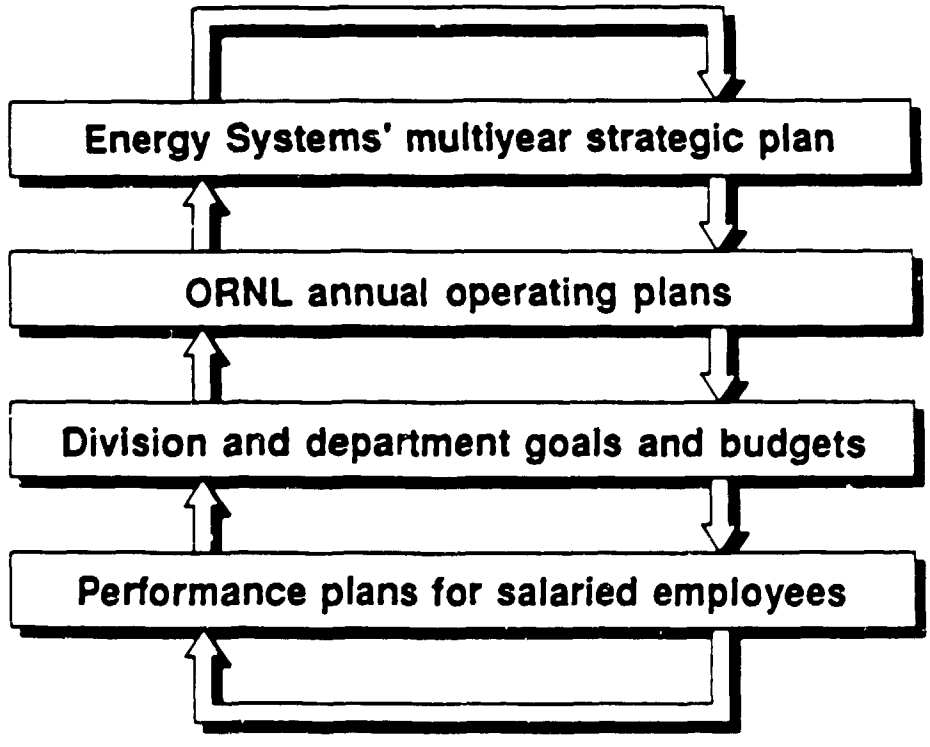

Fig. 6. The organizational performance planning and review process at Oak Ridge National Laboratory, operated by Martin Marietta Energy Systems, Inc.

A career review program identifies high-potential employees and, in concert with an aggressive affirmative action program, provides equal opportunities for minorities and women. Employee development plans are prepared for these individuals. The plans are monitored by division directors, associate directors, and the Laboratory Director. Periodic reviews of some are conducted by the Professional Managers Improvement Committee.

Animal Care and Use

The care of laboratory animals at ORNL meets or exceeds the requirements of the U.S. Department of Agriculture, the policies of the National Institutes of Health and DOE, and the principles of humane care of the American Veterinary Medical Association. The facilities are accredited by the American Association for Accreditation of Laboratory Animal Care and are supervised by a laboratory animal veterinarian. The membership of the ORNL Animal Care and Use Committee is shown in Table 2.

Division Advisory Committees

Each division undergoes a regularly scheduled review by an outside advisory committee that constructively critiques research activities, long-range and strategic planning, and future directions. The committees present their recommendations directly to the Laboratory Director. The membership of the advisory committee for each division is shown in Table 3.

Human Studies

Research involving human subjects at ORNL meets the requirements of the Department of Health and Human Services and DOE policy and the proposed policy of the Office of Science and Technology Policy on the protection of human subjects. For all research activities involving human subjects, the research proposals, consent forms, research practices, and research progress are reviewed and approved by a Committee on Human Studies that serves both ORNL and the Oak Ridge Associated Universities. The current members are listed in Table 4.

Internal Peer Review

All scientific publications and technical reports receive an internal peer review. This process serves as a quality control check and is closely monitored by ORNL management.

Long-Range Plans

ORNL participates in the DOE multiprogram laboratories institutional planning cycle. Components of the planning cycle include submission of preliminary data, completion of the on-site review, and approval of the Institutional Plan. The plan includes the five-year baseline of program projections and the fifteen-year strategic view for ORNL. The plan is an integration of DOE guidance and laboratory planning for R&D.

Five-year R&D plans are prepared by each division on a regular schedule to coincide with

Table 2. Members of Oak Ridge National Laboratory's (ORNL's) Animal Care and Use Committee

Name and degree	Affiliation
Gene A. Bingham, D.V.M.	Chairperson, Biology Division, ORNL
Lorrie G. Beevers-Laurence, Ph.D.	Oak Ridge Psychotherapy Practice
R. J. Michael Fry, M.D.	Biology Division, ORNL
John F. McCarthy, Ph.D.	Environmental Sciences Division, ORNL
Edward C. Schroeder, D.V.M.	College of Veterinary Medicine, The University of Tennessee, Knoxville

Table 3. Division Advisory Committee members for FY 1987 and FY 1988

Committee member	Year (FY)	Affiliation
		Biology Division
Dr. Robert Barker	1987	Provost, Cornell University 309 Day Hall Ithaca, New York 14853
Dr. Verne M. Chapman	1987	Chairman, Department of Molecular Biology and Associate Director for Scientific Affairs Roswell Park Memorial Institute Buffalo, New York 14263
Dr. Robert L. Dixon	1987–88	Director of Toxicology Sterling-Winthrop Research Institute Columbia Turnpike Rensselaer, New York 12144
Dr. Lorraine Flaherty	1987–88	Chief, Laboratory of Immunology Wadsworth Center for Laboratories and Research New York State Department of Health Albany, New York 12201
Dr. Henry C. Pitot	1987	Director, McArdle Laboratory for Cancer Research The University of Wisconsin Madison, Wisconsin 53706
Dr. William J. Schull	1988	Director, Center for Demographic & Population Genetics The University of Texas Health Science Center Post Office Box 20334 Houston, Texas 77225
Dr. Shirley M. Tilghman	1988	Howard A. Prior Professor of the Life Sciences Department of Molecular Genetics Princeton University Princeton, New Jersey 08544
		Environmental Sciences Division
Dr. Charles R. Goldman	1987	Professor of Limnology Director of Tahoe Research Group Division of Environmental Studies University of California Davis, California 95616
Dr. Charles J. Mankin	1987–88	Director, Oklahoma Geological Survey The University of Oklahoma Norman, Oklahoma 73019
Dr. Leonard H. Weinstein	1987	Program Director, Environmental Biology Boyce Thompson Institute for Plant Research Cornell University Ithaca, New York 14853

Table 3 (continued)

Committee member	Year (FY)	Affiliation
Professor M. Gordon Wolman	1987–88	The Johns Hopkins University Department of Geography and Environmental Engineering Baltimore, Maryland 21218
	Health and Safety Research Division	
Dr. J. Norman Bardsley	1987–88	Lawrence Livermore National Laboratory P.O. Box 808, MS L-296 Livermore, California 94550
Dr. A. Welford Castleman	1987–88	Pennsylvania State University College of Science 152 Davey Laboratory University Park, Pennsylvania 16802
Dr. William A. Mills	1987–88	Senior Technical Advisor ORAU/CIRRPC 1019 19th Street NW E700 Washington, D.C. 20036
Dr. John M. Palms	1987–88	Vice-President for Academic Affairs and Professor of Physics Emory University Atlanta, Georgia 30322

Advisory Committee reviews. The division plans address research directions and goals. In addition, the plans identify future resource needs and a strategy for achieving the stated goals. The Laboratory's senior management reviews and approves division plans.

ORNL Advisory Board

The charter of the ORNL Advisory Board is to critique and provide advice on ORNL's goals and missions and to give general guidance to future directions. Convened for the first time in June 1984, the board meets semiannually. Dr. W. J. Rutter of the University of California is the member of the board who closely reviews the ORNL BES Program.

Performance Improvement Project

During FY 1985, the Performance Improvement Project (PIP) was initiated by Martin Marietta Energy Systems, Inc. PIP is designed to measure improvement, activities, or projects; identify and implement opportunities for improvement; and enhance recognition and awards programs. Formal training in the PIP concept is provided to all monthly employees to ensure awareness of and total participation in PIP.

Quality Assurance

Quality assurance (QA) is a high priority at the Laboratory; it is accomplished through close working relationships between divisional QA coordinators and ORNL QA staff.

Others

Other management tools, such as planning retreats, commitment systems, and subcontract and financial tracking systems, help to ensure sound management of BES programs. Such widely used tools as the electronic mail system and computerized tracking systems help expedite communication for managers as well as staff.

A comprehensive human research development program provides opportunities to salaried employees for further training in their fields and for broaden-

Table 4. Members of the Oak Ridge Associated Universities/Oak Ridge National Laboratory Committee on Human Studies

Name and degree	Affiliation
William W. Burr, M.D.	Oak Ridge Associated Universities
William H. Calhoun, Ph.D.	The University of Tennessee
James E. Crook, M.D.	Oak Ridge Associated Universities
Kenneth Flatt, B.S.	Oak Ridge Associated Universities
Howard R. Friedman, Ph.D.	Regional Mental Health Center
R. J. Michael Fry, M.D.	Oak Ridge National Laboratory
Shirley Fry, M.B., B.Ch. (MPH)	Oak Ridge Associated Universities
A. Seaton Garrett, Jr., M.D.	Oak Ridge National Laboratory
Stephen V. Kaye, Ph.D.	Oak Ridge National Laboratory
Karl F. Hubner, M.D.	The University of Tennessee
Melvin E. Koons, J.D.	Tennessee Innovation Center
Robert Lange, M.D.	The University of Tennessee
Ten-Ching Lee, Ph.D.	Oak Ridge Associated Universities
C. C. Lushbaugh, M.D.	Oak Ridge Associated Universities
L. Clifford McKee, M.D.	Vanderbilt University
Ruby L. Miller, B.S.	Martin Marietta Energy Systems, Inc.

ing their education. Selected managers and staff with high potential are given the opportunity to attend management-training seminars conducted by outside organizations, including universities.

Research in Progress

Overview

The major goals of ORNL's Biomedical and Environmental Sciences Program are (1) to study the interaction of energy-related physical and chemical agents with living organisms, including their transport, chemical evolution, adverse health effects, and ultimate consequences in humans and in their environment; (2) to contribute to DOE's Nuclear Medicine Program and other beneficial applications programs; (3) to transfer research findings and technological developments outside the Laboratory; and (4) to collaborate, where possible, with universities and the private sector.

Research areas in biology include mammalian genetics, molecular genetics, protein engineering, carcinogenesis, radiation biology, and chemical interactions and effects. Environmental science research covers biogeochemistry, hydrology, environmental toxicology, global ecology, environmental risk analysis, geology, carbon dioxide (CO_2), and acidic deposition. Health and safety research encompasses epidemiology, health assessments, radiation and chemical physics, dosimetry, nuclear medicine, and instrumentation development for sensitive detection and monitoring of chemicals.

In addition, three unique user facilities are supported by OHER: the HPRR, the NERP, and the Bioprocessing Research Facility User Resource. The NERP program coordinates all environmental research activities with other land uses and serves as the repository of data on long-term reservation research. The bioprocessing facility integrates physical resources from the Biology and Chemical Technology divisions to include bioreactors, a flow cytometry laboratory, large-volume fermenters, and centrifugal analyzers. Users of these facilities include staff of national laboratories and industry and students and staff from universities. We are in the process of integrating the laboratory's structural biology research activities. These activities are mainly distributed among five ORNL divisions.

Biology

The Biology Division's research centers on the mechanisms of action of deleterious agents on biological systems, particularly genomic effects of energy-related substances. The approach to this work is experimental and uses materials at all levels of biological organization to obtain data for predicting and understanding potential hazards to human health. The major areas of emphasis are heritable genetic effects, mutagenesis, and carcinogenesis, all of which involve molecular, cellular, and organismal studies of the consequences of damage to genetic materials. The division has major responsibilities and unique capabilities for genetic studies in mice, protein engineering, and radiation carcinogenesis.

Mammalian Genetics

The continuing program in mouse genetics and germ-line mutagenesis has been vitalized by the strong emergence of new themes made possible by staff additions and collaborative efforts with other laboratories. To understand the mechanisms for, and assess the risk from, the induction of heritable mutational damage, the program seeks to perfect methods for efficient detection of such damage, explore factors that affect yield, investigate the organismic expressions of mutations, and analyze the structural nature of the damage at the chromosome, gene, and molecular levels. Other closely related developing themes concern the area of

molecular analysis of structure and function of several specific regions of the mouse genome. The altered genes and chromosomes that have been (and continue to be) produced in the course of mutagenesis experiments (and are subsequently maintained as mouse stocks) supply an unparalleled wealth of genetic tools for these molecular analyses. Reciprocally, as knowledge of the molecular structure of a region is obtained, elucidation of the manner of action of mutagenic agents is facilitated. In addition, studies are being performed on the mechanism of induction of chromosomal alterations and gene mutations and their role in adverse genetic and somatic effects. The advent of molecular techniques has made such studies considerably more informative. One approach to relating molecular structure of genomic regions to gene action is by insertional mutagenesis via transgenic mouse technology (injection of DNA into a zygote nucleus). To strengthen the emerging themes in mammalian genome analysis, two molecular geneticists have been added to the staff.

Molecular Genetics

Areas of emphasis in molecular genetics include genomic structure, regulation of gene expression, and structure and function of gene products. Visualization of higher-order chromatin structure and the three-dimensional structure of nucleosomes (the core particle of chromatin) utilize special techniques in electron microscope tomography developed locally and X-ray diffractometry. Cloning of segments of the eukaryotic genome and their subsequent sequencing will provide insights about the nature of regulatory elements of DNA and the propensity of small regions of DNA to undergo spontaneous mutations. Model systems being used to study the regulation of gene expression include oncogenes (associated with the conversion of normal cells to cancer cells), mammalian genes that are under hormonal control, and mouse globin genes that provide an experimental system for thalassemia, a human genetic disorder. Gene products under close scrutiny include ribulosebisphosphate carboxylase (a determinant of biomass yield), epidermal growth factor (a polypeptide intimately involved in cellular growth and differentiation), enzymes involved in transcription of DNA, enzymes involved in the repair of chemically damaged DNA, and membrane transport proteins that are responsive to environmental insults.

Protein Engineering

Protein engineering (site-directed mutagenesis), an emerging program that is unique among DOE laboratories, integrates many activities in molecular genetics. The ability to program specific mutations into cloned genes will permit the systematic design of new gene products as mechanistic probes of protein function and the tailoring of operons to alter the regulation of gene expression. Molecular modeling with three-dimensional computer graphics will guide the selection of mutant gene products to be constructed and will serve as a predictive tool of the probable structural consequences. Because protein engineering provides an avenue for optimizing functional properties of enzymes, it impinges on bioprocessing.

Radiation Carcinogenesis

The research program in radiation carcinogenesis includes two major components, experiments designed to improve the assessment of health risks from exposure to radiation and related, fundamental studies of the genetic and host factors that are responsible for the progression of cancer. The objectives of the research are to provide data required for estimates of cancer induction by high linear-energy transfer (LET) radiation and low-LET radiation, to investigate the factors that influence expression and suppression of radiation-induced initiation of potential cancer cells, elucidation of the nature of the factors that control expression of potential cancer cells, development of methods to extrapolate risk estimates for radiation cancer induction, and to attempt to distinguish cancers on the basis of the causative agent. Two collaborative studies are in progress, one with Lawrence Berkeley Laboratory on heavy ion carcinogenesis and one with the Inhalation Toxicology Research Institute on the role of pyrimidine dimer repair in ultraviolet (UV) radiation-induced damage. Planned in addition are radon and related high-LET studies on (1) alpha-particle activation of oncogenes, (2) gene rearrangement involving mobile gene elements, (3) induction of chromosome aberrations, (4) malignant transformation of tracheal cells, and (5) determination of radiation biological effectiveness for alpha-particle-induced

cancers. A search is currently in progress for an additional molecular biologist to contribute to these studies.

Health Effects Information Research

The information research program provides an active interface between bench scientists and the rapidly expanding base of information. Sound scientific data management, analysis, and validation provide the basis for accurate research decisions as well as reliable health hazard evaluations and risk assessments. The development and application of such data resources is a top priority and is carried out in a variety of research areas. More than 80 data bases are being maintained. The concept is epitomized by the ongoing Genetic Toxicology Program and the Hazardous Substances Data Bank. The Environmental Mutagen Data Base alone contains 61,000 records on 18,000 chemicals. Quality assurance is a major driving force in these as well as other data resource development projects. Quality control procedures are implemented during data base development and followed by intensive review by panels of experts to help ensure the accuracy and completeness of the file contents. Detailed knowledge of such data resources makes possible their application to several areas of concern related to the potential health and environmental effects of hazardous materials. Many hazard assessment working documents and publications continue to be developed for DOE and other government agencies. On a local basis, the capabilities and resources have been used to develop a computerized Materials Safety Data Sheet system for informing Energy Systems employees of potential hazards on the job and to assist in the study and cleanup of the environment around the Oak Ridge facilities. Along with these activities, the evaluation of evolving computing technologies and their application in customized computing systems is a continuing and growing area of involvement.

Environmental Sciences

Environmental research is designed to increase the ability to predict transport and effects of energy-related contaminants in the environment. Basic information is developed on mechanisms that govern ecosystem function, particularly in biogeochemical cycling studies on eastern watersheds. Through utilization of process studies with stable elements, radionuclides, and trace organics as well as mathematical simulation models, data and methodologies are developed that enhance abilities to site and operate energy systems in a cost-effective and environmentally safe manner.

Integrated Watershed Research

Over the past 20 years, Walker Branch watershed (WBW) on the DOE Oak Ridge Reservation (ORR) has been the site of extensive research that has resulted in the development of new concepts and techniques in watershed science. This work has brought national and international recognition in the area of biogeochemical cycling to ORNL and DOE. As investigations on WBW have entered their third decade, it is timely to review and refine the research objectives. The focus of the WBW Integrated Research Program for the next decade will be on the hypothesis that hydrologic, aeolian (i.e., wind), and biogeochemical linkages between upslope and downslope subsystem control the structure and productivity of watersheds. This research program involves a unique mix of scientific approaches and tools, including the integration of field characterization studies, laboratory and field experiments, and systems analysis and modeling; networks of state-of-the-art physical and chemical sensors and computer data-acquisition systems; extensive use of tracers to quantify pathways and rate processes; and experimental manipulations of watersheds.

Transport and Transformation

Understanding and predicting the effects of air pollution on forests must be based on accurate measures of the flux of airborne materials to the landscape. Existing methods of measurement are limited by chemistry and time constraints, and alternative approaches are required. Detailed studies of the interactions of precipitation with the forest canopy and the resulting chemistry of rain below the canopy are being used to develop methods to determine long-term mean fluxes of dry-deposited particles under field conditions. These methods and our results have been widely applied in other research by state, university, private, federal, and international agencies interested in the acidic rain phenomenon.

Coastal Transport and Accumulation Processes

This research involves the measurement of naturally occurring and man-made radionuclides to trace and quantify transport and accumulation processes within the coastal zone. The high correlation between the transport and deposition of radionuclides and many other trace substances—such as hazardous organics, trace metals, and pesticides—makes it possible to infer the distribution and biogeochemical fate of a large number of substances from relatively simple and inexpensive analyses of radionuclides. Recently, in cooperation with scientists from Skidaway Institute of Oceanography, these sensitive techniques have been used to show that coastal bays and estuaries serve as effective traps for substances transported landward from oceanic sources as well as for materials transported downstream from drainage basin sources. In addition, these techniques are now being applied in contaminant transport and fate studies being conducted in freshwater systems in the Southeast. For example, radionuclides released from Oak Ridge Facilities are being used to elucidate short- and long-term processes controlling contaminant transport and biogeochemical fate in stream, river, and reservoir ecosystems. Technical guidance on environmental research is provided to DOE programs and offices on a regular basis.

Subsurface Transport Processes

Research in the subsurface sciences is directed toward defining, understanding, and predicting the movement of energy-related contaminants in the subsurface in humid regions with highly organic natural waters. Association with natural organic colloids may alter the transport and fate of contaminants. The program consists of field and laboratory studies that are integrated with development and application of hydrologic and chemical transport models. New areas of emphasis include research on the role of colloids and microbial populations in affecting subsurface transport and transformation of energy by-products. ORNL will continue to support OHER's Site-Directed Subsurface Initiative. Unique field facilities consist of fully instrumented watersheds in which chemicals can be released and traced as they move through the soils in one, two, or three dimensions. Field-derived data are used in model development and verification.

Biological Responses to Stress

The productivity and biogeochemistry of forest ecosystems is highly dependent on the growth and physiology of component forest tree species, and OHER-sponsored research is addressing the processes governing the response of terrestrial vegetation to environmental stresses of natural and anthropogenic origin. Using a combination of field and laboratory studies, research is focusing on the mechanisms controlling (1) exchange (deposition and emission) of trace gases of the atmosphere-biosphere interface, (2) photosynthetic carbon dioxide assimilation and water use efficiency, and (3) interactive effects of multiple stresses on terrestrial vegetation. Each of these tasks is being addressed from the perspective of whole-plant physiology.

National Environmental Research Park

In 1980, 5500 ha (13,585 acres) of the ORR were designated as a NERP. Although not primarily a research program, the Oak Ridge NERP provides protected land areas with a data base of information and in close proximity to Laboratory facilities for research. The park lies in the heart of an eastern deciduous forest area of streams and watersheds, mesic hardwood forests, and extensive upland mixed forests. Elaborate monitoring systems enable users to measure environmental factors precisely and accurately for extended periods. Various sites in the park offer opportunities for aquatic, atmospheric, and terrestrial ecosystem analyses, such as biogeochemical cycling of pollutants resulting from energy-producing facilities, landscape alterations, and forest and wildlife management.

Use of the NERP by ORNL staff, university, high school, and junior high school personnel and other agencies has increased over the last five years and is expected to continue to increase. Current research programs in the park include a study of the effects of atmospheric deposition on vegetation, short-rotation woody crops field trials, and studies on how physiological processes in plants and forest nutrient relationships are influenced by intensive silviculture and biological monitoring of ORR streams and reservoirs.

Carbon Dioxide Research and Analysis Program

This activity is managed by ORNL for DOE and has been realigned along with other components of

the DOE Carbon Dioxide Research Program for the next five-year effort. New research is anticipated in resource analysis. Integrated regional resource analysis models will be developed to account for the responses of resources to the increasing CO_2 concentration and resulting climatic change. Research efforts focus on assembling and implementing disaggregated (multidimensional) models of the global carbon cycle. Management activities involve contract execution activities for the DOE Carbon Dioxide Research Program, particularly in the areas of oceanic and atmospheric data collection and analysis. This broad array of activities and expertise is necessary for developing the information and models needed to provide accurate projections of CO_2 buildup in the atmosphere over the next century from both natural and anthropogenic sources. Direct and indirect effects of CO_2 on forest communities are being evaluated through both experimental and mathematical simulation exercises.

The Carbon Dioxide Information Analysis Center (CDIAC) supports the nation's CO_2 research program and cooperates in information exchange with the international scientific community by addressing global atmospheric CO_2 problems. CDIAC's research reflects new programmatic directions, with emphasis on novel approaches to the exploratory analysis of highly variable data and to synthesizing information for evaluating complex environmental issues. CDIAC provides details on content, accessibility, format, and usefulness of the needed data sets. In addition to literature and numeric data, CDIAC collects, organizes, evaluates, packages, and disseminates computing technology (algorithms, codes, and models) as needed to support a global assessment of the CO_2 issue.

Landscape Patterns and Processes

For the past decade, ORNL has conducted a series of studies on the fundamental properties of natural systems and the response of these systems to natural and human disturbances. The scale of these studies has ranged from microcosms held under laboratory control to discrete watersheds in the southeastern United States. Our research indicates that detailed site-specific problems are not readily extrapolated to broader spatial scales, while broad-scale analyses have lacked the resolution necessary to incorporate detailed studies of spatial heterogeneity. Therefore, there has been a growing need to coalesce these widely disparate studies to develop first-order principles that address landscape problems.

We are currently conducting theoretical and modeling studies designed to develop methods for measuring ecological patterns of natural and managed landscapes, relating these patterns to processes, and estimating how these patterns will change as a result of broad-scale disturbances. Research results will be used to organize information from laboratory and site-specific studies for extrapolation to landscape scales. Extrapolation will provide several applications and may lead toward a general theory of landscape ecology with application to site management issues.

Anticipating Global Change

ORNL continues to offer the strongest encouragement and technical support to OHER planning for a global sciences initiative.

Health and Safety Research

Health and safety research is directed toward basic and applied research involving the potential health impacts of energy-related technologies.

Research includes (1) studies of the properties of physical, biological/chemical, and environmental systems and their interactions, (2) developing measurement capabilities that meet present and future needs for assessing exposures of people to various insults, and (3) assessment methodologies that allow quantitative evaluations concerning the present and future impacts of various energy strategies, energy production levels, and potential energy-related mishaps.

Radiation Calibration Laboratory

The Health and Safety Research Division is responsible for RADCAL, a new facility to house radiation sources and equipment for (1) radiation dosimetry research, (2) testing of compliance with performance standards, (3) expanding existing dosimetry intercomparison studies, (4) training of dosimetrists, and (5) calibration of operational instruments.

