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HEALTH AND SAFETY RESEARCH DIVISION PROGRESS REPORT FOR THE PERIOD April 1, 1987 - September 30, 1988

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Stephen V. Kaye
Director

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HEALTH AND SAFETY RESEARCH DIVISION PROGRESS REPORT FOR THE PERIOD APRIL 1, 1987 - SEPTEMBER 30, 1988

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FOREWORD

Stephen V. Kaye

The mission of the Health and Safety Research Division (HASRD) is to provide a sound scientific basis for the measurement and assessment of human health impacts of radiological and chemical substances. Our approach to fulfilling this mission is to conduct a broad program of experimental, theoretical, and field research based on a strong foundation of fundamental physical studies that blend into well-established programs in life sciences.

The business of the division is very complex, and many of our programs are carried out on a large scale. Since it is not feasible to summarize in detail all of our work over the period covered by this report (April 1, 1987, to September 30, 1988), we will cover only some of the highlights, but point the way to the extensive open literature that documents our findings.

In March 1988, I returned to HASRD after serving as the Interim Director of the Biology Division for a year. Phil Walsh ably served as Interim Director of HASRD during my absence. In May 1988 he left Oak Ridge National Laboratory (ORNL) to join a private firm.

On October 1, 1987, the entire Information Research and Analysis (IR&A) Section of the Biology Division transferred to HASRD. This section of over 80 staff members focuses on evaluation, analysis, and application of data resources related to the potential health and environmental effects of toxic substances. Tim Ensminger continued as the Section Head of IR&A. He and his staff have already become a vital part of HASRD and are providing a much needed complement to several of our major programs.

Alan Hawthorne was appointed Section Head of the Health Studies Section, and Barry Berven was appointed Section Head of the Environmental Measurements and Applications Section (formerly Dosimetry and Biophysical Transport Section). Both sections continued to handle the bulk of HASRD's instrumentation development and testing, environmental assessments and measurements, radiation dosimetry, and radiopharmaceutical development.

Another organizational change which occurred during the reporting period involved transfer of the Metabolism and Dosimetry Research Group from the

Environmental Measurements and Applications Section to the Health Studies Section. Keith Eckerman remains as the Group Leader. The Measurement Systems Research Group (formerly Measurement Applications Group) was transferred from the Health Studies Section to the Environmental Measurements and Applications Section. Dick Gammage continues as Group Leader and as coordinator of the division's Hazardous Waste Program.

Jim Turner, a senior scientist in the Biological and Radiation Physics Section, was named a Corporate Research Fellow of Martin Marietta Energy Systems, Inc. He is the author of two textbooks and numerous journal publications on neutron dosimetry, radiation physics, stopping power, high-LET dosimetry, and biotoxicity of chemical pollutants. During his career Jim Turner has demonstrated exceptional diversity and outstanding scientific quality as a researcher and teacher.

Tuan Vo-Dinh, Group Leader of the Advanced Monitoring Development Group, was the 1988 recipient of the New York Society for Applied Spectroscopy Gold Medal for his contributions to the advancement of spectroscopy in the fields of analytical, environmental, and biophysical chemistry. The medal was presented at an award symposium organized in Dr. Vo-Dinh's honor.

In 1985 the division established the Excellence in Research Award to be presented annually to a HASRD staff member for either applied research (odd-numbered years) or basic research (even-numbered years). The award is given for outstanding examples of creative and innovative contributions to science, as judged by a special panel of senior ORNL staff. The 1986 award was presented to Russ Knapp for his synthesis of a new, structurally modified fatty acid incorporating metabolic blocking for use in nuclear cardiology. In 1987 the award was presented to Eph Klots for his internationally recognized leadership in developing a theoretical treatment of electron attachment to molecular clusters.

HASRD staff were honored for outstanding contributions to the company and community during the Energy Systems Awards Night ceremony held in May 1988. Scott Hunter and Loucas Christophorou won an Inventor's Award for development of gas mixtures that possess temperature-enhanced glow discharge characteristics for use in repetitive pulsed-power closing switches. Publication Awards were received by L. G. Christophorou, S. R. Hunter, L. A. Pinnaduwage, J. G. Carter, A. A. Christodoulides, and S. M. Spyrou for their journal article "Optically Enhanced Electron Attachment," and by T. Vo-Dinh, B. J. Tromberg, G. D. Griffin, K. R. Ambrose,

M. J. Sepaniak, and E. M. Gardenhire for their journal article "Antibody-Based Fiberoptics Biosensor for the Carcinogen Benzo(a)pyrene."

We are particularly proud that HASRD staff were awarded a total of six patents during the reporting period. Additionally, two of our new R&D items were recipients of R&D 100 awards: the "Crystal Laser Monitor" developed by C. H. Chen, S. D. Kramer, and M. P. McCann, and the "Fiber-Optics Fluoroimmuno Sensor" developed by T. Vo-Dinh, M. J. Sepaniak, B. J. Tromberg, G. D. Griffin, and K. R. Ambrose. A total of eight R&D 100 awards have been won by HASRD staff since 1980--an important indicator of continued innovation in carrying out our mission.