This facility is currently being outfitted with beta, gamma, neutron, and X-ray radiation sources. All combinations of NBS-calibrated sources are being installed to meet the requirements of the two U.S.

performance standards test programs: National Voluntary Laboratory Accreditation Program and the Department of Energy Laboratory Accreditation Program.

Metabolism and Dosimetry Research Studies

Research in metabolism and dosimetry is directed toward understanding the relationship between radiation exposure and the dose to organs of the body. These relationships are defined through the modeling of the metabolism of radionuclides taken into the body and the modeling of the deposition of ionizing energy within the radiosensitive tissues from these intakes or from exposures to radiation external to the body. Such relationships provide a cornerstone for development of radiation protection guidelines for the numerous radionuclides encountered in the workplace and environment and serve an important role in the evaluation of diagnostic procedures involving radiopharmaceuticals and diagnostic X-ray machines. Development of metabolic and dosimetric models that allow consideration of special characteristics of individuals or of segments of the population is now in progress.

Dosimetry for Human Exposures

Critical contributions to the joint U.S.-Japan Dosimetry reevaluation effort were completed and are documented by the authorship of three chapters in *U.S.-Japan Joint Reassessment of Atomic Bomb Radiation Dosimetry in Hiroshima and Nagasaki*, Vol. 1, W. C. Roesch, editor, Radiation Effects Research Foundation, Hiroshima, Japan (1987). The publication documents in detail a new nuclear radiation dosimetry system, DS86, resulting from a joint, seven-year U.S.-Japan dosimetry reassessment effort. The dosimetry system was developed after extensive reexamination of existing human exposure data and incorporation of recent information. The new dosimetry system will support more accurate, defensible estimates of risk from radiation exposure.

G. D. Kerr spearheaded important parts of the U.S. technical effort and assisted in the completion of the cited publication while on assignment in FY 1987 to the Radiation Effects Research Foundation in Hiroshima.

Chemical and Radiological Physics

The physical and technological research activities under OHER support are directed toward increasing knowledge of the interactions of potentially hazardous agents with biological and environmental systems and toward ensuring a technical capability for characterizing and quantitatively measuring such agents in various settings. The research consists of studies of the structures and properties of materials of biological or environmental importance; the physical and chemical mechanisms that govern the formation, transport, and chemical transformation of radiation products in liquid media; the pollutants in the atmosphere, hydrosphere, and biosphere; and of the development of advanced instrumentation needed to satisfy the requirements of OHER.

Included in the scope of this work are theoretical and experimental studies of interactions at the atomic, molecular, and macroscopic levels in solids, liquids, and gases and on solid surfaces and solid-liquid interfaces. Also, detailed Monte Carlo studies are made of the physical and chemical evolution of radiation-induced products in natural media and in biological materials.

Instrument Development

Emphasis is placed on developing techniques that provide advanced instrumentation for characterizing and sensitively detecting a wide variety of radiological and chemical species. Included in this effort are unique applications of laser optical techniques, UV and soft X-ray spectroscopic techniques, electron-beam microlithography, scanning tunneling microscopy, surface-enhanced Raman spectroscopy, and advanced neutron dosimetry and microdosimetry, and a new program in picosecond spectrographic studies.

A continuing research activity is the development of new instruments and measurement techniques to support evaluation of the potential health and environmental impact of developing energy technologies. This research includes advanced studies on monitoring chemical exposures of humans through instrumentation and biological indicator systems. Results of this research have led to cost-effective luminescence techniques for rapid screening of samples containing polynuclear aromatic compounds as well as portable instrumentation for on-site use at operating facilities. Recently, applications have been made to the detection of DNA adducts. Development of promising techniques for other biological indicators is in progress.

The OHER-funded developmental research has resulted in support from other agencies and organizations for applied studies. Transferring this technology to the commercial sector is an important objective that has met with noteworthy success in the past four years.

Health Physics Research Reactor

The Health and Safety Research Division was responsible for the HPRR through the first quarter of FY 1988. The reactor is a unique research facility. A small, unshielded, unmoderated fast reactor, the HPRR yields up to 1×10^{17} fissions in the pulse mode and 10 kW in the steady state mode. The HPRR is used in technology transfer and in radiobiology and dosimetry research. It is also used for criticality alarm testing, weapon simulation, education, training, and instrumentation development. Stewardship for this facility is being considered by another division.

Nuclear Medicine

The Nuclear Medicine Program is involved in the design, development, and animal testing of new radiopharmaceuticals for diagnostic and therapeutic applications in nuclear medicine. The program continues to receive widespread international recognition for the innovation of new, improved radiolabeling techniques and the design of tissue-specific agents for the evaluation of tissue metabolism, perfusion, and anatomy. Emphasis on research in cardiovascular disease has resulted in the development of radioiodinated fatty acid energy substrate analogues uniquely suited for evaluation of the early stages of heart disease. These agents are now being clinically tested. The new, improved osmium-191/iridium-191m radionuclide "generator" system producing iridium-191m ($T_{1/2}$ = 5 s) for cardiovascular studies was awarded a patent, and marketing of this technology is being aggressively pursued. Interaction with over 25 medical cooperative programs with clinics, hospitals, and various other research institutions allows effective, rapid technology transfer to bring these agents into clinical use. A Center of Excellence in nuclear medicine is being proposed in conjunction with UT and Oak Ridge Associated Universities.

Risk Assessment

The Risk Assessment Program is focusing on an evaluation of the scientific bases for assumptions used in the cancer risk assessment process. The cancer process can be separated into a pharmacokinetic phase and a pharmacodynamics phase. The former relates applied dose to effective dose at the target tissue, while the latter relates effective dose with biological effect. The program is evaluating the use of biologically based pharmacokinetic and pharmacodynamic models in risk assessment.

Program Accomplishments

Accomplishments in the Biomedical and Environmental Sciences programs include advances toward understanding potential health and environmental impacts of energy technologies and fundamental biological processes, as well as developing innovative research techniques and instrumentation. These research findings have resulted in numerous publications and awards (Tables 5 and 6). Numbers and types of publications are presented in the Resource Quantitation chapter (see also Trimble et al. 1987).

The most significant biomedical and environmental research accomplishments are listed below by division. Editorial board memberships and offices held by Biomedical and Environmental Sciences personnel are presented in Tables 7 and 8, respectively. Research highlights for the OHER Program are included in Appendix A.

Analytical Chemistry

1. Resolution of 500,000 theoretical plates for the separation of nucleotides by micellar electrokinetic capillary chromatography has been achieved.
2. Wall-catalyzed oxidation reactions in conjunction with negative ion mass spectrometry were found to yield structural insight regarding the position of alkyl and amine substituents on aromatic ring systems.
3. Laser desorption Fourier transform mass spectrometry has allowed the mass spectra of modified nucleotides and small oligonucleotides to be obtained. Combined with MS/MS techniques, this approach has been used to distinguish six isomeric methyl-substituted guanosines.

Biology

1. Produced chromosome aberrations by introduction of restriction endonucleases into mammalian cells by osmolytic shock.
2. Used expression studies with dominant skeletal mutations to discover a strong effect of genetic background on penetrance, as well as to demonstrate interactions (both synergistic and antagonistic) between independent mutations.
3. Applied alkaline-elution techniques to mouse sperm DNA and demonstrated that the frequency of single-strand breaks induced in germ cells parallels that for certain transmitted genetic effects.
4. Prepared monoclonal antibodies that reach specifically with a glycoprotein marker on endothelial cells of the blood vessels of the mouse lung.
5. Demonstrated that the clinically useful antidiuretic amiloride and several analogs, known to function by preventing Na^+ and water reabsorption in the distal tubule of the kidney, have the further effect of inhibiting both Na^+ and glucose reabsorption in cloned cultured cells derived from the proximal tubule.

Environmental Sciences

1. Plutonium-238 releases from the Savannah River Plant have been used to show that coastal bays and estuaries serve as effective traps for radionuclides transported landward from oceanic sources as well as from land-based sources.
2. Three indices of pattern derived from information theory and fractal geometry have been

Table 5. Professional, corporate, and organizational awards received by Office of Health and Environmental Research-supported personnel in FY 1987

Recipient(s)	Award
Auerbach, S. I.	DOE Distinguished Associate Award (1987)
Callcott, T. A., and E. T. Arakawa	Martin Marietta Energy Systems, Inc., Inventor Award (1986) for design, construction, and testing of a new type of soft X-ray emission spectrometer that is the most efficient instrument of its type in the world
Chen, C-H., S. D. Kramer, and M. P. McCann	I-R 100 Award, "Crystal Laser Monitor" (1987)
Christophorou, L. G.	Martin Marietta Energy Systems, Inc., Inventor Award (1986) for continued, innovative development of gaseous media for advanced technologies that led to 13 patents and, particularly, for the patents on repetitive pulsed-power switches.
Coutant, C. C.	Society for Technical Communications Distinguished Technical Communication Award (1987) Technical Communication Award, East Tennessee Chapter of the Society for Technical Communications (1987)
DeAngelis, D. L., W. M. Post, and C. C. Travis	Martin Marietta Energy Systems, Inc., Publication Award (1987) for *Positive Feedback in Natural Systems*
Gardner. R. H.	Martin Marietta Energy Systems, Inc., Technical Achievement Award (1987)
Griesemer, R. A.	Ohio State University, Distinguished Alumnus Award (1987)
Hartman, F. C., C. D. Stringer, S. Milanez, and E. H. Lee	Martin Marietta Energy Systems, Inc., Publication Award (1987)
Hunsaker, C. T.	Association for Women in Science Award for Service to the East Tennessee Chapter (1987)
Kanciruk, P.	EPA Bronze Medal for Commendable Service
King, A. W.	University of Tennessee Chancellor's Citation for Extraordinary Professional Promise (1986)
Knapp, F. F., Jr.	ORNL Health and Safety Research Division Excellence in Research Award (1987)
Lindberg, S. E.	Alexander von Humboldt Research Fellowship Award, University of Gottingen (1987)
Lindberg, S. E., G. M. Lovett (Cary Arboretum), D. D. Richter (Duke University), and D. W. Johnson	Martin Marietta Energy Systems, Inc., Publication Award (1987)
Luxmoore, R. J.	Martin Marietta Energy Systems, Inc., Technical Achievement Award (1987)

Table 5 (continued)

Recipient(s)	Award
Olins, A. L.	Eleanor Roosevelt International Cancer Fellowship (1987)
	Theodor Boveri Award, University of Wurzburg (1987)
Olins, D. E.	American Cancer Society, Scholar in Cancer Research Award (1987)
	Theodor Boveri Award, University of Wurzburg (1987)
O'Neill, R. V.	Martin Marietta Energy Systems, Inc., Technical Achievement Award (1987)
Ramos, S. J.	Martin Marietta Energy Systems, Inc., Operational Performance Award (1986) for organizing and leading a PIP team that significantly reduced the probability of incorrect exclusion recommendations on property surveys at Grand Junction, Colorado
Reichle, D. E.	Martin Marietta Energy Systems, Inc., Community Service Award (1987)
Russell, L. B.	U.S. Department of Energy, Distinguished Associate Award (1987)
	Who's Who in America (1987)
Sims, C. S.	Martin Marietta Energy Systems, Inc., Operational Performance Award (1986) for materially expanding the research and technology transfer applications of the Health Physics Research Reactor and for establishing international leadership in neutron dosimetry
Skinner, D. M.	Women in Cell Biology, American Society of Cell Biology, Career Recognition Award (1987)
Srivastava, P. C.	Martin Marietta Energy Systems, Inc., Inventor Award (1986) for development of an innovative approach for the brain-specific delivery of diagnostic radiopharmaceuticals.
Trabalka, J. R.	Technical Communication Award, East Tennessee Chapter of the Society for Technical Communication (1987)
Travis, C. C. (Editor)	Society for Technical Communication Award, Recognition of Merit in Whole Periodicals (1987) for the publication *Risk Analysis*
Ullrich, R. L.	Radiation Research Society, Research Award (1987)
Vo-Dinh, T., M. J. Sepaniak, B. J. Tromberg, G. D. Griffin, and K. R. Ambrose	I•R 100 Award, "Fiber-Optics Fluoroimmuno Sensor" (1987)
Walton, B. T.	Association for Women in Science for Distinguished and Sustained Contributions to Science (1987)
Yeh, G. T.	Martin Marietta Energy Systems, Inc., Publication Award (1987)

Table 6. Professional, corporate, and organizational achievements received by Office of Health and Environmental Research-supported personnel in FY 1987

Recipient(s)	Achievement
Auerbach, S. I.	Appointed member of the Executive Committee, Science Advisory Board, U.S. Environmental Protection Agency
	Appointed member of the Committee on Magnetic Fusion, Energy Engineering Board, National Academy of Engineering
Compton, R. N.	Corporate Fellow, Martin Marietta Energy Systems, Inc. (1987)
Hively, L. M.	Full-time Advisor to Office of Energy Research, Office of Fusion Energy, U.S. Department of Energy (1986–1987)
Kaye, S. V.	Fellow, American Association for the Advancement of Science (1987)
Kerr, G. D.	Visiting Scientist, Radiation Effects Research Foundation, Japan (September 1986–August 1987)
Knapp, F. F., Jr.	Awarded Patent CNID 4449, "Osmium-191/Iridium-191m Radionuclide Generator"
Kroodsma, R. L.	Elective member, American Ornithologists' Union
Payne, M. G.	Awarded U. S. Patent 4,694,197, "Double Pulsed Time-of-Flight Mass Spectrometer"
Ritchie, R. H.	Recipient, NATO Research Grant (1987–1988)
Russell, L. B.	Inducted into the National Academy of Sciences (1987)
Sauers, I.	Awarded U.S. Patent 4,633,082, "Process for Measuring Degradation of Sulfur Hexafluoride in High-Voltage Systems"
Turner, M.	Fellow, Alexander Hollaender Distinguished Postdoctoral Fellowship
Vo-Dinh, T.	Awarded Patent CNID 4532, "Practical Substrate and Apparatus for Static and Continuous Monitoring by Surface-Enhanced Raman Spectroscopy"

shown to capture major features of landscape pattern, and one index is correlated with degree of human manipulation of the landscape.

3. Results from Walker Branch watershed on the mechanisms and rates of calcium dry deposition have been selected by EPA for application to a large-scale study of lake acidification for the National Acid Precipitation Assessment Program.

4. Isotopic studies of sulfur dynamics in trees on Walker Branch watershed have shown that leaching of internal foliar S from tree leaves by rainfall is a minor component of throughfall sulfate; therefore, the dry deposition (gaseous and particulate) of S to forests impacted by sulfur pollution may be estimated from measurements of sulfate in throughfall.

5. ORNL hosted an international meeting for DOE's Subsurface Transport Program. Scientists attending the meeting concluded that ample evidence exists to show that colloidal particles in aquifers are capable of binding organic and inorganic contaminants and altering their mobility in the subsurface environment.

6. The United States and the People's Republic of China (PRC) signed a joint agreement to study global climate change. Communications links for data exchange have been enhanced

Table 7. Editorial board memberships of Office of Health and Environmental Research-supported personnel during FY 1987

Board member	Publication
Adams, S. M.	*Biological Communities of the Southeastern United States* (1985–)
Adler, H. I.	*Radiation Research*, Associate Editor (1980–1987)
Auerbach, S. I.	*Environmental and Experimental Botany* (1967–) *Environmental International* (1979–)
Bondietti, E. A.	*Journal of Environmental Radioactivity*, Associate Editor, (1983–)
Buchanan, M. V.	*Biomedical and Environmental Mass Spectrometry* (1986–1990) *Fourier Transform Mass Spectrometry: Evolution, Innovation and Applications*, ACS Books, Editor (1987–)
Cook, J. S.	*American Journal of Physiology*, Associate Editor (1981–1987), Acting Editor (1984–1985) *Cell and General Physiology*, American Physiological Society Handbook Series, (1982–present) *Current Topics in Membranes and Transport*, Advisory Board (1983–present) *News in Physiological Sciences*, Editorial Board (1985–1986), Deputy Editor (1986–1988)
Coutant, C. C.	*Transactions of the American Fisheries Society* (1986–)
Eckerman, K. F.	*Radiation Protection Dosimetry Journal* Editorial Board Member, (1980–present)
Generoso, W. M.	*Teratogenesis, Carcinogenesis, and Mutagenesis* (1979–present) *Mutation Research* (1985–1988) *Molecular Toxicology* (1987–present)
Hamm, R. N.	*Radiation Research*, Associate Editor (1985–1988)
Hartman, F. C.	*Journal of Protein Chemistry* (1982–1992) *Journal of Biological Chemistry* (1983–1988)
Hunsaker, C. T.	*The Environmental Professional* (1986–)
Johnson, D. W.	*Journal of Environmental Quality*, Associate Editor (1985–)
Kimmel, B. L.	*Lake and Reservoir Management* (1986–) *Limnology and Oceanography* (1987–1990)
Klots, C. E.	*International Journal of Mass Spectrometry and Ion Physics* Associate Editor (1983–present)
Lindberg, S. E.	*Advances in Environmental Sciences* (1986–)
Luxmoore, R. J.	*Soil Science Society of America Journal*, Associate Editor (1986–) *Tree Physiology*, Associate Editor (1986–)
Mazur, P.	*Cryobiology* (1967–present)
Norby, R. J.	*Tree Physiology* (1987)
Olins, A. L.	*European Journal of Cell Biology* (1982–present) *Molecular and Cellular Biochemistry* (1982–1985)
Olins, D. E.	*Molecular and Cellular Biochemistry* (1983–1986)
Preston, R. J.	*Mutation Research* (1977–present) *Environmental and Experimental Botany* (1979–present) *Mutation Research Letters*, Managing Editor (1980–present) *Teratogenesis, Carcinogenesis, and Mutagenesis* (1980–present)
Regan, J. D.	*Cell Biology and Toxicology* (1983–present)
Reichle, D. E.	*Pedobiologia* (1975–) *Journal of Soil Biology and Ecology* (1987–) *Advanced Texts in the Life Sciences*, Series Editor, Springer-Verlag (1978–)

Table 7 (continued)

Board member	Publication
Russell, L. B.	*Mutation Research* (1976–present) *Mouse News Letter* (1986–)
Sega, G. A.	*Environmental Mutagenesis* (1985–)
Skinner, D. M.	*Growth* (1979–present) *Gene* (1986–present)
Smith, E. D.	*Nuclear Safety*, Environmental Effects Section Editor (1985–)
Stow, S. H.	*Environmental Geology and Water Resources* (1984–)
Suter, G. W.	*Environmental Toxicology and Chemistry* (1987–1989) *SETAC News*, Associate Editor
Travis, C. C.	*Risk Analysis*, Editor-in-Chief (1983–present)
Ullrich, R. L.	*Radiation Research* (1983–1989)
Van Hook, R. I.	*Biomass*, Associate Editor (1985–)
Watson, A. P.	*Environmental Management*, Book Review Editor (1984–present)
Witherspoon, J. P.	*Nuclear Safety*, Environmental Effects Editor (1983–)
Yalcintas, M. G.	*Biology and Medicine Division Newsletter* American Nuclear Society, Editor (1985–present)

by Carbon Dioxide Information Analysis Center-designed computerized data acquisition and certification systems and by interactions with visiting PRC scientists.

Health and Safety Research

1. Developed, constructed, and installed at the National Synchrotron Light Source a new type of soft X-ray emission spectrometer that is the most efficient instrument of its type in the world.
2. Obtained first observation of optically enhanced electron attachment.
3. Obtained first identification of multiphoton ionization mechanisms in liquids.
4. Developed two electron scanning-tunneling microscopes and obtained atomic resolution of solid surfaces in ultrahigh vacuum and in air.
5. Documented extensive work to produce a single set of predicted urinary excretion rates consistent with available physiologic and metabolic information, which significantly increases the accuracy of estimates of plutonium body burdens from bioassay measurements.
6. Contributed to formulation and documentation of a new nuclear radiation dosimetry system, DS86. The new system resulted from a joint, seven-year U.S.-Japan dosimetry reassessment effort.
7. Constructed a computerized axial tomography (CAT)-scan imaging workstation, centered around an IBM PC/AT, for processing data acquired under normal medical diagnostic procedures. The data obtained is being used to establish digital representations of the body for use in radiation transport calculations.
8. Developed a physiologically based pharmacokinetic model for metabolism of methyl chloroform in mice, rats, and humans.
9. Developed a new technique for conducting two-photon spectroscopic studies of high-lying molecular energy levels. The method involves the use of the ninth harmonic of an Nd:YAG laser plus a tunable dye laser to efficiently access states with energy >10 eV.

Table 8. Officers of societies among Office of Health and Environmental Research-supported personnel during FY 1987

Officer	Office, Society
Berven, B. A.	Chairman, Environmental Section of the Health Physics Society Standards Committee (1985–present)
Buchanan, M. V.	Advisory Committee, National Science Foundation, Biological Facilities Center Program Chairman, Environmental Applications Group, American Society for Mass Spectrometry Councilor, East Tennessee Mass Spectrometry Discussion Group
Chester, R. O.	Member, Executive Committee of the Environmental Sciences Division, American Nuclear Society (1985–1988)
Compton, R. N.	Executive Committee Member, Division of Electron and Atomic Physics, American Physical Society (1984–1987)
Coutant, C. C.	President, Southern Division, American Fisheries Society (1987)
	President, Tennessee Chapter, American Fisheries Society (1987)
Cristy, M. T.	Vice-Chairman, Task Group on Revision of Reference Man, Committee 2 on Secondary Limits, International Commission on Radiological Protection (1984–present)
Cushman, J. H.	President, East Tennessee Chapter, Association for Women in Science (1985–1986)
Eckerman, K. F.	Chairman, Task Group on Dose Calculations, Committee 2 on Secondary Limits, International Commission on Radiological Protection (1982–present)
Foley, R. D.	Treasurer, East Tennessee Chapter, Health Physics Society (1986–)
Gammage, R. B.	Chairman, Indoor Air Quality Committee, American Industrial Hygiene Association (1987–1988)
Graham, R. L.	Vice President, East Tennessee Chapter, Association for Women in Science (1987–1988)
Huff, D. D.	President, Tennessee Section of the American Institute of Hydrology
Lindberg, S. E.	Secretary, National Atmospheric Deposition Program Member, Executive Committee, National Atmospheric Deposition Program
Little, C. A.	Chairman, Awards Subcommittee, Manpower and Professional Education Committee, Health Physics Society (1986–1987)
Mazur, P.	Board of Governors, Society for Cryobiology (1981–1987) Chairman, Publications Committee, Society for Cryobiology (1974–)
Preston, R. J.	Chairman, Nominating Committee, Environmental Mutagen Society (1986–)
Ramsey, R. S.	Program Chairman, East Tennessee Chromatography Discussion Group
Reichle, D. E.	Chairman, Public Affairs Committee, Ecological Society of America Member, National Board of Governors, The Nature Conservancy (1982–) Member, Governing Council, Ecological Society of America
Ritchie, R. H.	Member, Executive Committee, Southeastern Section, American Physical Society
Sigmon, C. F.	Treasurer, East Tennessee Chapter, Association for Women in Science (1987–1988)
Sims, C. S.	Chairman, ANSI N13.11 Review Working Group, Health Physics Society (February 1987–present)

Table 8 (continued)

Officer	Office, Society
Skinner, D. M.	Board of Governors (North America), The Crustacean Society (1987–)
Solomon, A. M.	Chairman, Education Committee, Ecological Society of America (1983–)
Stow, S. H.	Secretary-Treasurer, Southeastern Section, Geological Society of America (1980–1987) Councilor, Geological Society of America (1986–1989)
Swaja, R. E.	Chairman, ASTM E10.04 Committee on Criticality Accident Dosimetry (1986–present)
Travis, C. C.	Chairman, Scientific Bases for Risk Assessment Assumption, Office of Science and Technology Policy (1986–present)
	President-elect, Society for Risk Analysis, East Tennessee Chapter (1987–1988)
Trimble, J. L.	President, East Tennessee Chapter, Association for Women in Science (1987–1988)
Vo-Dinh, T.	Cochairman, International Committee on Polycyclic Aromatic Compounds (1985–present)
	Secretary, Technical Committee TT-6 on Energy–Environmental Interactions, Air Pollution Control Association (1984–present)
	Program Chairman, Air Pollution Control Association, East Tennessee Chapter (1987–present)
Walton, B. T.	Board of Directors, Society of Environmental Toxicology and Chemistry (1984–1987)
Wright, L. L.	Secretary, East Tennessee Chapter, Association for Women in Science (1986–1988)
Yalcintas, M. G.	Chairman, Organ Dose Committee, Biology and Medicine Division, American Nuclear Society (1980–present)
	Chairman, Program Committee, Biology and Medicine Division, American Nuclear Society (1984–present)

10. Showed how a two-photon interference effect produced a new and comprehensive explanation for low efficiencies of four-wave mixing schemes for ultraviolet light production in which two-photon resonances are used to enhance the yields of ultraviolet photons.
11. Initiated clinical testing of the new iodine-123–labeled, methyl-branched, fatty acid agent for evaluation of heart disease.
12. Developed a new radioiodinated-maleimide-protein-labeling method for the radioiodination of antibodies and other proteins, which overcomes the problems associated with loss of iodide encountered with current methods.
13. Further developed fluoroimmunosensor technology, using laser excitation, which results in an absolute limit of detection of femtomoles 10^{-15} for benzopyrene and attomoles 10^{-18} for benzo(a)pyrene tetrol.
14. First demonstrated that calcium atoms of the periodic chart form stable negative ions in their electronic ground state.

Program Orientation

The ORNL/OHER budget proposal for FY 1987–1990 is summarized in Table 9. Budgets for FY 1988 and FY 1989 are expected to increase above these initial planning estimates. Significant planned activities summarized by division follow.

Biology

During the past several years, a major consolidation of effort has taken place to strengthen and focus the division's research program on experimental genetics. The effort, which started prior to FY 1987 to integrate significant molecular genetics initiatives into the mammalian genetics program, will continue in FY 1988 and FY 1989. By FY 1989 and beyond, our work with modern molecular tools such as insertional mutagenesis will be well established. The program in radiation carcinogenesis will be maintained, contingent on the availability of the Health Physics Research Reactor for neutron irradiations and the Biology Division's ^{137}Cs sources. Expected trends in molecular genetics research in the new initiative in protein engineering and in radiation carcinogenesis are briefly described below.

The Mammalian Genetics Program, in addition to pursuing several exciting discoveries growing out of germ-line mutagenesis studies, is embarking on a long-range activity to gain molecular access to several regions of the mouse genome. The objectives are to explore the structural nature of induced mutations and of the normal DNA from which they arose, to identify hitherto unknown genes and gene products that are important for normal mammalian development, to correlate defined DNA sequences with physiologically significant heritable types, and to directly analyze the structure and function of homologous regions of the human genome. The major genetic tools for achieving these objectives are a series of overlapping deletions, derived from past mutagenesis studies, that have already been utilized for the construction of functional maps in chromosomal regions of considerable length. Consequently, after molecular chromosome mapping within these regions has been achieved, the outcome need not stand alone as a sterile catalog; it can be readily associated with the functional information. To augment the structure-function correlations, saturation mutagenesis experiments have also been initiated that will load the regions corresponding to the long deletions with point mutations or very small deletions. In a related but independent effort, a project of insertional mutagenesis is planned in which

Table 9. Oak Ridge National Laboratory/Office of Health and Environmental Research budget and subcontracts (thousands of dollars)

Budget	FY 1987	FY 1988	FY 1989	FY 1990
Total ORNL/OHER in-house budget	22,866	22,648	23,602	25,038
Total subcontracts	2,861 (11.1%)[a]	2,925 (11.4%)[a]	2,975 (11.1%)[a]	3,100 (11.0%)
Total ORNL/OHER budget	25,727	25,573	26,577	28,138

[a]Percent of total ORNL/OHER budget.

mutations will be induced by the integration of exogenous DNA introduced into the male pronucleus of the fertilized egg. Once such mutations have been recovered, the disrupted regions of DNA are readily analyzable by virtue of the integrated foreign sequences.

Among the mutagenesis studies in progress are several areas that are receiving special emphasis. The extreme sensitivity of the zygote to a unique combination of endpoints is being intensively investigated in cytogenetic and developmental analyses. Collaborative studies were initiated to explore whether chemicals can bring about mutations by stimulating insertion of transposable elements. Other areas of emphasis include the basic mechanisms underlying correlations between dominant phenotypes (which are highly important for risk considerations) and presumed balance chromosome rearrangements and other aberrations; the use of isolated specific germ-cell types for the detection of potentially transmissible genetic damages; study of adduct locations in chromatin to illuminate the basis for dose-rate effects and for stage-related sensitivities; and the use of X-autosome translocations as tools for studies of gene action, chromosomal synapsis, genome mapping, and the derivation of DNA libraries enriched for desired chromosomal segments.

Protein engineering, a new initiative in 1985, has made significant strides. Protein engineering utilizes recombinant DNA technology to systematically change protein structure, thereby providing a powerful tool for elucidating enzyme mechanisms and potentially for altering the properties of enzymes in predictable and desirable fashions. The two major objectives were to establish this newly emerging expertise within the Biology Division and to subsequently apply this expertise to questions concerning the mechanism of action of proteins relevant to DOE missions. Initiated with partial support from ORNL's Laboratory Director's R&D Fund, this program represents a collaborative effort that involves eight senior staff members of the Molecular Genetics Section (Biology Division) and integrates activities in biochemistry and molecular genetics. Research is focusing on the structure/function correlations of three proteins: ribulose bisphosphate carboxylase (a determinant of biomass yield), DNA-O^6-methylguanine methyltransferase (a DNA repair enzyme), and human epidermal growth factor (a polypeptide that regulates cell growth and differentiation).

Ubiquitous among photosynthetic organisms, ribulose bisphosphate carboxylase (Rubisco) is essential for net conversion of atmospheric CO_2 into carbohydrates. Thus, this enzyme is a major cornerstone of living processes and is highly relevant to the production of biomass for energy and to the global CO_2 issue (i.e., the greenhouse phenomenon). The enzyme is bifunctional. Although multiple substrate specificities among enzymes are not unusual, the bifunctionality of Rubisco is perhaps unprecedented in that the two reactions catalyzed are the initial steps in competing metabolic pathways—photosynthetic assimilation of CO_2 and photorespiration, the latter of which is an energy-wasteful process without a known function that results in the release of previously fixed CO_2. The objectives of site-directed mutagenesis studies are (1) to understand the mechanism of this complex enzyme, especially the roles of specific amino acids and domains in interaction with substrates and in mediating the discrete catalytic steps, and (2) to evaluate the feasibility of improving the carboxylase/oxygenase activity ratio and thereby provide an approach to enhancing biomass yields. A large number of Rubisco mutants have been constructed in which specific amino acids within the catalytic site have been replaced by other amino acids. Characterization of these mutant proteins has provided insights into the precise catalytic roles of the essential amino acids.

DNA-O^6-methylguanine methyltransferase is an enzyme that repairs mutagenic lesions in DNA caused by a variety of environmental chemicals. Specific structural alterations have been introduced into this enzyme by site-directed mutagenesis to explain the process of alkyl-group transfer between the DNA and protein. Insights into the regulation of gene expression for this repair enzyme are also being gleaned.

The involvement of extracellular protein factors in the regulation of DNA replication, specific RNA synthesis, and cell division has long been recognized. Several factors have been isolated with the ability to stimulate the growth of cells and the expression of specific genes believed to be involved in the entrance of mammalian cells into and progression through the cell cycle. One of the most

highly studied among these is epidermal growth factor (EGF), a 6-kDa single polypeptide chain with three internal disulfide bonds, which is known to initiate its action through high-affinity binding to the specific cell surface EGF receptor. In response to EGF, the receptor undergoes autophosphorylation on tyrosine residues by its intrinsic protein kinase activity besides phosphorylation of exogenous substrates. Despite the variety of functions elicited in response to EGF, little is known about the biochemical mechanisms by which EGF activates the receptor's tyrosine kinase activity, stimulates the internalization of the EGF-receptor complex, and eventually stimulates DNA replication and specific RNA synthesis and cell division. The major objective of the research is to identify the amino acid residues in EGF that are necessary for (1) its binding to the EGF receptor, (2) stimulation of the EGF receptor protein kinase activity, and (3) stimulation of the growth of quiescent cells.

During the past year, the gene for human EGF was assembled from DNA fragments synthesized in an automated DNA synthesizer and cloned into *Escherichia coli* to generate the product as a bacterial secretory protein. The recombinant protein was purified to homogeneity and found to be identical in structure and function to authentic human EGF. Structure-function analysis by site-directed mutagenesis was initiated at several sites of EGF based on its solution structure, the amino acid residues conserved through evolution, and studies with fragments of EGF. The results have shown that tyrosine-37, arginine-41, and leucine-47 are in regions of the molecule that are critical for its binding to the EGF receptor.

Ongoing work on neutron carcinogenesis, heavy-ion carcinogenesis, and UV carcinogenesis in whole animals and in the in vivo-in vitro model systems will continue. In addition, new studies are planned (depending on the availability of funds) on radon and related high-LET radiations that include (1) alpha-particle activation of oncogenes, (2) gene rearrangement involving mobile gene elements, (3) induction of chromosome aberrations, (4) malignant transformation of tracheal cells, and (5) determination of the relative biological effectiveness for alpha-particle-induced cancers. Future work will also involve the question of whether specific radiation-induced chromosome aberrations are causally related to the induction of myeloid leukemia, mammary cancer, and fibrosarcomas. The pertinent molecular changes that result from the chromosome aberrations will be determined.

During the past year, the information research and analysis efforts have focused on validation, analysis, and application of data resources in areas related to the potential health and environmental effects of hazardous substances. Under a multiyear task with the Department of the Army, water quality criteria are being defined for Army-relevant chemicals. To date, three finished reports and four draft reports have been prepared. The data base that was assessed in a study of hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX) shows some indication of carcinogenic potential; however, the available data were not sufficient to be more definite. Recommendations were made for additional research to fill in the existing data gaps. The findings of the report were used to assess the potential toxicity of RDX-contaminated well water in a Nebraska community. The contamination was assumed to have originated from a nearby Army ammunition plant. An additional study for the Army focused attention on the carcinogenic potential of 2,6-dinitrotoluene (2,6-DNT). It was determined that the reported carcinogenicity of 2,4-dinitrotoluene was in reality due to contamination with the 2,6 isomer.

The evaluation and development of chemical scoring systems is an ongoing task. A scoring system was designed to assist the Environmental Protection Agency (EPA) in identifying chemicals needing further review, testing, or regulatory action. Two EPA reports and two journal articles (the most recent is in draft form) have highlighted this effort. The system was developed for the Office of Toxic Substances and has been used in modified form for the Office of Air and Radiation and the Office of Solid Waste. Current efforts are focused on the Office of Policy, Planning, and Evaluation and their need for a weight-of-evidence ranking system.

The first phase of the EPA Gene-Tox Program has consisted of the evaluation of 72 specific short-term bioassays for mutagenicity and the development of an accompanying data base on the chemical induction of tumors in laboratory animals. The purpose was to select an appropriate battery of tests for determination of mutagenicity and the possible correlation between mutagenicity

and carcinogenicity. This literature was acquired, initially screened, and made available to the Gene-Tox work groups by the Environmental Mutagen Information Center and primarily encompassed the period 1969–1979. This work resulted in the formation of an evaluated data base of 2724 unique chemical agents. Updating some assay systems through a portion of 1986 brought the data base to almost 4000 chemicals. Each of the 37 papers published to date includes carcinogenicity data where available.

The second phase of the EPA Gene-Tox Program, a plan to summarize this information and make recommendations and correlations, is in process but is not complete. Analysis of the sensitivity of specific assays for particular classes of compounds is being conducted. Ten bioassays have been defined as routine. These cross several phylogenetic levels and include both in vivo and in vitro procedures. They include analysis for reverse mutation, direct DNA damage, sex-linked lethal gene mutation, chromosome aberrations, chromosome alterations, and germ cell damage. Coverage of all types of genetic damage can be obtained by using a battery of these tests. The estimated price per test and performance period has been determined.

Environmental Sciences

In ORNL's OHER environmental research program, decreased funding is anticipated during the next several years. Research has been consolidated into investigations of integrated watershed processes. Studies designed to increase the understanding of the mechanisms whereby the environment modifies contaminants and how such materials move through and affect the receiving ecosystems are receiving emphasis.

Basic ecological research in aquatic and terrestrial systems in the Southeastern and Appalachian regions is being maintained. Research on landscape systems analysis, focusing on quantification of landscape patterns and on investigation of relationships between pattern statistics and environmental processes continues. Use of remote sensing for regional evaluation of factors such as land use, pollution damage, vegetation cover, vegetation productivity, geology, and hydrology and for testing and developing hypotheses concerning landscape dynamics and structure is increasing. The understanding developed in such studies continues to be valuable input for assessing the potential ecological effects associated with the future development proposed for this region.

Research capabilities related to nuclear technologies were redirected. Emphasis will continue to center on chronic releases and the long-term behavior of the radionuclides in typical Eastern environments. Radio tracers ^{35}S and ^{7}Be are being used to investigate the biogeochemical cycling and ecologic phenomena that govern element transport in forest ecosystems. Expertise is being developed in geosciences to conduct research more effectively and to analyze waste management issues.

Continued development in environmental chemistry and efficient utilization of simulation modeling will provide more accurate predictions concerning transport, fate, and ecological effects of organic contaminants. This research provides technology transfer to the site-specific Remedial Action Programs at all Oak Ridge facilities. The extension of this research toward new applications in environmental risk analysis is being pursued.

Research in earth sciences related to energy residues will emphasize geology, hydrology, and environmental chemistry. These areas will continue to emphasize research on contaminant transport in the geosphere. The emphasis will include research on mechanisms of sorption/desorption with host media, with continuing development of analytical capabilities to predict the mobility of contaminants in these systems. Analysis of regional landscapes is emphasizing the development of new mathematical approaches for quantifying spatial patterns in terms of physical and biological attributes.

During the past year, there has been a significant effort to address the potential transport and effects of atmospheric contaminants on aquatic ecosystems. Emphasis has been placed on understanding the interactions between terrestrial and aquatic ecosystems and integrating the appropriate expertise available at the various DOE facilities. ORNL will continue to develop and demonstrate approaches for quantifying ecological response to environmental stress at regional landscape scales.

During the next five years, Carbon Dioxide Research Program activities will encompass new research in terrestrial/aquatic carbon dynamics

and global carbon cycle modeling, as well as new responsibilities in carbon cycle research management for DOE. The principal purpose of this program is to provide assistance to the Division of Carbon Dioxide Research in development, management, and research activities. In carrying out this task, the program is responsible for monitoring research progress of ORNL subcontracts, DOE contracts, and in-house projects; identifying research needs to support global carbon cycle model development; and recommending methods for fulfilling these needs. The monitoring involves preparing and updating multiyear research plans for DOE.

The ORNL staff executes and administers subcontracts to universities and major research institutions for new or continuing research supporting the Carbon Dioxide Research Program, concentrating on model development and oceanic and terrestrial biospheric data acquisition. The ORNL staff prepares technical and topical reports to update research progress, to provide responses to specific questions, and to resolve technical issues. The CDIAC continues to broaden its efforts in support of the international CO_2 research community.

Health and Safety Research

Health and safety research develops new experimental and theoretical methods and improves methods for assessing human health impacts of energy technologies. Activities include studies of interactions of potentially hazardous agents with biological and environmental systems and ensuring a technical capability for characterizing and quantitatively measuring such agents in various settings. Long-range goals include identification of effective steps toward the amelioration of potential health and environmental risks associated with new and existing technologies. This program consists of studies involving the structures and properties of materials of biological or environmental importance; the physical and chemical mechanisms that govern transport and chemical transformations of pollutants in the atmosphere, hydrosphere, and biosphere; and the details of direct interactions of harmful agents with biological materials.

In physical and technological programs, emphasis on elucidation of physical mechanisms underlying formation and interactions of hazardous agents associated with various energy technologies is continuing. Particular attention will be given to processes occurring on surfaces of solids and liquids and on the use of state-of-the-art laser techniques for detecting and characterizing a wide variety of chemical species. A major new initiative involves implementation of a picosecond laser program for studies of fast chemical processes including early chemical steps in irradiated biological materials, behavior of radicals in liquids and gases, and nonlinear optical phenomena. A major commitment of capital equipment toward this project was made in FY 1987. A second commitment of similar magnitude will be required in FY 1988.

A growing emphasis will be placed on combined physical, chemical, and biological research directed at fundamental chemical dosimetry and dose concepts that are relevant to human health protection. One focus will be on events occurring at the ultimate target molecule or cell. Current work has involved studies of the binding of electrophiles, such as toxic metal ions, to basic sites of target RNA and DNA molecules. Research will be expanded to include organic adducts, distorted conformation, and changes in gene expression. The active ongoing collaboration between the Health and Safety Research and Biology divisions will continue and be expanded to incorporate newly initiated experimental studies that will contribute to OHER's human genome initiative. A newly initiated program uses scanning-tunneling microscopes capable of single-atom resolution. Emphasis will be placed on studies of the structures of biological systems including the human genome.

Research will also include methodologies and devices that can be used for problems relating to hazardous chemical wastes, fugitive emissions, exposure monitoring (including skin biological monitoring), and chemical dosimetry. Existing portable instruments and cost-effective monitoring techniques will become more focused on analyzing workplace samples in ways that reflect the degree of potential hazard to the worker. Clinical-biological as well as exposure-monitoring techniques will be included. These activities will require concomitant studies of the nature of fugitive emissions vis-à-vis process stream materials and field characterization of hazardous chemical wastes. Parallel research will be conducted to develop dosimetry concepts at both the applied and

fundamental levels. Several of these projects will be carried out jointly with the Analytical Chemistry, Biology, and Environmental Sciences divisions.

A continuing research activity is the development of new instruments and measurement techniques to support evaluation of the potential health and environmental impacts of developing energy technologies. Results of this research have led to cost-effective luminescence techniques for rapid screening of samples containing polynuclear aromatic compounds as well as portable instrumentation for on-site use at operating facilities. The OHER-funded developmental research has resulted in support from other agencies and organizations for applied studies. Transfer of this technology to the commercial sector is an important objective.

An increased effort is being made to establish a viable program in risk analysis. Past work has focused on developing methodologies to quantify exposure and the impact of environmental pollutants on human health. These methods have been applied to characterize the risk from direct coal liquefaction facilities, liquid-metal fast breeder reactors, hazardous waste incineration, and extra-low-frequency electromagnetic fields. Methodology development in risk analysis is concentrating on low-dose and interspecies extrapolations and pharmacokinetic modeling. Potential growth areas include several areas of national concern: hazardous waste management, groundwater pollution, and health effects of biotechnology. Success in attracting funding in these areas will depend on our ability to combine the Health and Safety Research Division's diverse areas of expertise to provide new insights into both applied and methodological risk analysis issues.

Information research and analysis activities in support of various government agencies (EPA, NIH, DOD, and DOE) have been carried out since the early 1970s. These activities focus on validation, analysis, and application of data resources in research areas related to the potential health and environmental effects of hazardous substances. Development of validated health effects data bases is a continuing endeavor. The Hazardous Substances Data Bank now contains more than 4500 records, each consisting of 140 data fields describing specific attributes of specific chemicals. The Gene-Tox Database consists of data validated by 23 expert panels which evaluated 74 short-term bioassays for determining the mutagenic potential of chemical substances. The initial work (including data through 1979) resulted in an evaluated data base of 2724 unique agents, and updating through 1986 brought the total to about 4000 chemicals. The genetic data and expertise developed by this work since 1969 within the Environmental Mutagen Information Center has potential for a strong supporting role in the DOE Human Genome Program. Additionally, the Fossil Energy Safety, Health and Environmental Information Systems provides a framework for integrating many data bases pertaining to various aspects of power plant operations and environmental concerns.

These and many other data resources on topics such as acid precipitation, remedial actions, environmental teratogens, and environmental carcinogens provide a strong base for the preparation of numerous assessment reports by the scientific staff of the Laboratory. Such resources can also play a major role in risk analysis.

Indoor air quality research is focusing on radon entry and mitigating effectiveness. Our broad-based assessment of this complex exposure problem has been supplemented by new studies focused on reduction of dosimetric and risk uncertainties. Such studies may lead to better exposure guidance.

A long-term division activity has been the development and evaluation of new radiopharmaceuticals for diagnostic and therapeutic applications in nuclear medicine. Major emphasis is on the development of agents for the evaluation of heart disease, cerebral blood flow, and regional evaluation of tissue metabolism. Tissue-specific agents, such as our recently labeled fatty acids, have proven to be valuable additions to the field. Clinical evaluations are currently under way using distributions of radiolabeled agents through our Medical Cooperative Program. New emphasis will be placed on protein labeling activities, development of a rhenium-188 radionuclide generator, and collaborative studies with The University of Tennessee to develop new radiolabeled, tissue-specific agents using positron emission tomography (PET) technology.

The HPRR is expected to resume operation with activities in several areas:

- training nuclear power plant health physics personnel in neutron dosimetry,

- conducting international dosimetry intercomparison studies,
- developing neutron dosimeters,
- testing criticality alarm monitors,
- supporting neutron radiobiology experiments, and
- testing physical systems (e.g., pumped lasers, neutron effects on materials, and shield effectiveness).

An outstanding feature of the division's research program is the broad interaction between divisional staff members and university professors, postdoctoral fellows, graduate students, and undergraduate students. University relations activities will continue to be a vital component of the division and will be enhanced as opportunities arise in the future.

Major Foreign Meetings

To maintain and enhance international collaborations and to share research results, ORNL researchers will seek OHER approval to attend major society meetings and symposia held in foreign countries. We have also developed numerous foreign contacts as a result of the Chernobyl nuclear power station accident. These contacts have increased the foreign travel requirements. A list of major foreign meetings scheduled for FY 1988 and FY 1989 is included in Table 10. It is anticipated that more than one ORNL researcher will seek approval to participate in these meetings.

Table 10. Major foreign meetings during FY 1988 and FY 1989

Meeting	Location	Date
Workshop on Methods for Assessing the Reliability of Environmental Transfer Models	Athens, Greece	October 1987
2nd Workshop on Radioiodinated Free Fatty Acids	Amsterdam, The Netherlands	November 1987
4th International Symposium on the Natural Radiation Environment	Lisbon, Portugal	December 1987
7th International Congress of the International Radiation Protection Association	Sydney, Australia	April 1988
International Conference on Radiation Protection Principles in Nuclear Energy	Sydney, Australia	April 1988
13th International Radiocarbon Conference	Yogoslavia	June 1988
NATO Workshop on Biologically Based Methods for Cancer Risk Assessment	Corfu, Greece	June 1988
7th International Symposium on Radiopharmaceutical Chemistry	Groningen, The Netherlands	July 1988
4th International Congress of Cell Biology	Montreal, Canada	August 1988
4th International Symposium on Regulated Streams	Laughborough, UK	August 1988
XVI International Congress of Genetics	Toronto, Canada	August 1988
9th International Conference on Gas Discharges	Venice, Italy	September 1988
14th L. H. Gray Conference on Low-Dose Radiation–Biological Basis of Risk Assessment	Oxford, UK	September 1988
10th Symposium on Microdosimetry	Rome, Italy	Summer 1989
24th Congress of the International Association of Theoretical and Applied Limnology	Munich, Federal Republic of Germany	August 1989

Work for Non-OHER Organizations

Other DOE Organizations

Approximately 58% of the funds for ORNL's BES Program is provided by organizations other than OHER (Fig. 1). DOE's Assistant Secretary for Environment, Safety, and Health (ASESH) provided about 11% of the BES funding in FY 1987, which will increase to about 15% in FY 1988.

Funding for life sciences research is also received from the Assistant Secretary for Nuclear Energy and the Assistant Secretary for Conservation and Renewable Energy.

The importance of non-OHER-funded research has increased relative to DOE programs. For example, recently initiated studies on the Y-12 site related to how ecosystems respond to contaminants have utilized techniques developed during the OHER Synthetic Fuels Program. This area will increase in importance over the next five years through applications at other DOE and federal sites.

Non-OHER support is particularly significant for work in the areas of geohydrology, geochemistry, and health risk assessment. The importance of these disciplines, along with environmental engineering, in proper waste management is recognized and sought both by waste research sponsors and waste operations groups. Integration of OHER research with applied waste studies provides contact with the basic research programs and ensures that the most current insights into environmental transport processes are used in designing and operating waste facilities and remedial actions.

Assistant Secretary for Environment, Safety, and Health

The Environmental Sciences Division is continuing to provide technical support to ASESH's offices of Nuclear Safety (ONS), Environmental Guidance and Compliance (OEGC), National Environmental Policy Act (NEPA) Project Assistance, and Environmental Audit. In support of ONS, division staff provide analyses and evaluations of proposed radiation protection orders. During the past year, a critical review of the chemical and radiological toxicity of uranium was prepared. In support of OEGC, division staff lead a multidisciplinary team that prepares analyses of regulatory initiatives related to hazardous waste management and other EPA programs. These analyses evaluate the technical approaches used in proposed rules and the implications of new requirements on DOE facilities and operations. The analyses and comments prepared by the ORNL team are used by OEGC in formulating DOE responses to EPA and other regulatory agencies on proposed requirements that might affect the department's activities. Technical support to the Office of NEPA Project Assistance consists of providing reviews and analyses of environmental impact statements and environmental assessments prepared for DOE and preparing background materials for use by DOE staff in developing guidance on NEPA compliance issues. This support also provides technical assistance in evaluating environmental analyses related to DOE's high-level nuclear waste repository program.

ORNL is participating in the DOE Environmental Survey as one of three laboratories providing sampling and analysis support. This support is provided to the Office of Environmental Audit. In addition, ORNL is responsible for sample traffic routing among the survey laboratories and for providing assistance to DOE for management of data from the survey. The DOE Environmental Survey's aim is to evaluate potential environmental problems at

approximately 40 DOE sites throughout the United States.

ORNL will continue to assist ASESH's Office of Environmental Analysis in developing environmental assessment methodologies and environmental, economic, and energy data bases and in analyzing important energy and environmental issues such as air quality, acid deposition, and water resource impacts. Assistance is also provided in planning and preparedness for environmental protection and public safety, which includes assisting DOE in implementing its supporting responsibilities to other federal, state, and local agencies in radiological emergencies. One problem being studied is the development of procedures, equipment, and techniques for decontamination and emergency operation in contaminated environments.

ORNL's cooperative work with foreign countries is exemplified by the technical advice and equipment the Laboratory provides to the Junta de Energia Nuclear in Spain for measuring radionuclides in people and in environmental samples such as food products, soil, and air. ORNL's assistance allows for increased counting capacity by alpha spectrometry of samples containing ^{239}Pu and by rapid, accurate, and inexpensive techniques of samples containing ^{241}Am.

Assistant Secretary for Nuclear Energy

The largest component of this work is the Radiological Survey Activities (RASA) for the Uranium Mill Tailings Remedial Action Program (UMTRAP). A RASA office has been opened in Grand Junction, Colorado, to assist in UMTRAP. The UMTRAP effort is primarily radiological surveys on private property near inactive mill tailings sites. Advancing state-of-the-art equipment and methodologies are an integral component of UMTRAP. The surveys will be completed by FY 1989.

Assistant Secretary for Conservation and Renewable Energy

The Environmental Sciences Division is responsible for the terrestrial production activities for DOE's Biofuels and Municipal Waste Technology Division. The division manages the Short Rotation Woody Crops and Herbaceous Energy Crops programs and supports the necessary in-house research and analyses. The programs are focused on maximizing the productivity of terrestrial biomass to be utilized for energy while minimizing costs and environmental effects. Field research is conducted at university, industry, and other federal agency research sites. Economic, environmental, and regional analyses are conducted at ORNL to ensure proper growth and development of each of the program's components.

Environmental technical assistance is provided to the Division of Geothermal and Hydropower Development. A continuing focus of current research is to provide guidance on the resolution of major environmental constraints to hydropower development.

Health and safety research work involves analyzing laboratory and human data in order to help focus research on the potential health effects of high-voltage, 60-Hz transmission lines. This area of research is of potential interest to OHER.

Dielectrics research is being carried out for the Division of Electrical Energy Systems of the Office of Energy Storage and Distribution. Researchers are studying the physical properties of dielectric materials, the mechanisms of breakdown of such materials, and the development of superior dielectric materials. This work has been conducted over several years. Five international symposia on gaseous dielectrics have been organized and hosted, and the proceedings have been published. Studies of the toxicity and potential environmental effects of products formed during electrical breakdown of dielectric materials are also carried out. Research is also being conducted to delineate and understand the basic physical mechanisms of dielectric breakdown at an electrode/solid insulator interface. The work focuses on the effects of microstructures, defects, impurities, and filament formation.

Non-DOE Organizations

Other federal agencies that provide funding through interagency agreements with DOE include the EPA, the Department of Health and Human Services (HHS), National Oceanic and Atmospheric Administration (NOAA), National Science Foundation (NSF), and the U.S. Army, Navy, and Air Force. Both DOE and non-DOE sponsors benefit from the work done for other agencies because the work is complementary, and all of it is performed in the same general locations in laboratories where facilities, equipment, and staff are shared.

Air Force

Basic studies are being carried out on the interactions of low-energy electrons with solids. Theoretical and experimental studies are being performed on photon emission from irradiated solids. This work grew out of and is complementary to the basic research in radiation physics that has been carried out in the physical and technological studies program in OHER over the past 30 years. Development and evaluation of the Defense Priority Model for ranking Department of Defense waste sites continues. Technical support is being provided for environmental assessments and impact statements.

Army

Efforts for the Army include studying the feasibility of using U.S. Army high-volume hazardous waste streams as supplementary feedstocks in industrial boilers, validating data for the Energy Conservation Investment Program, performing a development study for an Energy Conservation Technical Information and Analysis Center, developing surface-enhanced Raman scattering for chemical detection, performing theoretical and experimental research on photon emission from irradiated solids, and preparing environmental assessments for the demilitarization of chemical agents spread by the Army. Assistance with analysis of environmental matters for the Army Corps of Engineers and the Waterways Experiments Station continues. Possible health and environmental effects of munition wastes have been studied, and munition production waste disposal methods are being assessed. Work is being done for the Army at the HPRR to address the transmissivity of infrared laser windows in nuclear radiation environments.

Department of Health and Human Services

HHS supports research in carcinogenesis, genetics, and toxicology. HHS funding is expected to remain relatively constant over the next five years. The main branches of HHS that provide support are the National Cancer Institute (NCI); the National Heart, Lung, and Blood Institute (NHLBI); the National Institute of Environmental Health Sciences, including the National Toxicology Program (NTP); the National Institute of General Medical Sciences (NIGMS); the Food and Drug Administration (FDA); and the National Library of Medicine (NLM). Genetic, reproductive, and general toxicology data bases are being developed for the FDA, NLM, and NTP, which are available nationally as well as in other countries.

For NCI, ORNL is studying the mechanisms of viral-, chemical-, and UV-radiation–induced carcinogenesis; cocarcinogenesis of ionizing (X-rays or neutrons) and UV radiation; and DNA repair mechanisms in carcinogenesis. Two organ systems that have been widely studied are the respiratory tract and the skin. Both organs are important interfaces between the body and potentially hazardous agents in the environment. During the next five years, questions about the responses of ecological systems and how they relate to potential human health effects will be addressed.

For NHLBI and NCI, the Nuclear Medicine Program is developing a basic understanding of the chemistry and physiology of cerebrovascular and cardiovascular imaging agents. NIGMS has also sponsored ORNL and UT for a joint, multidisciplinary research project aimed at developing a new generation of fiberoptics-based fluoroimmunosensors to study biological and chemical systems of toxicological interest. This work, in conjunction with OHER-supported efforts, resulted in an I•R 100 award last year.

For the Agency for Toxic Substances and Disease Registry (ATSDR), the Office of Risk Analysis is providing guidance on the performance of health assessment at hazardous waste sites on the Superfund list. Methodologies to predict acute and chronic health effects resulting from exposures to hazardous chemicals are being developed.

Electric Power Research Institute

Research sponsored by the Electric Power Research Institute (EPRI) addresses critical national issues related to electric power generation. Major efforts in this area are directed at understanding the processes and mechanisms by which atmospheric deposition of energy-related pollutants affects ecosystems.

A major four-year project on the effects of acidic deposition on the nutrient status of forest ecosystems, the Integrated Forest Study Program, was initiated in CY 1985. ORNL is the lead organization, with coinvestigators from the State University

of New York at Syracuse and at Albany, the University of Pennsylvania, the University of Washington, the National Park Service, and the Norwegian Forest Research Institute. This program involves mineral cycling studies at sites in New York, Washington, North Carolina, Tennessee, and Norway. Mechanistic laboratory and field research will be conducted at ORNL and the University of Georgia in support of this field-oriented project.

Beginning in 1987, a major three-year study on the effects of wet and dry deposition on loblolly pine will be initiated as part of EPRI's research program, Responses of Plants to Interacting Stresses. The ORNL component, which is being conducted in collaboration with the Tennessee Valley Authority (TVA), complements similar research being initiated at universities. ORNL will examine the influence of ozone, soil magnesium level, and acidic precipitation, singly and in combination, on the growth of loblolly pine under field conditions. The focus of the research is the whole-plant physiological processes governing the response of seedlings to stress of natural and anthropogenic origin. The research will be conducted at the Air Pollution Effects Field Research Facility at NERP.

A multiyear project has recently been funded by EPRI to investigate compensation mechanisms and how they may affect important fish populations. This project builds on historic fish population modeling expertise developed in the early days of environmental assessment activities.

Environmental Protection Agency

ORNL's work for EPA addresses numerous health and environmental problems and issues. The research focuses on identifying the effects of pollutants associated with energy-production processes, effluents, and disposal, such as the effects of utility effluents on the environment. During the past year, studies have been initiated to relate the effects of contaminant releases to ecological responses using ecosystem simulations. In addition, research also addresses the toxicity of leachates of solid wastes, human health hazards from incineration of hazardous chemicals, and the effects of acid precipitation on agricultural systems and forest soils. Analysis of the relationships between atmospheric deposition and surface water chemistry on a regional scale is leading to the development of multivariate statistical models to relate deposition watershed characteristics and lake chemistry. Continuing development and refinement of these methods will improve capability to extrapolate from site-specific data to predict the distribution and effects of atmospheric deposition across regions experiencing acidic deposition.

Acid precipitation activities continue to include coordination and administration for assessment purposes, as well as an active participation in the Interagency Task Force on Acid Precipitation. ORNL manages and analyzes data coming from the National Surface Water Survey and the National Soils Survey, major EPA programs providing input to assessments of the acidic deposition problems. Data bases have been developed to examine the relationship between soils characteristics and the delayed-response lakes in the northeastern United States. ORNL has developed data that EPA will use in establishing a modified extraction procedure for designating wastes as hazardous. Continued development of these modified procedures, including toxicological evaluation, will provide the necessary information for establishing this modified standard.

Continuing projects in environmental risk analysis include a focus on methods development and evaluation in marine systems and evaluation of fish population and ecosystem models. Literature reviews and chemical hazard information profiles are prepared for EPA-selected topics and chemicals. Administrative management, coordination, and information support will continue to be provided to the EPA Gene-Tox Program to help evaluate mutagenicity bioassay systems. Interim guidance will be recommended to EPA on the use of genetic bioassays to screen samples of wastewater effluents.

EPA is supporting research at ORNL to evaluate the use of physiologically based pharmacokinetic models in the risk assessment process. The models allow for prediction of the relationships between applied dose and effective dose to target tissue. The chief advantage of physiologically based models is that, by simply changing the physiological parameters, the same model can be used to describe the dynamics of chemical transport and metabolism in mice, rats, and humans. These models are being used to investigate interspecies extrapolation and the extrapolation of dose between routes of administration.

ORNL is also conducting risk-analysis and epidemiological studies for EPA. Field research on the relationship between cardiovascular disease and hard water and chlorination was completed. Analysis of data from the full set of communities is under way.

A major collaborative research project to investigate radon entry and mitigation effectiveness is being sponsored by EPA, TVA, and DOE/OHER. This project is investigating seven houses in New Jersey and eight houses in the Tennessee Valley area. Continuous monitoring of radon, temperature, and differential pressures is being conducted in basements and main floors of the homes. Detailed premitigation measurements are conducted prior to installation of mitigation, such as subslab ventilation. Several months of pre- and postmitigation monitoring is conducted in both warm and cold weather to evaluate mitigation effectiveness.

Navy

Basic studies are being conducted of the fundamental properties of gases and gas mixtures appropriate for use in diffuse discharge switches for assessment purposes. ORNL is also involved in studies of the properties of high-energy metastable negative ions and the laser-induced formation of molecular ions from excited atoms. Studies are also conducted on interaction of intense electron beams with condensed matter. This work complements and supports OHER studies of negative ion reactions relevant to energy deposition by ionizing radiation. ORNL provides technical support to the Navy on compliance with environmental regulations.

Sedimentation processes and heavy metals deposition in the vicinity of the inactive fleet at Pearl Harbor are being determined through dating and analysis of sediment cores.

The National Science Foundation

NSF continues to support basic ecosystem analysis research that complements OHER work at ORNL. Systems analysis of aquatic and terrestrial ecosystems in both theoretical and empirical studies are contributing to the understanding of forest growth dynamics, food chains, hierarchical organizations, and landscape ecology. A new research project focuses on the ecological processes and interactions that contribute to ecosystem resilience, the ability of an ecosystem to recover from disturbance. This research, which combines ecosystem simulation modeling and system-level experimentation, should provide a direct link between existing theory and empirical results. An improved understanding of ecosystem recovery processes derived from this basic research will benefit the ORNL studies of disturbed aquatic systems near the Oak Ridge facilities that are being conducted in concert with remedial action efforts. Studies addressing linked global element cycles as related to climate and each other emphasize carbon, nitrogen, and phosphorus. A new initiative with NSF is developing; it involves a collaborative effort between ORNL, the Great Smoky Mountains National Park, and UT to address the role of spatial and temporal heterogeneity in ecosystem resiliency.

NSF, in conjunction with DOE, continues to provide support for the National Center for Small Angle Scattering Research. This is a national user-dedicated facility that makes two main instruments available to users: the NSF-constructed, 30-m small-angle neutron-scattering instrument and the DOE-constructed, 10-m small-angle X-ray-scattering camera. These instruments are intended to provide state-of-the art capability for investigating structures of condensed matter on the scale of tens to hundreds of angstroms. They are used extensively for materials science research, as well as for research in biology, chemistry, polymer science, and diffraction physics. A theoretical program to study nonlinear interactions of intense electron beams in matter is under way.

NSF supports ORNL research to evaluate the scientific bases for assumptions used in the risk assessment process. The major assumptions arise from the necessity to extrapolate experimental results (1) across species from rats or mice to humans, (2) from the high-dose regions to which animals are exposed in the laboratory to the low-dose regions to which humans are exposed in the environment, and (3) across routes of administration. The work is intended for use by federal agencies responsible for regulating human exposure to chemical carcinogens.

U.S. Nuclear Regulatory Commission

At the request of the Nuclear Regulatory Commission (NRC), modifications were made to codes on

their Emergency Operations Center computer. The five-volume *NRC Severe Reactor Accident Incident Response Training Manual* has been issued. The manual provides NRC personnel with information for guidance in responding to several reactor accidents.

American Petroleum Institute

American Petroleum Institute (API) supports research at ORNL to evaluate the pharmacokinetics and pharmacodynamics of benzene in humans. The work is intended to provide a better estimate of the risk of developing leukemia following exposure to low doses of benzene.

U.S. Department of Agriculture

The U.S. Department of Agriculture Forest Service/EPA Forest Research Cooperatives established to address acid rain issues identified by the National Acid Precipitation Assessment Program (NAPAP) have selected ORNL to (1) evaluate genotypic control of loblolly pine response to ozone and acid rain as part of the southern commercial forest research cooperative and to (2) develop a thorough understanding of the physiological mechanisms governing red spruce response to acid rain as part of the northern spruce research cooperative. In addition, ORNL is providing planning leadership for development of the eastern hardwood cooperative. The southern commerical cooperative, on behalf of all the cooperatives, recently selected ORNL to lead the effort on developing whole-tree exposure methodology and coordinating the efforts with other institutions.

Other Support for Life Sciences Research

Other agencies that support life sciences research include TVA, the National Aeronautics and Space Administration, the NOAA, the Consumer Product Safety Commission (CPSC), the National Research Council of Canada, the Air Force, the U.S. Park Service, the Federal Energy Regulatory Commission (FERC), and several universities.

Research for the Park Service focuses on regional analyses of environmental perturbations. ORNL is conducting research on the mechanisms of physiological response of forest tree seedlings to combined stresses of ozone and acid precipitation as a part of the Forest Service/EPA/NAPAP-sponsored Forest Response Program. Controlled exposure and field exposure methodologies developed at ORNL are being applied for both the Spruce-fir and Southern Commercial Pine Research Cooperatives of the program. ORNL provides input to environmental impact statements for hydroelectric projects for the FERC and is preparing assessments of multiple hydro development on river basins.

Work is being conducted for the Defense Nuclear Agency to provide better estimates of early radiation mortality and duty incapacitation from exposure to ionizing radiation.

The collaborative interaction with Children's Hospital has provided access to anatomical information that is being used in establishing an anatomical data base for children. This data base will be useful in the revision of the ICRP Reference Man report. Further development of anatomical models for radiation transport calculations will also draw upon this data base.

The Defense Nuclear Agency-supported effort to measure residual ^{60}Co activation in Hiroshima steel is designed to address a major unresolved technical issue identified in the DS286 documentation developed under the DOE/OHER-supported Dosimetry for Human Exposure Program.

Two indoor air quality field studies were completed. Approximately 400 homes were monitored for a broad range of indoor air pollutants, including radon, formaldehyde, combustion gases, particulates, organics, and microorganisms. Multiagency support by EPA, CPSC, TVA, EPRI, and other private organizations allowed cost-effective use of limited resources to maximize the information obtained.

Issues

This section highlights the major infrastructural barriers, significant issues, concerns, and problems that could pose constraints on program development or the attainment of major goals and objectives.

Personnel

The ORNL Biomedical and Environmental Sciences (BES) Program has been restructured around a smaller number of major research clusters and activities, and we are continuing to build around initiatives in areas selected from Laboratory-wide and biomedical and environmental sciences planning activities. Several staff members have been added in key areas, such as Molecular Genetics, consistent with long-range plans and discussions with OHER personnel. The most recent addition to the staff, Dr. Richard Woychik, worked with Dr. P. Leder at Harvard University. A small number of individuals will be added through replacements and normal attrition. However, most of the ORNL staff additions will most likely come through the increased use of distinguished scientists, visiting scientists, and postdoctoral appointees. One Wigner Fellow, Dr. Laura B. Toran, is currently working in the Environmental Sciences Division (ESD) as a hydrologist. Wigner Fellowships are awarded by ORNL on a competitive basis to outstanding scientists who have recently completed doctorates. An OHER-supported Hollaender Fellow, Dr. Monica Turner, is working in ESD as an ecologist. We have also hired several minority scientists in keeping with out Affirmative Action planning.

Distinguished Scientists

Dr. David White, the first Distinguished Scientist in the Biomedical and Environmental Sciences Program, joined ORNL early in 1986. Dr. White has been working with the Environmental Sciences, Biology, and Chemical Technology divisions and has attracted about 20 individuals to work at ORNL in activities related to his interests. Dr. White is housed in offices and laboratories in the Environmental Sciences and Biology divisions. Among Dr. White's many interests is the use of biological organisms to alter hazardous wastes.

Dr. Robert Hatcher has been with the Environmental Sciences Division for about 18 months, working in the area of structural geology. Six individuals are now involved in these activities who were not previously associated with ORNL. Dr. David Joy, an electron microscopist, joined ORNL's Metals and Ceramics Division in 1987. Dr. Joy will also work with ORNL scientists on the microscopy of biological systems.

Interviews and negotiations are ongoing with several other distinguished scientist candidates. A joint working group has been established with UT at Knoxville to identify potential distinguished scientists in several areas of life sciences research. The distinguished scientist activities are part of the Science Alliance Program with UT at Knoxville. There are now 11 distinguished scientists at ORNL in the program.

Cost sharing or full support from OHER of these individuals is welcome.

Capital Equipment

The reliance on sophisticated equipment in the biological sciences places a high demand on capital equipment budgets. OHER is encouraged to make its case for an increased capital equipment budget, as recommended by its advisory committee (HERAC review of OHER 5-year plan, 1984).

The budget level this year was <5% of the operating budget, as opposed to the recommended level of 15%. Modern biology requires a firm commitment to sophisticated instrumentation, and the 4.3% appropriated is grossly inadequate.

Work for Others

Work for others (WFO) is a major part of ORNL's integrated biomedical and life sciences program. As noted last year, we were pleased that OHER took the initiative to form a committee to investigate WFO activities and make recommendations to OHER. However, the findings of this committee were never transmitted to the contractor laboratories.

Major programs of national prominence such as acid deposition are heavily dependent on funding from agencies other than DOE. Major supporters include EPA, EPRI, and some of the other participants of the National Acid Precipitation Assessment Program (NAPAP), to which DOE belongs. NAPAP was established by law in 1980 and will terminate in a few years. We still feel the need for assistance from and joint planning with OHER to ensure that major activities in this important area do not disappear after the termination of NAPAP. This issue requires top OHER management attention.

ORNL is continuing to work closely with the private sector in keeping with the goals and aspirations of DOE. Work for EPRI is an example of an important part of the integrated acid deposition program. Work in this area should be considered as a special category of WFO.

It has been suggested that OHER explore the possibility of developing arrangements (memoranda of understanding, blanket work orders, or basic ordering agreements) with organizations such as EPRI, the Gas Research Institute, and perhaps NSF. ORNL is particularly pleased that DOE is now forming joint working groups with individuals in NSF. The areas of interest identified were biotechnology, molecular biology, and the human genome. The purpose of these agreements would be to facilitate arrangements for conducting research with these organizations. However, the plan for OHER to interact with NSF staff (Dr. Kingsbury) apparently has not been implemented.

Construction

A critical problem requiring immediate resolution has been the aging of the energy-inefficient facilities used by the Biology Division at the Y-12 site. In addition to the marginal service and utility capacities of the buildings, the cost of utilities was consuming almost 25% of the total research operating budget. This high cost of conducting research was adversely affecting ORNL's competitiveness in basic biological research and placed the future of this program in jeopardy. In FY 1987, the Biology Division staff began an interim program of reducing costs by eliminating facilities and consolidating research activities. Biological research projects formerly located in the largest building (9207) were moved into two smaller buildings nearby. The long-range plan is to move the major research components of the Biology Division from the Y-12 Plant to specially designed biological research facilities located in the Life Sciences complex at ORNL. It is quite clear that the only long-term solution is the construction of these new facilities. Leasing of facilities is not permitted.

Conceptual design has been completed for the proposed Molecular Genetics Laboratory as an FY 1990 line-item construction project (Table 11). The proposed laboratory will provide the resources required for advanced-level molecular genetics research. The building will be of cost-effective modular design, with one-time engineering and design costs, and additions will be modular units of the same design.

Because DOE/OHER's established genetics research program investigates the genetic effects of energy-related physical agents and chemicals, it is essential that ORNL have new laboratory and animal space designed specifically for handling hazardous chemicals safely, with an air supply system that can achieve the required high number of air exchanges per hour to meet the requirements for experimental animal quarters.

The obvious programmatic advantage to relocating the Biology Division in the existing Life Sciences complex at ORNL is that the close proximity to the Biomedical and Environmental Sciences divisions would provide an opportunity to share resources and thus enhance collaborative research efforts. Many essential facilities for modern biological research (e.g., structural biology) are located

Table 11. Proposed line-item construction projects for Oak Ridge National Laboratory's Biomedical and Environmental Sciences Program

Project	Estimated Cost ($M)	FY	Comment
Upgrade air supply system, Part I, Bldg. 9210	2.8	1990	DOE approved CDR[a] 11/83 CDR updated 12/85
Molecular Genetics Laboratory	9.9	1990	CDR completed 1/87
Upgrade air supply system, Part II, Bldg. 9210	3.8	1992	No approval to prepare CDR

[a]Conceptual Design Report.

at ORNL. These facilities include the National Center for Small-Angle Scattering Research (NCSASR) and the Bioprocessing Research Facility.

Operating Budget

We strongly recommend more joint planning between OHER and its contractor laboratories. Several years ago, OHER developed plans for three-year budgets with the intent of making annual revisions to account for the realities of the federal budget. Unfortunately, these plans were never implemented. It is imperative that OHER work closely with its constituencies to formulate joint R&D plans, including budgets.

Health Physics Research Reactor

The Health Physics Research Reactor (HPRR) is still shut down and, therefore, is not available for use by the Biology and Health and Safety Research divisions or other users. It is important that the HPRR be made available for research in radiation biology and radiation dosimetry. We strongly encourage OHER to develop a plan to protect unique or rare radiation facilities at several of its contractor laboratories.

Resource Quantitation

Staff and Publications

The total Biomedical and Environmental Sciences (BES) Program staff at ORNL approached 600 at the end of FY 1987. About half of the total professional staff holds Ph.D.s, two individuals are M.D.s, two individuals are D.V.M.s, and the remainder have M.S. or B.S. degrees. In addition, many of the professional staff members hold university appointments.

ORNL's research programs provide opportunities for graduate as well as undergraduate students to work with researchers. The visiting scientists program is highly successful. Increasing emphasis is being placed on both the periodic and longer-term appointments of visiting scientists and students to offset the reduction in professional staff that occurred between 1981 and 1983. Table 12 shows the staff composition of the ORNL BES program.

The professional staff continues to maintain an excellent publication record using a variety of publication media: scientific journals, books and book chapters, and ORNL reports (Trimble et al. 1987). Table 13 provides numbers and types of publications for the OHER program.

Table 12. Oak Ridge National Laboratory Biomedical and Environmental Sciences research staff (full-time equivalents)

	FY 1986		FY 1987		FY 1988 estimated	
	OHER	Total	OHER	Total	OHER	Total
Professional (scientific)	79	210	78[a]	202	77	248
Postdoctorates	16	26	20	37	20	40
Technicians	50	168	54	194	51	134
Animal care	35	43	32	41	29	37
Total direct personnel	180	447	184	474	177	459
Professional (administrative)	9	17	5.5	14	5.5	17
Clerical, administrative support	33	90	30	92	31	127
Maintenance[b]	5	8	2	4	2	3
Total indirect personnel	47	115	37.5	110	38.5	147
Visiting scientists[c]	34	83	36	57	36	69
Graduate students	58	118	57	114	48	100
Undergraduates	13	50	19	62	19	57

[a]FY 1987: 71 Ph.D., 2 M.D., 2 D.V.M., 33 M.S., 18 B.S.
[b]In laboratory overhead.
[c]Includes both resident and periodic.

Table 13. Office of Health and Environmental Research-supported publications

	CY 1985	CY 1986	CY 1987[a]
Journal articles	166	185	121
Proceedings	12	38	12
Books, chapters	35	16	9
Reports	40	29	25
Meeting presentations	303	358	369

[a]1987 figures may be incomplete.

User Facility Statistics

User facility statistics for the Bioprocessing Research Facility, HPRR, and NERP are given in Table 14.

Meetings Organized

BES staff members Dr. C. W. Gehrs, Dr. P. J. Walsh, and Dr. W. M. Generoso are organizing an international symposium, "Bioindicators: Exposure and Effects," to be held March 20–23, 1988, in Knoxville, Tennessee. Organisms live in an environment containing a myriad of potentially harmful materials and integrate these into a realistic dose. This symposium is designed to identify various molecular, biochemical, and ecological indicators that enable quantification of dose and determination of risk to human and other organisms living in various environments. Biologists, ecologists, epidemiologists, medical researchers, and regulators from around the world will participate in the symposium. Five formal sessions are planned: (1) molecular epidemiology, (2) ecological indicators of human health, (3) biological indicators of environmental health, (4) biological mechanisms, and (5) forecasting human and environmental health. For more information on the symposium, contact Dr. C. W. Gehrs, Oak Ridge National Laboratory, Environmental Sciences Division, P.O. Box X, Oak Ridge, Tennessee 37831.

Dr. R. H. Ritchie of the Health and Safety Research Division is organizing an international symposium, "11th Werner Brandt Workshop on Penetration Phenomena," to be held in Oak Ridge,

Table 14. User facility data for FY 1987

User affiliation	Bioprocessing Research Facility	Health Physics Research Reactor	Oak Ridge National Environmental Research Park[a]
Participants			
University	3	7	43
Industry	1	5	8
U.S. Government Laboratories	0	0	7
DOE Laboratories	0	14	0
ORNL	1	8	51
Foreign	4	0	6
Others	0	0	15
Total	9	34	130
User days			
University	105	14	1319
Industry	90	8	767
U.S. Government Laboratories	0	0	185
DOE Laboratories	0	28	0
ORNL	30	57	2277
Foreign	115	0	94
Others	0	0	523
Total	340	107	5165

[a]Data do not include 2022 school students (1011 user days) who participated in the Ecological Study Center's environmental research activities.

Tennessee, on April 14–15, 1988. This workshop will include various topics in penetration phenomena, with emphasis on inelastic effects in STM and STEM, vicinage and wake effects, convoy electrons, and track structure.

Drs. M. W. England and J. E. Turner of the Health and Safety Research Division, together with Dr. T. W. Schultz of The University of Tennessee, are organizing an international workshop "QSAR 88." This is the third international workshop on Quantitative Structure—Activity Relationships in Environmental Toxicology and will be held in Knoxville Tennessee, on May 22–26, 1988. Information on this workshop can be obtained from Dr. M. W. England, Oak Ridge National Laboratory, Health and Safety Research Division, P.O. Box X, Oak Ridge, Tennessee 37831-6123.

Drs. R. A. Popp, R. J. Preston, W. K. Yang, J. L. Epler, and E. M. Rinchik are organizing the Biology Division's Fortieth Anniversary research conference, "Transposable Elements in Mutagenesis and Regulation of Gene Expression." The conference, which is being dedicated to Dr. Alexander Hollaender, will be held April 11–14, 1988, in Gatlinburg, Tennessee. The program is designed to present studies of specific genes and gene regulatory functions related to mutagenesis, gene expression, and neoplastic processes.

Meetings organized by ORNL BES staff during FY 1987 are listed below.

Environmental Sciences Division

International Conference on Heavy Metals in the Environment, New Orleans, Louisiana, September 1987. Chairman: S. E. Lindberg.

Short Rotation Woody Crops Program Annual Contractors' Meeting, Oak Ridge, Tennessee, August 1987. Chairman: J. W. Ranney.

Herbaceous Energy Crops Program Annual Subcontractors' Review, Oak Ridge, Tennessee, August 1987. Chairman: J. H. Cushman.

IAEA 2nd Research Coordination Meeting on Migration and Biological Transport of Radionuclides from Shallow Land Burial, September 1987. Chairman: N. H. Cutshall.

Land Use and Carbon Dioxide Workshop, May 1987. Chairman: M. P. Farrell.

Ocean Carbon Cycle Workshop, May 1987. Chairman: M. P. Farrell.

Positive Feedback and Carbon Dioxide Workshop, June 1987. Chairman: M. P. Farrell.

Global CO_2 Modeling Workshop, July 1987. Chairman: M. P. Farrell.

Transport of Contaminants in the Subsurface: Role of Organic and Inorganic Colloidal Particles, Manteo, North Carolina, October 1986. Chairman: J. F. McCathy.

Health and Safety Research Division

10th Werner Brandt Workshop on Penetration Phenomena, Alicante, Spain, January 1987. Organizers: R. H. Ritchie and Alberto Gras-Marti.

Carcinogen Risk Assessment, Washington, D.C., April 1987. Organizer: C. C. Travis.

Fifth International Symposium on Gaseous Dielectrics, Knoxville, Tennessee, May 1987. Organizer: L. G. Christophorou.

The Liquid State and Its Electrical Properties, NATO ASI, Sintra, Portugal, July 1987. Codirector: L. G. Christophorou.

13th Personnel Dosimetry Intercomparison Study, Oak Ridge, Tennessee, July 1987. Organizer: C. S. Sims.

References

D. E. Reichle, 1987. *Environmental Sciences Division Annual Progress Report for Period Ending September 30, 1986*, ORNL-6327, Oak Ridge National Laboratory, Oak Ridge, Tennessee, 190 pp.

Griesemer, R. A., 1987. *Biology Division Progress Report for the Period of October 1, 1985–September 30, 1986*, ORNL-6353, Oak Ridge National Laboratory, Oak Ridge, Tennessee, 212 pp.

Walsh, P. J., 1987. *Health and Safety Research Division Progress Report for the Period October 1, 1985–March 31, 1987*, ORNL-6389, Oak Ridge National Laboratory, Oak Ridge, Tennessee, 158 pp.

Postma, H., J. R. Merriman, F. R. Mynatt, C. R. Richmond, M. W. Rosenthal, D. B. Trauger, R. S. Wiltshire, A. Zucker, M. L. Sollenberger, T. D. Anderson, J. R. Engel, L. L. Horton, C. A. Johnson, R. E. Pudelek, and J. E. Swift, 1987. *Oak Ridge National Laboratory Institutional Plan FY 1988–FY 1993*, ORNL/PPA-87/2, Oak Ridge National Laboratory, Oak Ridge, Tennessee, 169 pp.

Richmond, C. R., and J. L. Trimble, 1987. *Biomedical and Environmental Sciences Programs at the Oak Ridge National Laboratory*, Oak Ridge National Laboratory, Oak Ridge, Tennessee, 81 pp.

Trimble, J. L., G. R. Carter, W. C. Carter, J. R. Ellis, and V. S. Norman, 1987. *Biomedical and Environmental Sciences Program Publications 1986*, ORNL-6397, Oak Ridge National Laboratory, Oak Ridge, Tennessee, 65 pp.

Appendix A: Research Highlights

The following ORNL research highlights for FY 1987 are included in this Appendix:

1. Colloidal material is important in contaminant transport in the subsurface environment;
2. Isotopic studies of sulfur dynamics in forest trees;
3. ^{238}Pu, a tracer for river-ocean exchange processes;
4. Discovery of two new mechanisms of chemical mutagenesis;
5. Laser-based fiberoptics fluoroimmunosensor (FIS) for chemical and biological monitoring;
6. Crystal laser monitor;
7. Scanning-tunneling microscopy; and
8. Unlocking the structure-function secrets of CO_2-fixation enzyme.

Colloidal Material is Important in Contaminant Transport in the Subsurface Environment

Research at ORNL sponsored by the Subsurface Transport Program has made significant progress in explaining the role of colloids in contaminant transport. The research focuses on the role of colloidal organic macromolecules (COM) in enhancing the mobility of hydrophobic organic contaminants such as polynuclear aromatic hydrocarbons and polychlorinated biphenyls. Laboratory studies have described the chemical and structural properties of COM that affect the binding of the contaminants to COM—with the goal of predicting the amount of contaminant that measures the transport of COM in natural subsurface systems. Field studies measure the transport of COM in different subsurface environments to determine whether organic macromolecules that bind the contaminants are mobile in groundwater and are potentially capable of cotransporting the contaminants. This research will permit the role of COM in mobilizing organic contaminants to be incorporated in computer models and will significantly improve our capabilities to predict the transport of energy-related wastes in groundwater.

Principal investigator: Dr. J. F. McCarthy
Environmental Sciences Division
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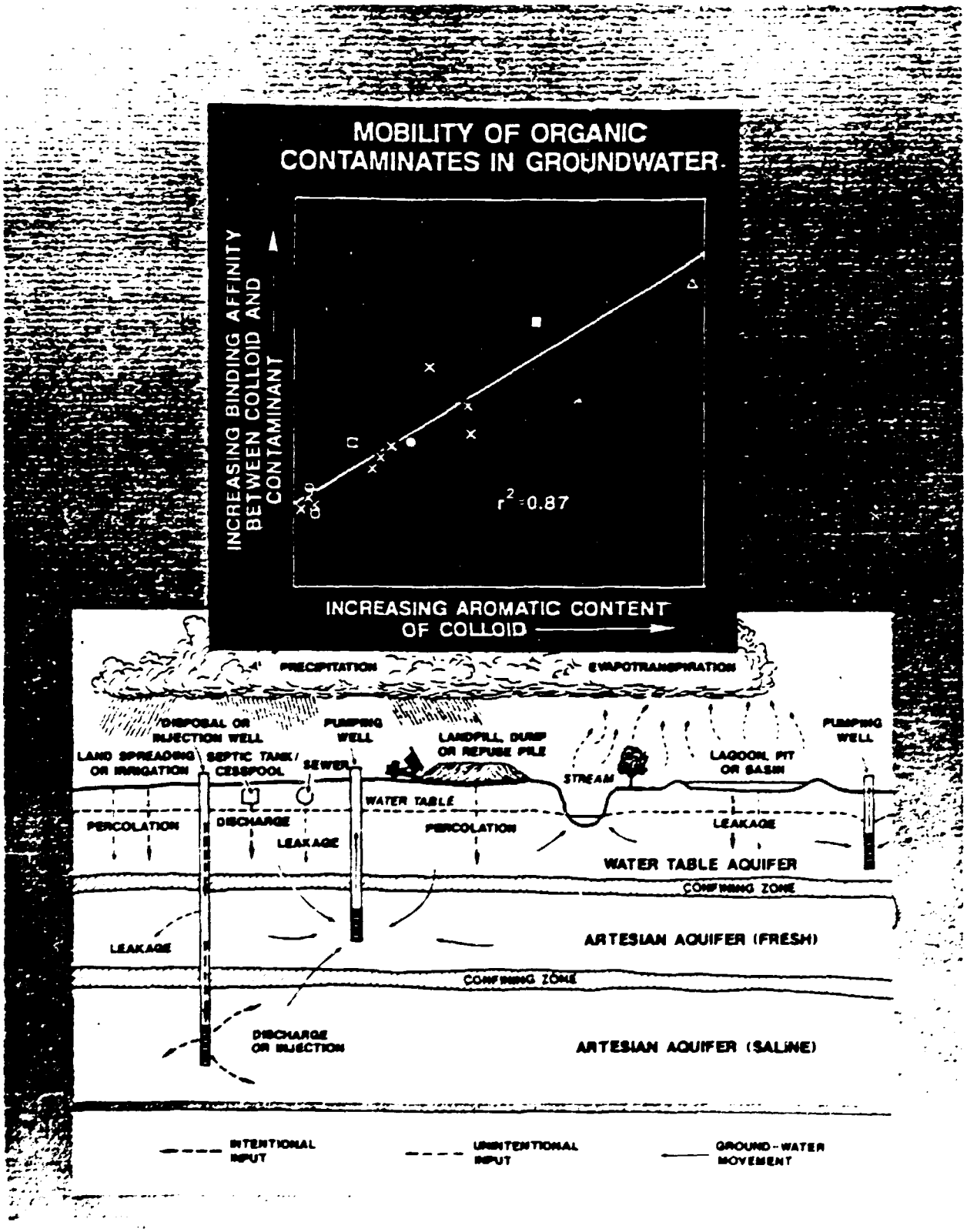
Caption for figure on the following page:

Natural organic matter in the colloidal size range can sorb environmental contaminants and enhance their transport in subsurface systems. However, organic colloids vary in their capacity for binding contaminants. The affinity of organic colloids from different surface and groundwaters for sorbing hydrophobic organic contaminants (such as polycyclic aromatic hydrocarbons) is directly related to the aromatic content of the colloidal material. The aromatic content is estimated spectrophotometrically from the absorption of 270 nm. This easily measured parameter increases capabilities to predict the mobility of contaminants in subsurface quaifers. (ORNL-PHOTO 1372-87)

ORNL-PHOTO 1372-87



Isotopic Studies of Sulfur Dynamics in Forest Trees

The atmospheric deposition of sulfur (S) to Walker Branch watershed, near Oak Ridge, Tennessee, far exceeds the total annual S requirement of the watershed forest. Geochemical factors are important in the watershed's retention of atmospheric inputs of S, but little is known about how forest trees cope with S in excess of their nutritional demands. Sulfur-35 (a short-lived radioisotope) has been used in small amounts to reveal the cycling (e.g., leaf fall, translocation, and rainfall leaching), storage, and biogenic emission of S by trees. These isotopic studies indicate little aboveground storage of S in tree wood; instead, S is translocated to roots, where some is lost to the soil through root death, and S is recycled back to the atmosphere by means of foliar emissions of volatile S compounds. Models of S cycling in forests do not normally account for these S dynamics in trees. Although dry deposition (gases and particles) of S from the atmosphere is a major contributor of S to the watershed, dry-deposition measurements are difficult to obtain because of the complexity of the forest canopy. It was determined that leaching of S from tree leaves by rainfall is a minor component of the S measured in throughfall (rainfall passing through the forest trees to the ground), and therefore, dry deposition is the major component of the S found in net throughfall (throughfall minus the contribution of incident rainfall). The significance of this finding is that during the growing season, when foliage is present, the amount of dry deposition to this forest can be estimated from sulfate in net throughfall. In addition to techniques using surrogate surfaces, throughfall measurement is a promising technique for estimating dry deposition of S to other forests impacted by S pollution because the tree canopy is the surface onto which deposition occurs.

Principal investigator: Mr. C. T. Garten, Jr.
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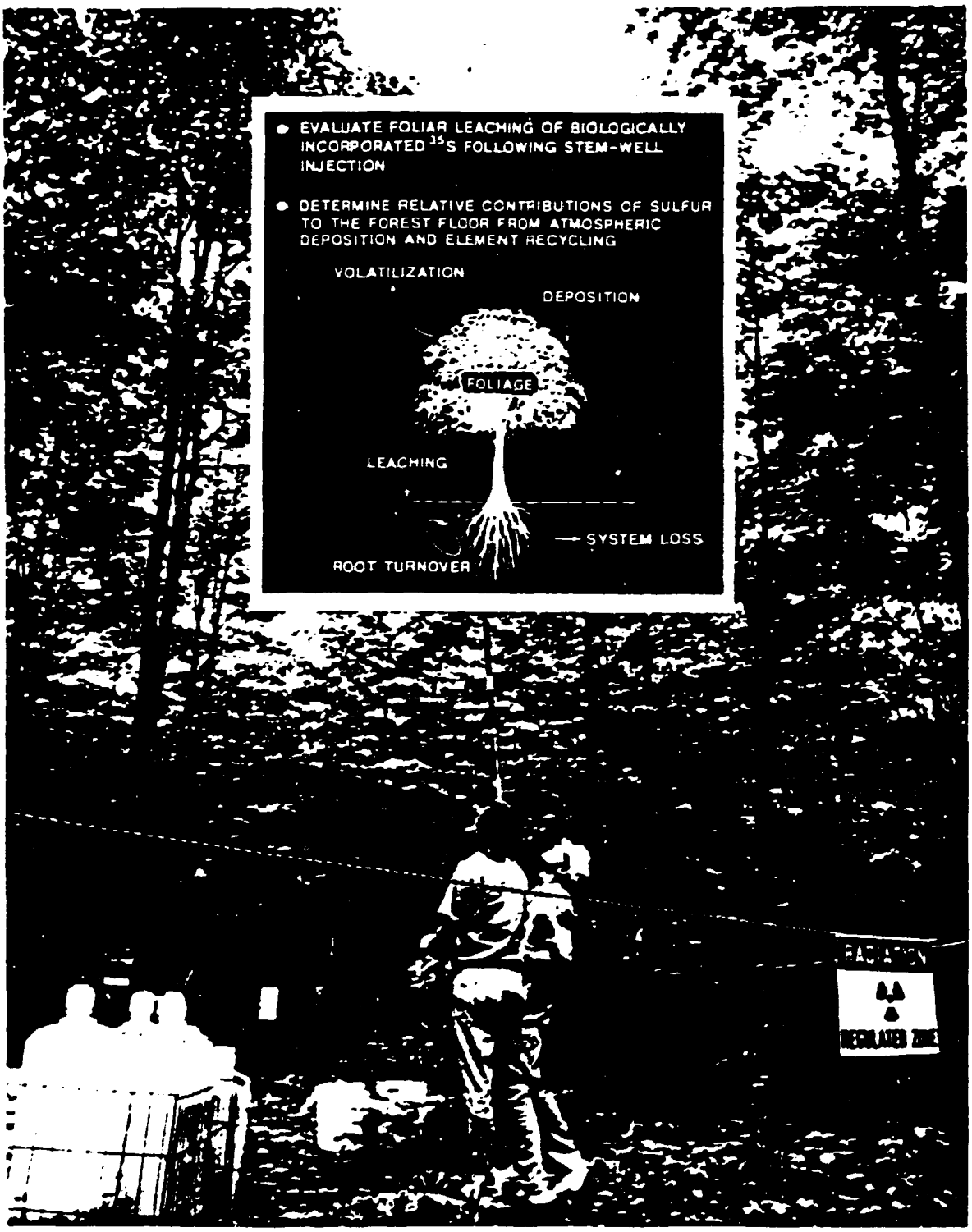
615/574-7355 (FTS: 624-7355)

Caption for figure on the following page:

Scientists sample foliage and stems in addition to litter and soil to determine ^{35}S concentrations in these components. The data from the samples are used to determine the relative contributions of sulfur to the forest floor from atmospheric deposition and element recycling. (ORNL-PHOTO 4670-88)

ORNL-PHOTO 4670-88



^{238}Pu, a Tracer for River-Ocean Exchange Processes

Plutonium-238 from the Savannah River Plant labels riverborne particles and provides a unique opportunity for tracing river-ocean exchange processes. Results indicate that inputs of plutonium from oceanic sources greatly exceed inputs from riverborne or drainage-basin sources as far upstream as 30 km in the Savannah River estuary, which is near the landward limit of seawater penetration. Because river-estuarine areas serve as effective traps for fine particles and associated substances, this landward transport from marine sources has important implications concerning the disposal of chemically reactive substances in oceanic waters off submergent coastlines. In addition, these results provide a rationale for the elevated plutonium and excess lead-210 concentrations and inventories that often occur in fine-grained estuarine and coastal sediments.

Principal investigator: Dr. C. R. Olsen
Environmental Sciences Division
Oak Ridge National Laboratory
615/576-0505 (FTS: 626-0505)

Caption for figure on the following page:

Large-volume water samples are collected for the extraction and measurement of naturally occurring and man-made radionuclides. The distribution of these radionuclides, including ^{7}Be, ^{60}Co ^{134}Cs, ^{137}Cs, ^{210}Pb, ^{222}Rn, ^{226}Ra, ^{238}Pu, and ^{239,240}Pu are used to quantify transport and accumulation processes in rivers, reservoirs, estuaries, and coastal waters. (ORNL-PHOTO 0592-87)

ORNL-PHOTO 0592-87

Discovery of Two New Mechanisms of Chemical Mutagenesis

DNA may not be the molecular target for certain induced genetic effects; and the outcome of chemical treatment at a certain germ-cell stage may be radically different from the types of outcomes reported earlier. These are the findings of two separate studies with ethylene oxide (EtO), but similar results have since been observed for certain other chemicals as well.

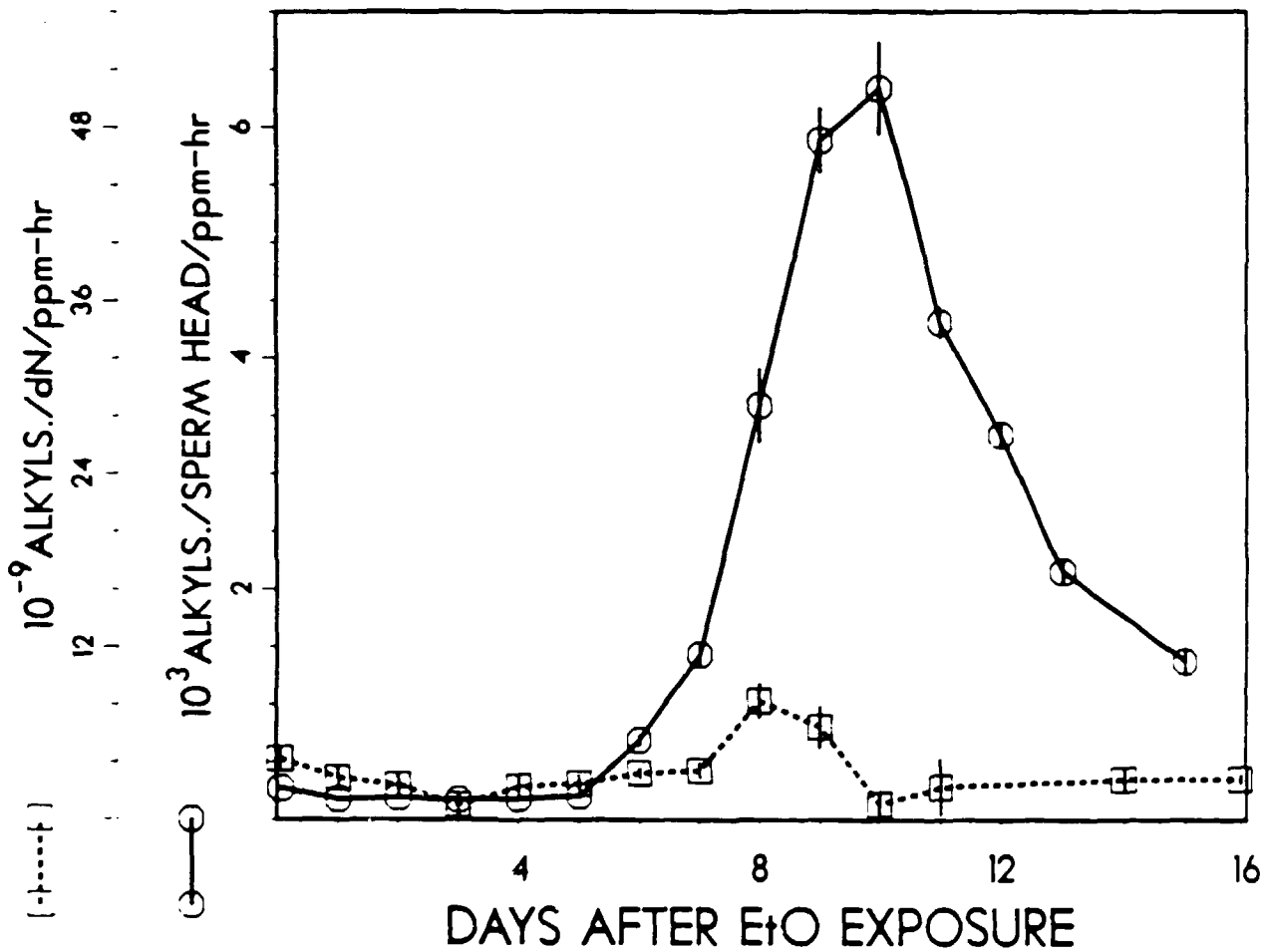
For years, the dogma has been that the target for chemically induced genetic effects is DNA. Biology Division investigators now show that in near-mature male reproductive cells of the mouse, the target may, in fact, be protamine, the predominant protein associated with the chromosomal DNA in these cells. The investigators measured alkylations in the sperm of mice that had been exposed by inhalation to very low levels of ^{3}H-labeled EtO. The stage-related pattern of sperm protamine alkylation paralleled that for certain heritable effects; by contrast, very little alkylation was found in the DNA.

When EtO is administered to mice shortly after sperm has entered the egg (early zygote stage), almost one-third of the resulting offspring die in the latter part of pregnancy—many of them being malformed in a variety of ways. By contrast, all previous work with radiation administered to zygotes had shown an all-or-none effect, namely, very early embryonic death but normality of survivors. In the past, congenital anomalies following radiation or chemical exposure have been generated only by treatment during the period of major organogenesis (i.e., later in development) and have been stage specific, rather than highly varied, as now reported for EtO-exposed zygotes.

Principal investigators: Drs. W. M. Generoso and G. A. Sega
Biology Division
Oak Ridge National Laboratory
615/574-0861 (FTS: 624-0861)
615/574-0848 (FTS: 624-0848)

Caption for figure on the following page:

EtO alkylation in sperm heads recovered from the vasa deferentia of mice over a two-week period following inhalation exposure (○—○). DNA was purified from remaining portions of the vas sperm samples except for the 14-d and 16-d time points where epididymal sperm DNA was used. The EtO binding in the sperm DNA over the two-week period was then determined as alkylation per deoxynucleotide (dN) (□—□). All results were normalized to 1 ppm/h of EtO exposure. Error bars represent ± 1 SD.


10^{-9}ALKYLS./dN/ppm-hr
12
24
36
48
10^{3}ALKYLS./SPERM HEAD/ppm-hr
2
4
6
4
8
12
16
DAYS AFTER EtO EXPOSURE

Laser-Based Fiberoptics Fluoroimmunosensor (FIS) for Chemical and Biological Monitoring

Recent developments in fluorescence instrumentation, biotechnology, and fiberoptics research have opened new possibilities for the development of sensitive and selective tools to measure human exposure to hazardous environmental chemicals and important biological compounds. Researchers in the Health and Safety Research Division have recently developed an instrument integrating fiberoptics, laser technology, antibody development, and immunofluorescence spectroscopy for use in the detection of trace amounts of carcinogenic compounds and their metabolites in complex samples.

The device is a unique fluorimmunosensor (FIS) that derives its analytical selectivity through the specificity of antibody-antigen reactions. Antibodies are immobilized at the terminus of a fiberoptical within the FIS, thus allowing both in vitro and in vivo fluorescence assays. High sensitivity is provided by laser excitation through a fiberoptic waveguide to the sensing and where antibodies are attached. Targeted antigens in biological samples or in complex environmental mixtures attached to the antibodies are excited by the laser radiation, and then fluorescence is detected by a sensitive optical technique.

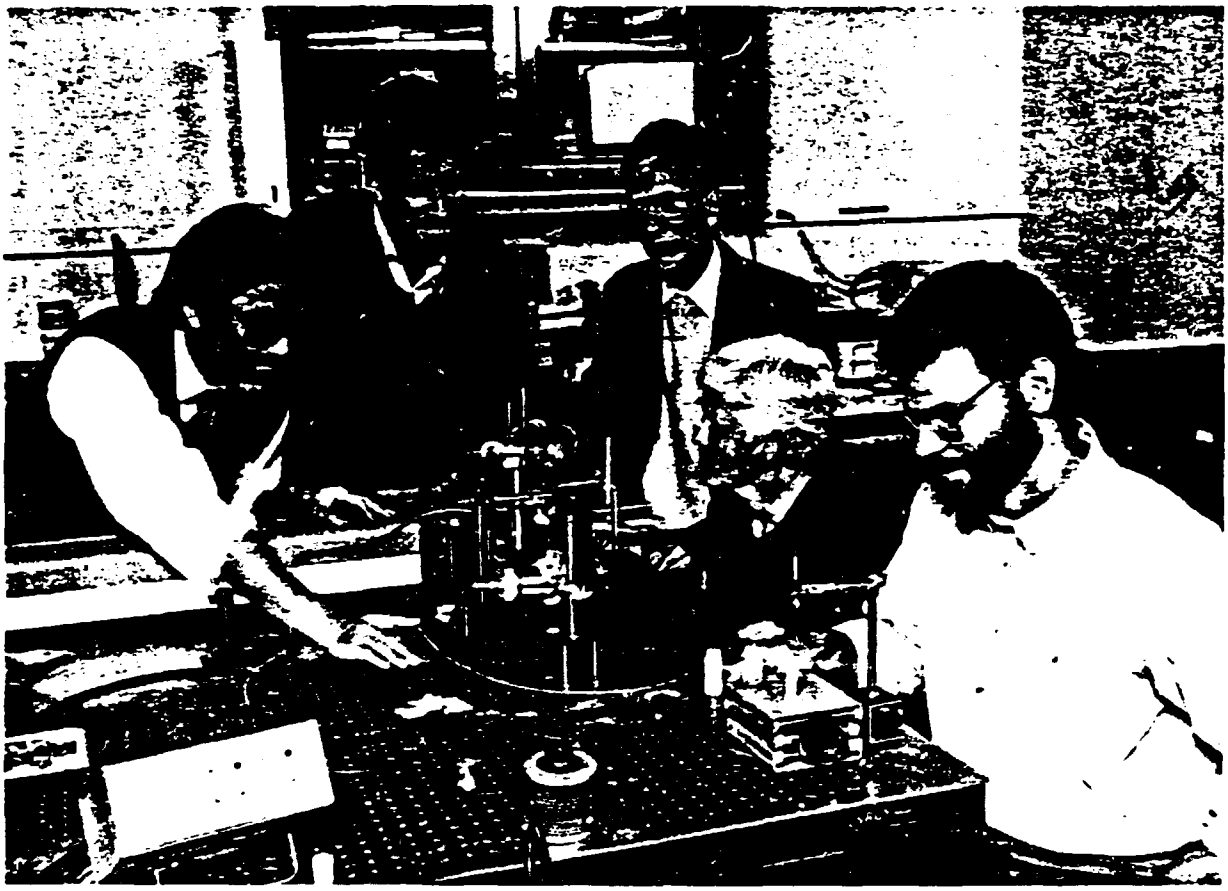
The FIS is a device with wide-ranging applications to chemical, biological, and environmental monitoring. Not only fluorescent but weakly fluorescent or nonfluorescent species can be monitored by fluorotagging methods. The feasibility of the FIS has recently been demonstrated by the detection of femtomole amounts of benzo(a)pyrene, a potent carcinogenic precursor frequently found in environmental and biological samples. Another positive feature of this FIS device is its ability to use minute amounts of sample (microliters), which should make it suitable for clinical analyses of human body fluids. The FIS was a recipient of an I•R 100 Award in 1987.

Principal investigator: Dr. T. Vo-Dinh
Health and Safety Research Division
Oak Ridge National Laboratory
615/624-6308

Caption for figure on the following page:

Researchers from Oak Ridge National Laboratory and The University of Tennessee are developing an antibody-based fluoroimmunosensor (FIS) for detecting femtomoles of carcinogens and related biological compounds in minute amounts of body fluids (I•R 100 Award winner in 1987). (Left to right: T. Vo-Dinh, M. J. Sepaniak, G. D. Griffin, K. R. Ambrose, and B. J. Tromberg.) (ORNL-PHOTO 10100-87)

ORNL-PHOTO 10100-87



Crystal Laser Monitor

Ultraviolet lasers have found many important applications in science and industry. Because an ultraviolet laser beam is not visible to the human eye, the characteristics of the beam are not readily determined. But in most applications, it is important to know the size, shape, divergence, and the energy distribution of a laser beam. At ORNL, a simple and inexpensive ultraviolet laser beam monitor has been developed, for which an I•R 100 Award was granted in 1987. The monitor consists of an alkali halide crystal such as sodium chloride, potassium chloride, or cesium bromide doped with a material such as thallium or excess alkali metal. When such a crystal is put in an ultraviolet laser beam, the resulting two-photon absorptions produce color centers in the transparent crystal. Thus, a three-dimensional color pattern develops in the crystal corresponding to the spatial and energy distribution of the ultraviolet laser beam to which the crystal was exposed. Once an ultraviolet laser beam has produced a colored intensity profile in the crystal, the crystal may be removed from the laser beam and viewed from all angles.

The three-dimensional profile of an ultraviolet laser beam will persist over long periods of time, or it can be erased to allow the monitor to be used again because heating or exposing the crystal to bright visible light removes all of the color centers. Thus, the monitor may be used and erased an indefinite number of times.

Principal investigator: Dr. C. H. Chen
Health and Safety Research Division
Oak Ridge National Laboratory
615/574-5895 (FTS: 624-5895)

Caption for figure on the following page:

C. H. (Winston) Chen (center) holds a sample alkali halide crystal as he and other developers, Steven Kramer (left), and Michael McCann (right), stand behind a laser beam that is monitored by the rectangular crystal in the foreground. The Crystal Laser Monitor was a 1987 I•R 100 Award recipient. (ORNL-PHOTO 0086-85)

ORNL-PHOTO 0086-85

Scanning-Tunneling Microscopy

The recent invention of scanning-tunneling microscopy (STM) by the Nobel Laureates of 1986, G. Binnig and H. Rohrer, permits resolution of the electronic distribution of individual atoms. The ORNL STM facility has four electron STMs, three of which we constructed during the past two years. One of these operates in ultrahigh vacuum and has been used to obtain micrographs of atomic positions at the surfaces of several materials. It is currently being used to investigate the possibility of chemical identification of single clusters of nanometer size.

Three of our STMs operate in a fluid environment, which has enabled us to image arrays of carbon atoms. Biological applications are particularly well suited to these instruments, and we are currently obtaining contours of the tobacco-mosaic virus on gold substrates. We have also obtained micrographs that show the positions of long-chain hydrocarbon monomers on highly oriented pyrolytic graphite. Universities and other ORNL divisions have asked us to study a variety of samples in the STM facility, and much of the ensuing work has been successful.

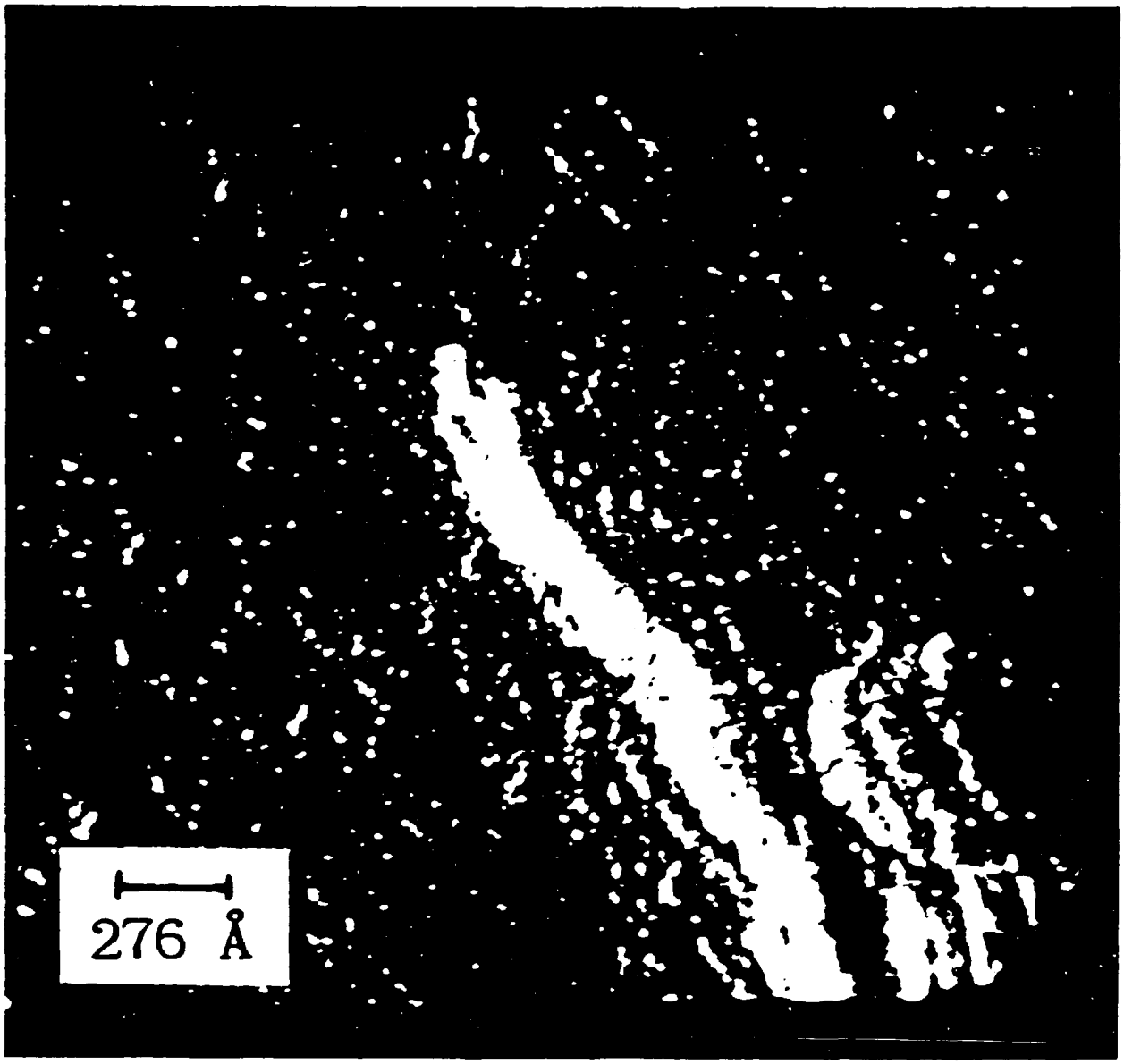
A unique photon STM invented in the ORNL Liquid and Submicron Physics Group may permit optical and ultraviolet imaging of a wide variety of samples that cannot be viewed by any other form of electron microscopy. It is expected that this instrument will exceed the resolution of ordinary optical microscopes by more than a factor of five in the sample plane and by a factor of fifty normal to the surface.

Principal investigator: Dr. T. L. Ferrell
Health and Safety Research Division
Oak Ridge National Laboratory
615/574-6214 (FTS: 624-6214)

Caption for figure on the following page:

Scanning-tunneling microscope image of tobacco-mosaic virus. The virus lies uncoated on a flat gold surface and was scanned in air. The dimensions of the virus are 250 nm long by 18 nm high. The protein cell structure can be seen as ribs separated by only 2.4 nm. This photograph represents the first complete STM image of a virus. (ORNL-PHOTO 0261-88)

ORNL-PHOTO 0261-88



Unlocking the Structure-Function Secrets of CO_2-Fixation Enzyme

The carbon di ide- (CO_2-) fixation enzyme is a cornerstone of life in that it enables photosynthetic organisms to convert atmospheric CO_2 into carbohydrates. Like many proteins, the CO_2-fixation enzyme contains multiple, identical catalytic subunits (polypeptide chains). When the subunits of a protein are chemically and structurally identical, a fundamental question arises as to why biological activity is not exhibited by monomers but rather requires subunit-subunit association. One possibility is that catalytic sites are created by association of subunits. This postulate has been tested directly by protein engineering of the CO_2-fixation enzyme.

Varied data have identified two amino acids that participate in catalysis and, hence, must be in spatial proximity. However, these two amino acids, glutamic acid at position 48 and lysine at position 166, are far apart on the linear polypeptide chain. Thus, their spatial proximity could be due to folding of individual subunits to generate an independent catalytic site within each subunit or could be due to interaction between subunits whereby position 48 on one subunit is adjacent to position 166 on another subunit. Catalytically inactive mutants result when other amino acids are placed at position 48 or 166 by protein engineering. However, when hydrids of these catalytically inactive mutants are formed by their coexpression from separate plasmids introduced into bacterial cells, enzyme activity is restored. Thus, the catalytic site must be created by subunit-subunit interaction, thereby explaining the absence of a monomeric form of this enzyme in nature. This finding is pertinent to ongoing structure/function correlation studies of the CO_2-fixation enzyme, with the ultimate goal of designing a superior enzyme and hence a superior plant for enhanced yields of biomass.

Principal investigator: Dr. F. C. Hartman
Biology Division
Oak Ridge National Laboratory
615/574-0959 (FTS: 624-0959)

Appendix B: OHER-Supported Publications

OHER-Supported Publications for CY 1987

A list of OHER-supported publications from ORNL's Biomedical and Environmental Sciences Program for FY 1987 follows. This list of 230 publications includes 164 refereed journal articles, 25 reports and/or documents, and 41 proceedings and/or book chapters. Because the list is compiled for the calendar year, the list may not be complete for 1986. The list is organized by ORNL division as follows: (1) Analytical Chemistry, (2) Biology, (3) Central Management Offices, (4) Chemical Technology, (5) Chemistry, (6) Computing and Telecommunications, (7) Energy, (8) Engineering Physics and Mathematics, (9) Environmental Sciences, and (10) Health and Safety Research. A complete list of ORNL's Biomedical and Environmental Sciences Program publications for CY 1986 was compiled in Trimble et al. 1987.

Analytical Chemistry Division

Buchanan, M. V., Rubin, I. B., Wise, M. B., and Glish, G. L., "Formation of M + 14 Anions from Fluorene: Negative Ion CI Studies Using GC/MS, MS/MS and FTMS," *Biomed. Environ. Mass Spectrom.* **14**, 395–99 (1987)

Buchanan, M. V., Rubin, I. B., Wise, M. B., and Glish, G. L., "Formation of M + 14 Anions from Fluorene: Negative Ion CI Studies Using GC/MS, MS/MS and FTMS," *Biomed. Environ. Mass Spectrom.* **14**, 395–99 (1987)

York, March 1986, Vol. 3, *Am. Chem. Soc., 1986*

Burton, D. E., Sepaniak, M. J., and Maskarinec, M. P., "The Effect of Injection Procedures on Efficiency in Micellar Electrokinetic Capillary Chromatography," *Chromatographia* **21**, 583–86 (1986)

Griest, W. H., Tomkins, B. A., Reagan, R. R., and Russell, J. W., "Comparison of Selected Four- to Six-Ring Polycyclic Aromatic Hydrocarbon Dermal Tumorigens in Coal-Derived Liquids and Solids," *Fuel* **66**, 408–11 (1987)

Ma, C. Y., Ho, C. -H., Caton, J. E., Griest, W. H., and Guerin, M. R., "Isolation and Identification of Benzoquinolines in Natural and Synthetic Crude Oils," *Fuel* **66**, 612–17 (1987)

Sepaniak, M. J., Burton, D. E., and Maskarinec, M. P., "Micellar Electrokinetic Capillary Chromatograpy," pp. 142–51 in *Ordered Media in Chemical Separations, Proceedings of the 191st Meeting of the American Chemical Society, New York, April 13–18, 1986, Am. Chem. Soc. Symp. Ser.* **342**, 1987

Wise, M. B., "Ultra-High-Resolution Daughter Ion Tandem Mass Spectra Using a

Differentially Pumped Dual Cell Fourier Transform Mass Spectrometer," *Anal. Chem.* **59**, 2289–93 (1987)

Wise, M. B., Buchanan, M. V., Parks, S. K., and Haas, J. W., III, "Multimode Ionization Cell for Gas Chromatographic Detection," *Rev. Sci. Instrum.* **57**, 3075–80 (1986)

Biology Division

Allison, D. P., Daw, C. S., and Rorvik, M. C., "The Construction and Operation of a Simple Inexpensive Slam Freezing Device for Electron Microscopy," *J. Microsc.* **147**, 103–8 (1987)

Arnaise, S., Boeuf, H., Buisson, J. P., Cantat, N., Demerseman, P., Einhorn, J., Lamotte, G., Lemelin, M., Brimer, P. A., Perdue, S. W., Hsie, A. W., Royer, R., Kelly, F., and Hofung, M., "Mutagenicity Testing. Genotoxic Activities of 2-Nitronaphthofurans and Related Molecules," *Mutagenesis* **1**, 217–29 (1986)

Ashley, T., and Russell, L. B., "A New Type of Nonhomologous Synapsis in T(X;4)1R1 Translocation Male Mice," *Cytogenet. Cell Genet.* **43**, 194–200 (1986)

Avner, P., Arnaud, D., Amar, L., Cambrou, J., Winking, H., and Russell, L. B., "Characterization of a Panel of Somatic Cell Hybrids for the Regional Mapping of the Mouse X Chromosome," *Proc. Natl. Acad. Sci. USA 84*, 5330–34 (1987)

Bielanski, A., Schneider, U., Pawlyshyn, V., and Mapletoft, R. J., "Factors Affecting Survival of Deep Frozen Bovine Embryos In Vitro: The Effect of Freezing Container and Method of Removing Cryoprotectant," *Theriogenology* **25**, 429–37 (1986)

Boulden, A. M., Foote, R. S., Fleming, G. S., and Mitra, S., "Purification and Some Properties of Human DNA-O^6-Methylguanine Methyltransferase," *J. Biosci.* **11**, 215–24 (1987)

Cadilla, C. L., Roberson, A. E., Harp, J. M., Olins, A. L., and Olins, D. E., "Subfractionation of Soluble Macronuclear Chromatin and Enrichment of Specific Genes as Chromatin from Euplotes eurystomus," *Nucleic Acids Res.* **14**, 8501–12 (1986)

Cook, J. S., "Spark" vs "Soup:z(cq A Scoop for "Soup," *News Physiol. Sci.* **1**, 206–8 (1986)

Cook, J. S., Shaffer, C., and Cragoe, E. J., Jr., "Inhibition by Amiloride Analogues of Na^+-Dependent Hexose Uptake in LLC-PK_1/Cl_4 Cells," *Am. J. Physiol.* **253** (*Cell Physiol.* **22**), C199-C204 (1987)

Dawson, W. D., and Cook, J. S., "Parallel Changes in Amino Acid Transport and Protein Kinase C Localization in LLC-PK_1 Cells Treated with TPA or Diradylglycerols," *J. Cell. Physiol.* **132**, 104–10 (1987)

Flanagan, J. M., and Jacobson, K. B., "Effect of Zinc Ions on tRNA Structures: 1. Reversed-Phase Chromatography," *J. Chromatogr.* **387**, 139–54 (1987)

Fry, R. J. M., "Neutron Effects in Humans: Protection Considerations," presented at Int. Neutron Therapy Workshop on Brachy vs Beam Therapy, Lexington, Ky., April 21–24, 1985, *Nucl. Sci. Appl.* **2**, 397–407 (1986)

Fry, R. J. M., "Radiation Effects in Space," *Adv. Space Res.* **6**, 261–68 (1986)

Fry, R. J. M., and Fry, S. A., "Ionizing Radiation: Late Somatic Effects in Humans," pp.

2422–23 in *Encyclopedia of Materials Science and Engineering*, Pergamon, Oxford, 1986

Fry, R. J. M., Storer, J. B., and Burns, F. J., "Radiation Induction of Cancer of the Skin," presented at Workshop on Radiation Damage to Skin: Fundamental and Practical Aspects, Paris, Oct. 9–11, 1985, *Br. J. Radiol.* **59** (Suppl. 19), 58–60 (1986)

Goad, M. E. P., Tryka, A. F., and Witschi, H. P., "Acute Respiratory Failure Induced by Bleomycin and Hyperoxia: Pulmonary Edema, Cell Kinetics, and Morphology," *Toxicol. Appl. Pharmacol.* **90**, 10–22 (1987)

Goad, M. E. P., Tryka, A. F., and Witschi, H. P., "Surfactant Alterations Following Acute Bleomycin and Hyperoxia-Induced Lung Damage," *Toxicol. Lett.* **82**, 173–78 (1986)

Hanson, W. R., Fry, R. J. M., Sallese, A. R., Frischer, H., Ahmad, T., and Ainsworth, E. J., "Comparison of Intestine and Bone Marrow Radiosensitivity of the BALB/c and the C57BL/6 Mouse Strains and Their $B6CF_1$ Offspring," *Radiat. Res.* **110**, 340–52 (1987)

Hartman, F. C., Larimer, F. W., Mural, R. J., Machanoff, R., and Soper, T. S., "Essentiality of Glu-48 of Ribulose Bisphosphate Carboxylase/Oxygenase as Demonstrated by Site-Directed Mutagenesis," *Biochem. Biophys. Res. Commun.* **145**, 1158–63 (1987)

Hartman, F. C., Soper, T. S., Niyogi, S. K., Mural, R. J., Foote, R. S., Mitra, S., Lee, E. H., Machanoff, R., and Larimer, F. W., "Function of Lys-166 of R. rubrum Ribulose-bisphosphate Carboxylase/Oxygenase as Examined by Site-Directed Mutagenesis," *J. Biol. Chem.* **262**, 3496–501 (1987)

Hellwig, R. J., and Niyogi, S. K., "A Review of Protein Factors and Nucleoprotein Complexes Involved in Specific Transcription by Eukaryotic RNA Polymerase II," pp. 107–10 in *Chemistry and Biology of Pteridines, Proceedings of the 8th International Symposium on Pteridines and Folic Acid Derivatives, Montreal, Canada, June 14–21, 1986*, Walter De Gruyter and Co., Berlin and New York, 1986

Helman, R. G., Hall, J. W., and Kao, J. Y., "Acute Dermal Toxicity: In Vivo and In Vitro Comparisons in Mice," *Fundam. Appl. Toxicol.* **7**, 94–100 (1986)

Jacobson, K. B., "Post-Translational Regulation of Two Enzymes, Tryptophan Oxygenase and Sepiapterin Synthase, in Drosophila," presented at Symposium, pp. 3–13 in *Recent Progress of Molecular Biology and Genetic Engineering of Korea, Proceedings of the 1st Conference on Molecular Biology & Genetic Engineering, Seoul, October 16–17, 1986*, Institution for Molecular Biology & Genetics, Seoul National University, Korea, 1986

Jacobson, K. B., and Ferre, J., "Use of C18 Silica Cartridges to Purify and Characterize Pterins," pp. 107–10 in *Chemistry and Biology of Pteridines, Proceedings of the 8th International Symposium on Pteridines and Folic Acid Derivatives, Montreal, Canada, June 14–21, 1986*, Walter de Gruyter and Co., Berlin and New York, 1986

Jamison, C. S., and Adler, H. I., "Mutations in *Escherichia coli* That Effect Sensitivity to Oxygen," *J. Bacteriol.* **169**, 5087–94 (1987)

Kao, J., and Hall, J., "Skin Absorption and Cutaneous First Pass Metabolism of Topical Steroids: In Vitro Studies with Mouse Skin in

Organ Culture," *J. Pharmacol. Exp. Ther.* **241**, 482–87 (1987)

Kennel, S. J., Hotchkiss, J. A., Rorvik, M. C., Allison, D. P., and Foote, L. J., "Rat Monoclonal Antibodies to Mouse Lung Components for Analysis of Fibrosis," *Exp. Mol. Pathol.* **47**, 110–24 (1987)

Kuemmerle, N. B., Ch'ang, L. -Y., Koh, C. K., Boone, L. R., and Yang, W. K., "Characterization of Two Solitary Long Terminal Repeats of Murine Leukemia Virus Type That Are Conserved in the Chromosome of Laboratory Inbred Mouse Strains," *Virology* **160**, 379–88 (1987)

Last, J. A., Warren, D. L., Pecquet-Goad, E., and Witschi, H. P., "Modification by Ozone of Lung Tumor Development in Mice," *J. Natl. Cancer Inst.* **78**, 149–54 (1987)

Lee, E. H., Soper, T. S., Mural, R. J., Stringer, C. D., and Hartman, F. C., "An Intersubunit Interaction at the Active Site of D-Ribulose-1,5-bisphosphate Carboxylase/Oxygenase as Revealed by Cross-Linking and Site-Directed Mutagenesis," *Biochemistry* **26**, 4599–604 (1987)

Lee, E. H., Stringer, C. D., and Hartman, F. C., "Distance Between Two Active-Site Lysines of Ribulose Bisphosphate Carboxylase from Rhodospirillum rubrum," *Proc. Natl. Acad. Sci.* **83**, 9383–87 (1986)

Ley, R. D., Applegate, L. A., Stuart, T. D., and Fry, R. J. M., "UV Radiation-Induced Skin Tumors in Monodelphis domestica," *Photodermatology* **4**, 144–47 (1987)

Lindenschmidt, R. C., Tryka, A. F., and Witschi, H. P., "Modification of Gastrointestinal Tumor Development in Rats by Dietary Butylated Hydroxytoluene," *Fundam. Appl. Toxicol.* **8**, 474–81 (1987)

Mann, R. C., "On Multiparameter Data Analysis in Flow Cytometry," *Cytometry* **8**, 184–89 (1987)

Mann, R. C., Mansfield, B. K., and Selkirk, J. K., "Methods for Computer Analysis and Comparison of Two-Dimensional Protein Patterns Obtained by Electrophoresis," presented at NATO Advanced Study Institute on Pattern Recognition, Spa, Belgium, June 9–20, 1986, pp. 529–37 in *Pattern Recognition Theory and Applications*, Springer-Verlag, Berlin, 1987

Merrick, B. A., and Selkirk, J. K., "Separation of Glucuronide, Sulfate and Glutathione Conjugates of Benzo(a)pyrene by HPLC," pp. 561–77 in *Polynuclear Aromatic Hydrocarbons, Proceedings of the 9th International Symposium on Chemistry, Characterization and Carcinogenesis, Columbus, Ohio, October 30–November 1, 1984*, Battelle Press, Columbus, Ohio, 1986

Miller, A. B., Bruce, W. R., Fry, R. J. M., and Hoffman, D., "Symposium: Carcinogenesis," presented at Symp. on Carcinogenesis, Toronto, Sept. 22, 1986, *Annales of the Royal College of Physicians and Surgeons of Canada*, **20**, 262–64 (1987)

Niyogi, S. K., Soper, T. S., Foote, R. S., Larimer, F. W., Mural, R. J., Mitra, S., Lee, E. H., Machanoff, R., and Hartman, F. C., "Site-Directed Mutagenesis to Determine Essential Residues of Ribulose-Bisphosphate Carboxylase of Rhodospirillum rubrum," *J. Biosci.* **11**, 203–14 (1987)

Oakberg, E. F., Gosslee, D. G., Huckins, C., and Cummings, C. C., "Do Spermatogonial

Stem Cells Have a Circadian Rhythm?" *Cell and Tissue Kinet.* **19**, 367–75 (1986)

Popp, R. A., D'Surney, S. J., and Wawrzyniak, C. J., "Changes in Expression of Murine Alpha- and Beta-Globin Genes During Development," presented at 5th Hemoglobin Switching Conf., Warrenton, Va., Sept. 30–Oct. 1, 1986, pp. 81–89 in *Progress in Clinical and Biological Research, Developmental Control of Globin Gene Expression*, Vol. 251, Alan R. Liss, Inc., New York, 1987

Preston, R. J., Dean, B. J., Galloway, S., Holden, H., McFee, A. F., and Shelby, M., "Mammalian In Vivo Cytogenetic Assays. Analysis of Chromosome Aberrations in Bone Marrow Cells," *Mutat. Res.* **189**, 157–65 (1987)

Preston, R. J., San Sebastian, J. R., and McFee, A. F., "The In Vitro Human Lymphocyte Assay for Assessing the Clastogenicity of Chemical Agents," *Mutat. Res.* **189**, 175–83 (1987)

Rothrock, R., Lee, K. -L., Isham, K. R., Johnson, A. C., and Kenney, F. T., "Different Mechanisms Control Developmental Activation of Transcription of Genes Subject to Identical Hormonal Regulation in Adult Liver," *Biochem. Biophys. Res. Commun.* **144**, 1182–87 (1987)

Roy, D., and Mitra, S., "Preliminary Studies on Molecular Characterization of the Two New Pseudomonas Species Capable of Utilizing Chloroaromatic Compounds," presented at Symposium, pp. 275–81 in *Proceedings of the 8th Symposium on Biotechnology for Fuels and Chemicals, Gatlinburg, Tennessee, May 13–16, 1986, Biotechnology and Bioengineering Symposium 17*, John Wiley, 1987

Russell, L. B., and Hunsicker, P. R., "Study of the Base Analog 6-Mercaptopurine in the Mouse Specific-Locus Test," *Mutat. Res.* **176**, 47–52 (1987)

Russell, W. L., "Ionizing Radiation: Genetic Effects in Humans," pp. 2421–22 in *Encyclopedia of Materials Science and Engineering*, Pergamon, 1986

Schneider, U., and Mazur, P., "Relative Influence of Unfrozen Fraction and Salt Concentration on the Survival of Slowly Frozen Eight-Cell Mouse Embryos," *Cryobiology* **24**, 17–41 (1987)

Sega, G. A., and Owens, J. G., "Binding of Ethylene Oxide in Spermiogenic Germ Cell Stages of the Mouse After Low-Level Inhalation Exposure," *Environ. Mol. Mutagen.* **10**, 119–27 (1987)

Sendelbach, L. E., and Witschi, H. P., "Bronchoalveolar Lavage in Rats and Mice Following Beryllium Sulfate Inhalation," *Toxicol. Appl. Pharmacol.* **90**, 322–29 (1987)

Sendelbach, L. E., and Witschi, H. P., "Protection by Parenteral Iron Administration Against the Inhalation Toxicity of Beryllium Sulfate," *Toxicol. Lett.* **35**, 321–25 (1987)

Siracusa, L. D., Russell, L. B., Eicher, E. M., Corrow, D., Copeland, N. G., and Jenkins, N. A., "Genetic Organization of the Agouti Region of the Mouse," *Genetics* **117**, 93–100 (1987)

Siracusa, L. D., Russell, L. B., Jenkins, N. A., and Copeland, N. G., "Allelic Variation Within the EMV-15 Locus Defines Cellular Sequences Closely Linked to the Agouti Locus on Mouse Chromosome 2," *Genetics* **117**, 85–92 (1987)

Snow, E. T., and Mitra, S., "Do Carcinogen-Modified Deoxynucleotide Procursors Contribute to Cellular Mutagenesis?" *Cancer Invest.* **5**, 119–25 (1987)

Stankowski, L. F., Jr., Tindall, K. R., and Hsie, A. W., "Quantitative and Molecular Analyses of Ethyl Methanesulfonate- and ICR-191-Induced Mutation in AS52 Cells," *Mutat. Res.* **160**, 133–47 (1986)

Stevens, A., and Maupin, M. K., "A 5' ⩾ 3' Exoribonuclease of *Saccharomyces cerevisiae:* Size and Novel Substrate Specificity," *Arch. Biochem. Biophys.* **252**, 339–347 (1987)

Stevens, A., and Maupin, M. K., "A 5' ⩾ 3' Exoribonuclease of Human Placental Nuclei: Purification and Substrate Specificity," *Nucleic Acids Res.* **15**, 695–708 (1987)

Thiessen, K. M., and Lalley, P. A., "New Gene Assignments and Syntenic Groups in the Baboon (*Papio papio*)," *Cytogenet. Cell Genet.* **42**, 19–23 (1986)

Thiessen, K. M., and Lalley, P. A., "Gene Assignments and Syntenic Groups in the Sacred Baboon (*Papio hamadryas*)," *Cytogenet. Cell Genet.* **44**, 82–88 (1987)

Ullrich, R. L., Jernigan, M. C., Satterfield, L. C., and Bowles, N. D., "Radiation Carcinogenesis: Time-Dose Relationships," *Radiat. Res.* **111**, 179–84 (1987)

Ullrich, R. L., and Preston, R. J., "Myeloid Leukemia in Male RFM Mice Following Irradiation with Fission Spectrum Neutrons or Gamma Rays," *Radiat. Res.* **109**, 165–70 (1987)

Wawrzyniak, C. J., and Popp, R. A., "Expression of the Two Adult Beta-Globin Genes in Mouse Yolk Sac and Fetal Liver Erythrocytes," *Dev. Biol.* **119**, 299–301 (1987)

Witschi, H. P., Godfrey, G., Frome, E., and Lindenschmidt, R. C., "Pulmonary Toxicity of Cytostatic Drugs: Cell Kinetics," *Fundam. Appl. Toxicol.* **8**, 253–62 (1987)

Witschi, H. P., Smith, L. H., Frome, E. L., Pequet-Goad, M. E., Griest, W. H., Ho, C. -h., and Guerin, M. R., "Skin Tumorigenic Potential of Crude and Refined Coal Liquids and Analogous Petroleum Products," *Fundam. Appl. Toxicol.* **9**, 297–303 (1987)

Witschi, H. P., Smith, L. H., Goad, M. E., Guerin, M. R., Griest, W. H., and Ho, C. -H., "Comparative Toxicity of Crude and Refined Coal Liquids and Analogous Petroleum Products. 1. Chronic Dermal Toxicity in Mice," pp. 144–46 in preprint of *American Chemical Society Symposium on Chemical Basis for Toxicological Response in Synthetic Fuel Liquids, New York, April 13–18, 1986*, Vol. 3, Am. Chem. Soc., 1986

Yim, J. J., Yoon, J., Park, Y. S., Grell, E. H., and Jacobson, K. B., "Mechanism of Suppression in Drosophila: Regulation of Tryptophan Oxygenase by the su(s)$^+$ Allele," *Biochem. Genet.* **25**, 359–74 (1987)

Central Management Offices

Richmond, C. R., and Trimble. J. L., *Biomedical and Environmental Sciences Program*, ORNL/M-304, Oak Ridge National Laboratory, February, 1987

Trimble, J. L., Carter, G. R., Carter, W. C., Ellis, J. R., and Norman, V. S., *Biomedical and Environmental Sciences Program Publications 1986*, ORNL-6397, Oak Ridge National Laboratory, June 1987

Chemical Technology Division

Burtis, C. A., "Advanced Technology and Its Impact on the Clinical Laboratory," *Clin. Chem.* **33**, 352–57 (1987)

Burtis, C. A., Johnson, W. F., and Walker, W. A., "Development of a Simple Device for Processing Whole Blood Samples into Measured Aliquots of Plasma," presented at 18th Annu. Oak Ridge Conf. Advanced Analytical Concepts for the Clinical Laboratory, Knoxville, Tenn., Apr. 17–18, 1986, *Clin. Chem.* **32**, 1642–47 (1986)

Chemistry Division

Baes, C. F., Jr., and Killough, G. G., "Chemical and Biological Processes in CO_2-Ocean Models," presented at ORNL 6th Life Sciences Symp. Global Carbon Cycle, pp. 329–47 in *The Changing Carbon Cycle: A Global Analysis, Proceedings of the 6th ORNL Life Sciences Symposium, Knoxville, Tennessee, October 31–November 2, 1983*, Springer-Verlag, 1986

Computing and Telecommunications Division

Ryman, J. C., Cristy, M., Eckerman, K. F., Davis, J. L., Tang, J. S., and Kerr, G. D., "A Code System To Compute Radiation Dose in Human Phantoms," presented at Winter Meet. Am. Nucl. Soc., Washington, D.C., Nov. 16–20, 1986, *Trans. Am. Nucl. Soc.* **53**, 37–38 (1986)

Energy Division

Darmstadter, J., Ayres, L. W., Ayres, R. U., Clark, W. C., Crosson, P., Graedel, T. E., McGill, R., Richards, J. F., and Tarr, J. A., *Impacts of World Development on Selected Characteristics of the Atmosphere: An Integrative Approach, Volume 2, Appendices*, ORNL/Sub/86-22033/1/V2, Oak Ridge National Laboratory, September 1987

Engineering Physics and Mathematics Division

Broadhead, B. L., Lillie, R. A., Pace, J. V., III, and Cacuci, D. G., "Sensitivity/Uncertainty Analysis for the Hiroshima Dosimetry Reevaluation Effort," presented at Conf., p. 149 in *Proceedings of the American Nuclear Society Topical Conference on Theory and Practices in Radiation Protection and Shielding, Knoxville, Tennessee, April 22–24, 1987*, Vol. 1, Am. Nucl. Soc., 1987

Gosslee, D. G., *Sample Size and Power Calculations for Tests on Potential Mutagens*, ORNL/TM-10251, Oak Ridge National Laborataory, January 1987

Hall, M. C. G., "Application of Adjoint Sensitivity Theory to an Atmospheric General Circulation Model," *J. Atmos. Sci.* **43**, 2644–51 (1986)

Lillie, R. A., Broadhead, B. L., Pace, J. V., III, and Cacuci, D. G., "Sensitivity/Uncertainty Analysis for the Nagasaki Dosimetry Reevaluation Effort," presented at Conf., pp. 139–48 in *Proceedings of the American Nuclear Society Topical Conference on Theory and Practices in Radiation Protection and Shielding, Knoxville, Tennessee, April 22–24, 1987*, Vol. 1, Am. Nucl. Soc., 1987

Schmoyer, R. L., "Convex Sets in Minimum-Distance Estimation," *Commun. Stat.–Theor. Methods* **15**, 3625–35 (1986)

Schmoyer, R. L., "Dose-Response Analysis Under Unimodality of Response-to-Dose," pp. 125–52 in *Proceedings of the Conference on Advances in Order-Restricted Inference, Iowa City, Iowa, September 11–13, 1985*, Springer-Verlag, 1986

Environmental Sciences Division

Adams, S. M. and DeAngelis, D. L., "Indirect Effects of Early Bass-Shad Interactions on Predator Population Structure and Food Web Dynamics," pp. 103–17 in *Predation*, University Press of New England, Hanover, N.H., 1987

Blaylock, B. G., Frank, M. L., Hoffman, F. O., and DeAngelis, D. L., "Behavior of Technetium in Freshwater Environments," presented at Seminar, pp. 79–89 in *Technetium in the Environment, Proceedings of the Scientific Seminar on Behavior of Technetium in the Environment, Cadarache, France, October 23–26, 1984*, Elsevier, London, 1986

Blaylock, B. G., Hoffman, F. O., and Frank, M. L., "Tritium in the Aquatic Environment," presented at Workshop on Environmental and Human Risks of Tritium, Karlsruhe, Federal Republic of Germany, Feb. 17–19, 1986, *Radiat. Prot. Dosim.* **16**, 65–71 (1986)

Bondietti, E. A., and Brantley, J. N., "Characteristics of Chernobyl Radioactivity in Tennessee USA," *Nature* **32**, 313–14 (1986)

Bondietti, E. A., and Garten, C. T., Jr., "Transfer of I-131 and Tc-95m from Pasture to Goat Milk," presented at Seminar, pp. 339–47 in *Technetium in the Environment, Proceedings of the Scientific Seminar on Behavior of Technetium in the Environment, Cadarache, France, October 23–26, 1984*, Elsevier, London, 1986

Bondietti, E. A., Papastefanou, C., and Rangarajan, C., "Aerodynamic Size Associations of Natural Radioactivity with Ambient Aerosols," pp. 171–91 in *Radon and Its Decay Products: Occurrence, Properties, and Health Effects, Proceedings of the 191st Meeting of the American Chemical Society, New York, April 13–18, 1986*, Am. Chem. Soc. Symp. Ser. **331**, 1987

Broecker, W. S., and Peng, T. -H., "Carbon Cycle: 1985, Glacial to Interglacial Changes in the Operation of the Global Carbon Cycle," *Radiocarbon* **28**, 309–27 (1986)

Broecker, W. S., and Peng, T. -H., "The Role of $CaCO_3$ Compensation in the Glacial to Interglacial Atmospheric CO_2 Change," *Global Biogeochem. Cycle* **1**, 15–29 (1987)

Broecker, W. S., Peng, T. -H., and Ostlund, G., "The Distribution of Bomb Tritium in the Ocean," *J. Geophys. Res.* **91**, 14331–44 (1986)

Bruce, R. R., and Luxmoore, R. J., "Water Retention: Field Methods," pp. 663–86 in *Methods of Soil Analysis*, Part I, Am. Soc. Agron., Madison, Wis., 1986

Casey, W. H., Bursey, C., and Olsen, C. R., "Chemical Controls on Ecology in a Coastal Wetland," *EOS Trans. Am. Geophys. Union* **67**, 1305, 1310–11 (1986)

Coutant, C. C., "Thermal Preference: When Does an Asset Become a Liability?" *Environ. Biol. Fishes* **18**, 161–72 (1987)

Dale, V. H., and Gardner, R. H., "Assessing Regional Impacts of Growth Declines Using a

Forest Succession Model," *J. Environ. Manage.* **24**, 83–93 (1987)

Edmonds, J. A., and Reilly, J. M.; (Ed.) Boden, T. A., and Reynolds, R. E., *The IEA/GRAU Long-Term Global Energy-CO_2 Model: Personal Computer Version A84PC*, ORNL/CDIC-16, Oak Ridge National Laboratory, December 1986

Gardner, R. H., Milne, B. T., Turner, M. G., and O'Neill, R. V., "Neutral Models for the Analysis of Broad-Scale Landscape Pattern," *Landscape Ecol.* **1**, 19–28 (1987)

Garten, C. T., Jr., Tucker, C. S., and Scott, T. G., "Plant Uptake of Neptunium-237 and Technetium-99 Under Field Conditions," *J. Environ. Radioact.* **4**, 91–99 (1986)

Hoffman, F. O., Gardner, R. H., and Bartell, S. M., "The Significance of Environmental Exposure Pathways for Technetium," presented at Seminar, pp. 359–76 in *Technetium in the Environment, Proceedings of the Scientific Seminar on Behavior of Technetium in the Environment, Cadarache, France, October 23–26, 1984*, Elsevier, London, 1986

Huston, M. A., and DeAngelis, D. L., "Size Bimodality in Monospecific Populations: A Critical Review of Potential Mechanisms," *Am. Nat.* **129**, 678–707 (1987)

Johnston, J. W., Jr., Shriner, D. S., and Abner, C. H., "Design and Performance of an Exposure System for Measuring the Response of Crops to Acid Rain Gaseous Pollutants in the Field," *J. Air Pollut. Control Assoc.* **36**, 894–99 (1986)

Kienast, F., "Radiodensitometric Tree-Ring Analysis Along Altitudinal Gradients: Some Alternative Procedures for Detecting Site, Climatic, and Potential CO_2 Effects on Tree Growth," pp. 452–62 in *Proceedings of the International Symposium on Ecological Aspects of Tree-Ring Analysis, Palisades, New York, August 17–21, 1986*, CONF-8608144, Oak Ridge National Laboratory, 1986

King, A. W., and DeAngelis, D. L., *Information for Seasonal Models of Carbon Fluxes in Agroecosystems*, ORNL/TM-9935, Oak Ridge National Laboratory, April 1987

Lindberg, S. E., "Emission and Deposition of Atmospheric Mercury Vapor," presented at United Nations Int. Council of Scientific Unions, Report on Biogeochemical Cycling, Toronto, Sept. 2–7, 1984, pp. 89–106 in *Lead, Mercury, Cadmium and Arsenic in the* Environment, Vol. 31, Wiley, 1987

Lindberg, S. E., "Group Report: Mercury," pp. 17–33 in *Lead, Mercury, Cadmium and Arsenic in the Environment*, Vol. 31, Wiley, 1987

Lindberg, S. E., "Atmospheric Deposition and Element Cycling Research at Walker Branch Watershed, Tennessee," pp. 114–15 in *Waldschaden Forest Decline—German and U.S. American Research into Causes*, Kernforschungsanlage (KFA) Juelich, Federal Republic of Germany, 1986

Lindberg, S. E., Davidson, C. I., Bondietti, E. A., Graustein, W. C., Livingston, R., Lovett, G., and Peters, J., "Surface Analysis Methods," pp. 31–48 in *Proceedings of the Workshop on Dry Deposition Measurement, Harper's Ferry, West Virginia, May 25–27, 1986*, NOAA/ATDD, Oak Ridge, Tenn., 1986

Lovett, G. M., and Lindberg, S. E., "Dry Deposition of Nitrate to a Deciduous Forest," *Biogeochemistry* **1**, 137–48 (1986)

Luxmoore, R. J., Norby, R. J., and O'Neill, E. G., "Seedling Tree Responses to Nutrient Stress Under Atmospheric CO_2 Enrichment," presented at 18th IUFRO World Congress, pp. 178–83 in *Proceedings of the 18th IUFRO World Congress Division 2, Ljubljana, Yugoslavia, September 8–12, 1986*, Vol. 1, IUFRO Secretariat, Vienna, 1986

Mann, L. K., "Changes in Soil Carbon Storage After Cultivation," *Soil Sci.* **142**, 279–88 (1986)

Mattice, J. S., and Wright, L. L., "Aspects of Growth of *Corbicula fluminea*," *Am. Malacol. Bull., Spec. Ed.* **2**, 167–78 (1986)

Norby, R. J., O'Neill, E. G., Hood, W. G., and Luxmoore, R. J., "Carbon Allocation, Root Exudation, and Mycorrhizal Colonization of *Pinus echinata* Seedlings Under CO_2 Enrichment," *Tree Physiol.* **3**, 203–10 (1987)

Norby, R. J., Pastor, J., and Melillo, J. M., "Carbon-Nitrogen Interactions in CO_2 Enriched White Oak: Physiological and Long-Term Perspectives," *Tree Physiol.* **2**, 233–41 (1986)

Norby, R. J., Taylor, G. E., Jr., McLaughlin, S. B., and Gunderson, C. A., "Drought Sensitivity of Red Spruce Seedlings Affected by Precipitation Chemistry," pp. 34–41 in *Proceedings of the 9th North American Forest Biology Workshop, Stillwater, Oklahoma, June 15–18, 1986*, Soc. Am. For., 1986

Pastor, J., and Post, W. M., "Influence of Climate, Soil Moisture, and Succession on Forest Carbon and Nitrogen Cycles," *Biogeochemistry* **1**, 3–27 (1986)

Peng, T. -H., "The Role of the Ocean in the Atmospheric CO_2 Problem," *Sci. Mon.* **18**, 615–21 (1986)

Peng, T. -H., and Freyer, H. D., "Revised Estimates of Atmospheric CO_2 Variations Based on the Tree-Ring ^{13}C Record," pp. 151–59 in *The Changing Carbon Cycle: A Global Analysis, Proceedings of the 6th ORNL Life Sciences Symposium, Knoxville, Tennessee, October 31–November 2, 1983*, Springer-Verlag, New York, 1986

Shugart, L. R., McCarthy, J. F., Jimenez, B., and Daniels, J., "Analysis of Adduct Formation in the Bluegill Sunfish (*Lepomis macrochirus*) Between Benzo[a]pyrene and DNA of the Liver and Hemoglobin of the Erythrocyte," *Aquat. Toxicol.* **9**, 319–25 (1987)

Singh, B. R., and Johnson, D. W., "Sulfate Content and Adsorption in Soils of Two Forest Watersheds in Southern Norway," *Water Air Soil Pollut.* **31**, 847–56 (1986)

Solomon, A. M., "Comparison of Taxon Calibrations, Modern Analogue Techniques, and Forest-Stand Simulation Models for the Quantitative Reconstruction of Past Vegetation: A Critique," *Earth Surf. Processes Landforms* **11**, 681–85 (1986)

Southworth, G. R., "Movement of Radiotracer Metal Cations Through a Forest Soil Column," *Environ. Int.* **13**, 197–201 (1987)

Southworth, G. R., Watson, K. W., and Keller, J. L., "Comparison of Models That Describe the Transport of Organic Compounds in Macroporous Soil," *Environ. Toxicol. Chem.* **6**, 251–57 (1987)

Stewart, A. J., "Responses of Stream Algae to Grazing Minnows and Nutrients: A Field Test for Interactions," *Oecologia* **72**, 1–7 (1987)

Stewart, A. J., and Wetzel, R. G., "Cryptophytes and Other Microflagellates as Couplers in Planktonic Community Dynamics," *Arch. Hydrobiol.* **106**, 1–19 (1986)

Takemoto, B. K., Shriner, D. S., and Johnston, J. W., Jr., "Physiological Responses of Soybean (*Glycine max L. Merr*) to Simulated Acid Rain and Ambient Ozone in the Field," *Water Air Soil Pollut.* **33**, 373–84 (1987)

Tripathi, V. S., "An Algorithm and a FORTRAN Program (CHEMEQUIL-2) for Calculation of Complex Equilibria," *Talanta* **33**, 1015–20 (1986)

Tripathi, V. S., Yeh, G. T., and Siegel, M. D., "A Benchmark in Portable FORTRAN: Speeds of CPU and In-Memory Data-Transfer Operations for Hydrogeochemical Models," *Comput. Geosci.* **13**, 405–08 (1987)

Health and Safety Research Division

Alak, A. M., and Vo-Dinh, T., "Surface-Enhanced Raman Spectrometry of Organophosphorous Chemical Agents," *Anal. Chem.* **59**, 2149–53 (1987)

Ambrose, K. R., Butler, T. A., Callahan, A. P., and Ferren, L. A., *In Vivo Toxicity of Arsenic Trioxide for Human Cells in Diffusion Chambers*, ORNL/TM-10231, Oak Ridge National Laboratory, December 1986

Ambrose, K. R., Owen, B. A., Goodman, M. M., and Knapp, F. F., Jr., "Evaluation of the Metabolism in Rat Hearts of Two New Radioiodinated 3-Methyl-Branched Fatty Acid Myocardial Imaging Agents," *Eur. J. Nucl. Med.* **12**, 486–91 (1987)

Arakawa, E. T., "Experimental Studies of Transition Radiation and Optical Bremsstrahlung," pp. 31–42 in *Proceedings of the Werner Brandt Workshop on Penetration Phenomena: Photon Emission from Irradiated Solids, Oak Ridge, Tennessee, April 15–16*, 1985, CONF-850484, Oak Ridge National Laboratory, 1986

Arakawa, E. T., Emerson, L. C., Juan, S. I., Ashley, J. C., and Williams, M. W., "The Optical Properties of Adenine from 1.8 to 80 eV," *Photochem. Photobiol.* **44**, 349–53 (1986)

Blazewicz, P. R., Payne, M. G., Garrett, W. R., and Miller, J. C., "Laser-Induced Third-Harmonic Generation in Forbidden Regions," *Phys. Rev. A* **34**, 5171–74 (1986)

Blazewicz, P. R., Stockdale, J. A. D., Miller, J. C., Efthimiopoulos, T., and Fotakis, C., "Four-Photon Excitation of Even-Parity Rydberg States in Krypton and Xenon," *Phys. Rev. A* **35**, 1092–98 (1987)

Blazewicz, P. R., Tang, X., Compton, R. N., and Stockdale, J. A. D., "Photoelectron Angular Distributions from Resonantly Enhanced Multiphoton Ionization of Xenon via the $6s[3/2]^0_1$ and $6s'[1/2]^0_1$ States: Experiment and Theory," *J. Opt. Soc. Am. B* **4**, 770–74 (1987)

Bloemer, M. J., Mantovani, J. G., Goudonnet, J. P., James, D. R., Warmack, R. J., and Ferrell, T. L., "Observation of Driven Surface-Plasmon Modes in Metal Particulates Above Tunnel Junctions," *Phys. Rev. B* **35**, 5947–54 (1987)

Bolch, W. E., Turner, J. E., and Hamm, R. N., *An Algorithm for Unfolding Neutron Dose and Dose Equivalent from Digitized Recoil-Particle Tracks*, ORNL/TM-10168, Oak Ridge National Laboratory, October 1986.

Bolch, W. E., Turner, J. E., Hamm, R. N., Hurst, G. S., and Wright, H. A., "A Method of Obtaining Neutron Dose and Dose Equivalent from Digital Measurements and Analysis of Recoil-Particle Tracks," *Health Phys.* **53**, 241–53 (1987)

Buncick, M. C., Warmack, R. J., and Ferrell, T. L., "Optical Absorbance of Silver Ellipsoidal Particles," *J. Opt. Soc. Am. B* **4**, 927–33 (1987)

Callcott, T. A., Tsang, K. L., Zhang, C. H., Ederer, D. L., and Arakawa, E. T., "A High-Efficiency Soft X-Ray Emission Spectrometer for Use with Synchrotron Radiation Excitation," *Rev. Sci. Instrum.* **57**, 2680–90 (1986)

Chen, C. H., and McCann, M. P., "Threshold of F-Center Formation of Alkali Halide Crystals by Two-Photon Absorption," *Opt. Commun.* **60**, 296–97 (1986)

Chen, C. H., McCann, M. P., and Wang, J. C., "Room-Temperature Two-Photon Induced Luminescence in Pure CsI," *Solid State Commun.* **61**, 559–62 (1987)

Christophorou, L. G., Hunter, S. R., Carter, J. G., and Spyrou, S. M., "Effects of Temperature on Dissociative and Nondissociative Electron Attachment," pp. 303–8 in *Proceedings of the Joint Symposium on Swarm Studies and Inelastic Electron Molecule Collisions, Tahoe City, California, July 19–23, 1985*, Springer-Verlag, New York, 1986.

Christophorou, L. G., Hunter, S. R., Pinnaduwage, L. A., Carter, J. G., Christodoulides, A. A., and Spyrou, S. M., "Optically Enhanced Electron Attachment," *Phys. Rev. Lett.* **58**, 1316–19 (1987)

Cristy, M., and Eckerman, K. F., *Specific Absorbed Fractions of Energy at Various Ages from Internal Photon Sources. I. Methods*, ORNL/TM-8381/V1, Oak Ridge National Laboratory, April 1987

Cristy, M., and Eckerman, K. F., *Specific Absorbed Fractions of Energy at Various Ages from Internal Photon Sources. II. One-Year-Old*, ORNL/TM-8381/V2, Oak Ridge National Laboratory, April 1987

Cristy, M., and Eckerman, K. F., *Specific Absorbed Fractions of Energy at Various Ages from Internal Photon Sources. III. Five-Year-Old*, ORNL/TM-8381/V3, Oak Ridge National Laboratory, April 1987

Cristy, M., and Eckerman, K. F., *Specific Absorbed Fractions of Energy at Various Ages from Internal Photon Sources. IV. Ten-Year-Old*, ORNL/TM-8381/V4, Oak Ridge National Laboratory, April 1987

Cristy, M., and Eckerman, K. F., *Specific Absorbed Fractions of Energy at Various Ages from Internal Photon Sources. V. Fifteen-Year-Old Male and Adult Female*, ORNL/TM-8381/V5, Oak Ridge National Laboratory, April 1987

Cristy, M., and Eckerman, K. F., *Specific Absorbed Fractions of Energy at Various Ages from Internal Photon Sources. VI. Newborn*, ORNL/TM-8381/V6, Oak Ridge National Laboratory, April 1987

Cristy, M., and Eckerman, K. F., *Specific Absorbed Fractions of Energy at Various*

Ages from Internal Photon Sources. VII. Adult Male, ORNL/TM-8381/V7, Oak Ridge National Laboratory, April 1987

Datskos, P. G. and Christophorou, L. G., "Variation of the Electron Attachment to n-C_4F_{10} with Temperature," *J. Chem. Phys.* **86**, 1982–90 (1987)

Dodhy, A., Stockdale, J. A. D., Compton, R. N., Tang, X., Lambropoulos, P., and Lyras, A., "Two-Photon Resonant Three-Photon Ionization of the nd^2D States of Cesium, Rubidium, and Sodium: Photoelectron Angular Distributions," *Phys. Rev. A* **35**, 2878–91 (1987)

Dudczak, R., Schmoliner, R., Angelberger, P., Knapp, F. F., Jr., and Goodman, M. M., "Structurally Modified Fatty Acids—Clinical Potential as Tracers of Metabolism," *Eur. J. Nucl. Med.* **12**, S45–S48 (1986)

Echenique, P. M., Gras-Marti, A., Manson, J. R., and Ritchie, R. H., "The Image Potential for a Tunneling Electron," *Phys. Rev. B* **35**, 7357–64 (1987)

Eckerman, K. F.; (ed.) Leggett, R. W., and Warren, B. P., *Age-Specific Models for Evaluating Dose and Risk from Internal Exposures to Radionuclides, Report of Current Work of the Metabolism and Dosimetry Research Group, July 1, 1985–June 30, 1987*, ORNL/TM-10080, Oak Ridge National Laboratory, September 1987

Eklund, P. C., Hoffman, D. M., Delong, L. E., Arakawa, E. T., Smith, J. L., and Fisk, Z., "Optical Properties of UBe_{13}, $CeBe_{13}$, and $ThBe_{13}$," *Phys. Rev. B* **35**, 4250–57 (1987)

Faidas, H., and Christophorou, L. G., "Multiphoton Ionization of Fluoranthene in Tetramethylsilane," *J. Chem. Phys.* **86**, 2505–9 (1987)

Ferrell, W. R., Payne, M. G., and Garrett, W. R., "Determination of Optical Constants in Noble Gases Through Multiphoton Ionization Measurements," *Phys. Rev. A* **35**, 5020–31 (1987)

Ferrell, W. R., Payne, M. G., and Garrett, W. R., "Resonance Broadening and Shifting of Spectral Lines in Xenon and Krypton," *Phys. Rev. A* **36**, 81–89 (1987)

Fung, K. W., Matthews, T. G., Tromberg, B. J., and Hawthorne, A. R., "Impact of Indoor Environmental Parameters on Formaldehyde Concentrations in Unoccupied Research Houses," *J. Air Pollut. Control Assoc.* **36**, 1244–49 (1986)

Garrett, W. R., Henderson, S. D., and Payne, M. G., "Observation of Laser-induced Collisional Energy Transfer in Xe-Ar Mixtures," *J. Opt. Soc. Am. B* **4**, 133–37 (1987)

Garrett, W. R., Henderson, S. D., and Payne, M. G., "Two-Color Interference Effect Involving Three-Photon Excitation and Four-Wave Mixing Processes," *Phys. Rev. A* **34**, 3463–65 (1986)

Garrett, W. R., Henderson, S. D., and Payne, M. G., "Multiphoton Ionization Spectra and Tunable Fifth Harmonic Production Near Five-Photon Resonances in Xe and Ar," *Phys. Rev. A* **35**, 5032–37 (1987)

Goudonnet, J. P., Inagaki, T., Arakawa, E. T., and Ferrell, T. L., "Angular and Polarization Dependence of Surface-Enhanced Raman Scattering in Attenuated-Total-Reflection Geometry," *Phys. Rev. B* **36**, 917–21 (1987)

Hawthorne, A. R., and Matthews, T. G., "Models for Estimating Organic Emissions from Building Materials: Formaldehyde Example," *Atmos. Environ.* **21**, 419–24 (1986)

Holton, G. A., Travis, C. C., Etnier, E. L., Cook, S. C., O'Donnell, F. R., Hetrick, D. M., and Dixon, E., "Assessment of Inhalation and Ingestion Population Exposures from Incinerated Hazardous Wastes," *Environ. Int.* **12**, 533–40 (1986)

Hunter, S. R., *Evaluation of a Digital Optical Ionizing Radiation Particle Track Detector*, ORNL/TM-10421, Oak Ridge National Laboratory, June 1987

Hunter, S. R., Carter, J. G., and Christophorou, L. G., "Electron Attachment and Ionization Processes in CF_4, C_2F_6, C_3F_8, and n-C_4F_{10}," *J. Chem. Phys.* **86**, 693–703 (1987)

Inagaki, T., Goudonnet, J. P., Royer, P., and Arakawa, E. T., "Optical Properties of Silver Island Films in the Attenuated-Total-Reflection Geometry," *Appl. Opt.* **25**, 3635–39 (1986)

Judish, J. P., and Wunderlich, R. K., "Measurement of the Diffusion Coefficient of Li in Argon," *J. Phys. B: At. Mol. Phys.* **20**, 2317–25 (1987)

Khare, B. N., Sagan, C., Ogino, H., Nagy, B., Er, C., Schram, K. H., and Arakawa, E. T., "Amino Acids Derived from Titan Tholins," *Icarus* **68**, 176–84 (1986)

Klots, C. E., "Temperatures of Evaporating Clusters," *Nature* **327**, 222–23 (1987)

Klots, C. E., "The Evaporative Ensemble," *Z. Phys. D. - Atoms, Mol. Clusters* **5**, 83–89 (1987)

Klots, C. E., "On the Energy Dependence of Unimolecular Rate Constants," *J. Phys. Chem.* **90**, 6063 (1986)

Klots, C. E., "Enthalpy Conversion in Sonic-Nozzle Expansions," *Chem. Phys. Lett.* **137**, 353–54 (1987)

Knapp, F. F., Jr., Ambrose, K. R., and Goodman, M. M., "New Radioiodinated Methyl-Branched Fatty Acids for Cardiac Studies," presented at Symp. Assessment of Myocardial Metabolism by Cardiac Imaging, Vienna, Oct. 26, 1985, *Eur. J. Nucl. Med.* **12**, S39–S44 (1986)

Knapp, F. F., Jr., Ambrose, K. R., Goodman, M. M., and Srivastava, P. C., *Nuclear Medicine Progress Report for Quarter Ending March 31, 1986*, ORNL/TM-10082, Oak Ridge National Laboratory, October 1986

Knapp, F. F., Jr., Ambrose, K. R., Goodman, M. M., and Srivastava, P. C., *Nuclear Medicine Progress Report for Quarter Ending June 30, 1986*, ORNL/TM-10238, Oak Ridge National Laboratory, December 1986

Knapp, F. F., Jr., Ambrose, K. R., Goodman, M. M., and Srivastava, P. C., *Nuclear Medicine Progress Report for Quarter Ending September 30, 1986*, ORNL/TM-10294, Oak Ridge National Laboratory, February 1987

Knapp, F. F., Jr., Ambrose, K. R., Goodman, M. M., and Srivastava, P. C., *Nuclear Medicine Progress Report for Quarter Ending December 31, 1986*, ORNL/TM-10377, Oak Ridge National Laboratory, June 1987

Knapp, F. F., Jr., Ambrose, K. R., and Srivastava, P. C., *Nuclear Medicine Progress Report for Quarter Ending March 31, 1987*, ORNL/TM-10441, Oak Ridge National Laboratory, August 1987

Knapp, F. F., Jr., Goodman, M. M., Ambrose, K. R., Som, P., Brill, A. B., Yamamoto, K., Kubota, K., Yonekura, Y., Dudczak, R., Angelberger, P., and Schmoliner, R., "The Development of Radioiodinated-Methyl-Branched Fatty Acids for Evaluation of Myocardial Disease by Single Photon Techniques," pp. 159–202 in *Noninvasive Imaging of Cardiac Metabolism*, Martinus Nijhoff Medical Publ., Amsterdam, 1987

Knapp, F. F., Jr., and Srivastava, P. C., "Potential New Approaches for the Development of Brain Imaging Agents for Single-Photon Applications," pp. 71–74 in *Proceedings of the Workshop on Amphetamines and pH-Shift Agents for Brain Imaging, Basic Research and Clinical Results, Bonn, Federal Republic of Germany, October 12–13, 1984*, Walter de Gruyton and Co., Berlin and New York, 1986

Kvale, T. J., Compton, R. N., Alton, G. D., Thompson, J. S., and Pegg, D. J., "Autodetachment Spectroscopy of Metastable Negative Ions," *Nucl. Instrum. Methods Phys. Res. B* **24/25**, 325–28 (1987)

Leggett, R. W., and Eckerman, K. F., "A Method for Estimating the Systemic Burden of Plutonium from Urinalyses," *Health Phys.* **52**, 337–46 (1987)

Lehmann, B. E., Loosli, H. H., Oeschger, H., Rauber, D., Hurst, G. S., Allman, S. L., Chen, C. H., Kramer, S. D., Thonnard, N., and Willis, R. D., "Laser Resonance Ionization Mass Spectrometry for Krypton-81 Analysis," *Radiocarbon* **28**, 223–28 (1986)

Martin, C., Arakawa, E. T., Callcott, T. A., and Warmack, R. J., "Attenuation Lengths of Low-Energy Electrons in Free-Standing Carbon Films," *J. Electron Spectrosc. Relat. Phenom.* **42**, 171–75 (1987)

Matthews, T. G., "Environmental Chamber Test Methodology for Characterizing Organic Vapors from Solid Emission Sources," presented at EPA Symp. Characterization of Contaminant Emissions from Indoor Sources, Research Triangle Park, N.C., May 13–15, 1985, *Atmos. Environ.* **21**, 321–29 (1987)

McCann, M. P., Chen, C. H., and Kramer, S. D., "Ultraviolet Laser Beam Monitor Using Alkali Halide Crystals," *Opt. Eng.* **25**, 1177–78 (1986)

McCann, M. P., Chen, C. H., and Payne, M. G., "Energy Level Determination Using Two-Photon (Vacuum Ultraviolet and Visible) Resonance Spectroscopy," *Appl. Spectrosc.* **41**, 399–401 (1987)

McCann, M. P., Chen, C. H., and Payne, M. G., "Vacuum Ultraviolet Generation and Use in Two-Photon Resonance Spectroscopy," *Chem. Phys. Lett.* **138**, 250–56 (1987)

Miller, J. C., "Multiphoton Ionization of Jet-Cooled Iodine," *J. Phys. Chem.* **91**, 2589–92 (1987)

Miller, J. C., "Multiphoton Spectroscopy of X-NO (X = Kr, Xe, CH_4) van der Waals Molecules," *J. Chem. Phys.* **86**, 3166–71 (1987)

Oyan, R., and Sims, C. S., "Radiation Dose from HPRR Gamma Rays," *Radiat. Prot. Dosim.* **16**, 213–17 (1986)

Payne, M. G., "Vacuum Ultraviolet Light Generation Applications to Resonance Ionization Spectroscopy," pp. 59–66 om *Proceedings of the 3rd International Symposium on Resonance Ionization and Its Applications, Swansea, Wales, September 7–12, 1986*, Inst. Phys. Conf. Ser. 84, 1987

Proctor, M. J., Stockdale, J. A. D., Efthimiopoulos, T., and Fotakis, C., "Third-Harmonic Generation and Ionization Processes in Kr," *Chem. Phys. Lett.* **137**, 223–25 (1987)

Reske, S. N., Knapp, F. F., Jr., and Winkler, C., "Metabolic Imaging of the Myocardium with Radioiodinated Aromatic Free Fatty Acids. I. Experimental Basis," *Am. J. Physiol. Imaging* **1**, 214–29 (1986)

Royer, P., Goudonnet, J. P., Warmack, R. J., and Ferrell, T. L., "Substrate Effects on Surface-Plasmon Spectra in Metal-Island Films," *Phys. Rev. B* **35**, 3753–59 (1987)

Russell, B. K., Mantovani, J. G., Anderson, V. E., Warmack, R. J., and Ferrell, T. L., "Experimental Test of the Mie Theory for Microlithographically Produced Silver Spheres," *Phys. Rev. B* **35**, 2151–54 (1987)

Sims, C. S., "New Personnel Dosimeter Performance Test Programs in the United States," pp. 183–88 in *Personnel Radiation Dosimetry*, IAEA-TECDOC-402, Vienna, 1987

Sims, C. S., "1986 Reference Neutron Dosimetry for the Health Physics Research Reactor," *Radiat. Prot. Dosim.* **15**, 41–44 (1986)

Sims, C. S., and Ragan, G. E., *Health Physics Research Reactor Reference Dosimetry*, ORNL-6240, Oak Ridge National Laboratory, June 1987

Siskel, R. L., Sims, C. S., and Swaja, R., "A Comparative Study of Three Types of Civil Defense High-Range Pocket Dosimeters," *Trans. Am. Nucl. Soc.* **54**, 304 (1987)

Sols, F., and Ritchie, R. H., "Self-Energy of an Electron in a Gap Between Two Metals and Near a Metallic Slab," *Phys. Rev. B* **35**, 9314–17 (1987)

Sols, F., and Ritchie, R. H., "The Interaction Between an Electron and the Polarization Modes of a Metal-Insulator Interface," *Solid State Commun.* **63**, 245–49 (1987)

Stockdale, J. A. D., "Dissociation of Internally Excited UF_6^- Ions in Collision with Argon Atoms," *Chem. Phys. Lett.* **137**, 399–402 (1987)

Stockdale, J. A. D., Efthimiopoulos, T., Fotakis, C., and Blazewicz, P. R., "Multiphoton Ionization of Krypton and Xenon: An Investigation of the Autoionizing Region Between $P_{1/2}$ and $P_{3/2}$ Thresholds," pp. 236–38 in *High Intensity Laser Processes*, Vol. 664, Proc. Photo-Opt. Instrum. Eng. Inst. Symp., Quebec City, June 2–6, 1986, Soc. Photo-Opt. Instrum. Eng., Bellingham, Wash., 1986

Sung, C. C., Mo, K., and Ritchie, R. H., "Dynamical Corrections to the Binding Energy of a Solvated Electron," *Chem. Phys. Lett.* **136**, 9–12 (1987)

Suter, G. W., Kallir, A. J., Wild, U. P., and Vo-Dinh, T., "Hydrogen-Bonding Properties of a Room-Temperature Phosphorescence Cellulose Substrate," *J. Phys. Chem.* **90**, 4941–45 (1986)

Suter, G. W., Kallir, A. J., Wild, U. P., and Vo-Dinh, T., "The External Heavy-Effect in Room Temperature Phosphorescence Spectroscopy," *Anal. Chem.* **59**, 1644–46 (1987)

Swaja, R. E., and Oyan, R., "Uncertainties Associated with Using Quick-Sort Techniques

To Estimate Neutron Doses Following Criticality Accidents," *Health Phys.* **50**, 28–29 (1986)

Swaja, R. E., and Scofield, P. A., "Factors Affecting the Gamma Response of TLD-700 Chips in Mixed-Radiation Fields," *Radiat. Prot. Manage.* **3**, 44–52 (1986)

Swaja, R. E., Weng, P. S., Sims, C. S., and Yeh, S. H., *Summary and Analysis of 1986 Personnel Dosimetry Intercomparison Study*, ORNL-6378, Oak Ridge National Laboratory, April 1987

Travis, C. C., Holton, G. A., Etnier, E. L., Cook, S. C., O'Donnell, F. R., Hetrick, D. M., and Dixon, E., "Potential Health Risk of Hazardous Waste Incineration," *J. Hazardous Mater.* **14**, 309–20 (1987)

Uziel, M., Ward, R. J., and Vo-Dinh, T., "Synchronous Fluorescence Measurement of BaP Metabolites in Human and Animal Urine," *Anal. Lett.* **20**, 761–76 (1987)

Varma, M., Varma, R. S., Kabalka, G. W., Srivastava, P. C., and Knapp, F. F., Jr., "The Tosylation of Alcohols," *J. Org. Chem.* **51**, 2386–88 (1986)

Vo-Dinh, T., "Characterization of Surface Contaminants by Luminescence Using Ultraviolet Excitation," pp. 103–22 in *Treatise on Clear Surface Technology*, Vol. 1, Plenum, 1987

Vo-Dinh, T., and Alak, A., "Enhanced Room-Temperature Phosphorescence of Anthracene on Cyclodextrin-Treated Filter Paper," *Appl. Spectrosc.* **41**, 963–66 (1987)

Vo-Dinh, T., Suter, G. W., Kallir, A. J., and Wild, U. P., "Fluorescence Line-Narrowing Spectrometry of Polycyclic Compounds on Filter Paper Substrates," *Anal. Chem.* **58**, 3135–39 (1986)

Vo-Dinh, T., and Uziel, M., "Laser-Induced Room-Temperature Phosphorescence Detection of Benzo(a)pyrene-DNA Adducts," *Anal. Chem.* **59**, 1093–95 (1987)

Vo-Dinh, T., Uziel, M., and Morrison, A. L., "Surface-Enhanced Raman Analysis of Benzo[a]pyrene-DNA Adducts of Silver-Coated Cellulose Substrates," *Appl. Spectrosc.* **41**, 605–10 (1987)

Walsh, P. J., *Health and Safety Research Division Progress Report for the Period October 1, 1985–March 31, 1987*, ORNL-6389, Oak Ridge National Laboratory, September 1987

Warmack, R. J., Ferrell, T. L., and Little, J. W., "Radiative Decay of Surface Plasmons," pp. 71–78 in *Proceedings of the Werner Brandt Workshop on Penetration Phenomena: Photon Emission from Irradiated Solids, Oak Ridge, Tennessee, April 15–16, 1985*, CONF-850484, Oak Ridge National Laboratory, 1986

Williams, L. R., and Leggett, R. W., "The Distribution of Intracellular Alkali Metals in Reference Man," *Phys. Med. Biol.* **32**, 173–90 (1987)

Wunderlich, R., Payne, M. G., and Garrett, W. R., "RIS and Competing Processes in High Concentration Atomic Vapors," presented at Symp., pp. 269–74 in *Proceedings of the 3rd International Symposium on Resonance Ionization Spectroscopy and Its Applications, Swansea, Wales, September 7–12, 1986*, Inst. Phys. Conf. Ser. 84, 1987