Overall, the division's programs have been very successful over the past 18 months and have continued to grow in several areas. We now have approximately 210 regular staff and 125 other staff associated with the division who are classified as subcontractors, students, guests, and postdoctoral fellows. This total staff is supported with a budget of 30 million dollars. One major area of emphasis has involved developing an advanced monitoring and risk assessment capability for hazardous chemicals in the environment. Our progress in tunneling microscopy has also been very successful, and a new type of photon tunneling microscope which we have invented is expected to be very valuable in studying the structures of nonconducting biological samples. Other progress was made in radiation dosimetry, construction and equipping of a Radiation Calibration Laboratory (RADCAL), technology transfer of our inventions, development of an extensive database system on toxicological profiles of hazardous substances, discovery of new laser-induced phenomena in nonlinear optics, etc. Many of these items are referenced in the body of this progress report.

We are confident that HASRD's work will continue to be a major contribution to the mission of ORNL, to the Department of Energy (DOE), and to the many other customers that we serve. This will be possible because of the highly experienced and competent staff who have performed so well, and the outstanding new scientists, technicians, and clerical staff that we have successfully recruited in the past couple of years.

1. HEALTH STUDIES SECTION

A. R. Hawthorne, Head

Staff

Research:

T. E. Aldrich
K. R. Ambrose[1]
M. Cristy
C. S. Dudney[2]
C. E. Easterly
K. F. Eckerman
R. B. Gammage
G. D. Griffin
T. D. Jones
G. D. Kerr
G. Killough
F. F. Knapp, Jr.
D. C. Kocher
R. W. Leggett
E. A. Zeighami
T. G. Matthews
D. W. McPherson
P. C. Srivastava
R. L. Tyndall
M. Uziel
T. Vo-Dinh
A. P. Watson

Technical Support:

J. L. Allred
A. P. Callahan
E. B. Cunningham
G. H. Miller
B. A. Owen
D. E. Rice
C. J. Rogers
D. L. Wilson

Clerical Support:

L. K. Ailey
A. W. Brown[2]
J. B. Cooper
D. H. Fisher
S. L. Freels
A. G. Golliher
L. G. Jackson
U. F. Strong
L. E. Thurston
B. P. Warren
R. R. Weston
A. D. White

Consultants:

A. Bockish
G. Fisher
M. M. Goodman
G. W. Kalbalka
C. Karagiannis
P. Keller
G. Kirsch
U. P. Wild
W. Mularz
J. Nobel
G. A. Vaughan

Guest Scientists:

L. A. Bull
B. L. Byrd
M. J. Capacci
M R. Dial
A. M. Hoyt
R. A. Jernigan
K. S. Ironside
J. Kropp
D. K. Mandt
K. P. Monar
R. J. Nichols
M. J. Nolan
C. T. Orebaugh
D. Pack-Grimm
H. F. Pang
A. J. Pappelis
M. J. Sepania
R. J. Saultz
M. G. Stabin
E. Tan
G. Umbricht
A. Underbrink
J. K. Williams

Students:

J. P. Alarie
J. L. Brown
S. E. Burns
L. S. Burtis
H. S. Bushe
N. Contolini
Y. Davidson
F. G. Dolislager
W. M. Hietpas
K. T. Kimball
S. J. Lambert
S. Landry
M. Laureano
R. Lloyd
S. Mahajan
R. E. Meyer
R. W. O'dell
T. H. Newport
K. Purcell
M. O. Sanchez
M. M. Sizemore
D. L. Stokes
B. J. Tromberg
R. J. Westfall
A. Tinger
M. Turner
N. B. Upadhyaya
R. J. Westfall
D. A. White
A. Wilke
L. Zuckerman

Postdoctoral Fellows:

A. M. Alak
J. M. Bello
S. L. Blystone
Y.-F. Cheng
L. R. Glass
A. Hasan
R. W. Johnson
D. S. Katz
E. C. Lisic

Subcontractors:

C. C. Banks
S. L. Bergwerk
M. L. Brown
L. T. Dillman
P. C. Gailey
C. B. Hamilton
K. A. Jessen
T. G. Nolan
L. R. Williams

Loanees from other divisions:

J. C. Holloway[3]
M. D. Morris[4]
J. C. Ryman[5]
R. L. Schenley[3]
A. J. Sjoreen[5]
R. C. Ward[5]
L. C. Waters[3]

Research in the Health Studies Section is directed toward developing and applying new methods for the measurement and assessment of human health impacts from radiation and chemicals. This research is organized into four groups. The Advanced Monitoring Development Group develops novel or improved instruments and methods for assessing human exposures to low levels of toxic chemicals as well as for measuring potential bioindicators of health effects. Human health effects assessment methodologies are developed and improved to assess the impact and relative risk of various technologies on human health by the Health Effects and Epidemiology Group. Understanding the radiation exposure-dose relationships through modeling the behavior of radionuclides within the body and the deposition of ionizing energy within radiosensitive tissues from these radionuclides or from radiation externally incident upon the body is the focus of the Metabolism and Dosimetry Research Group. The Nuclear Medicine Group is involved in the design and development of new tissue-specific radiopharmaceuticals for disease

diagnosis and therapy. Effective transfer of developed technology to the public (e.g., regulators and standard setting bodies) and commercial sectors is emphasized by all of the groups. Highlights of accomplishments during this reporting period are given in the following sections.

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[1]Part-time employee.
[2]Dual capacity.
[3]Biology Division.
[4]Engineering Physics and Mathematics Division.
[5]Computing and Telecommunications Division.

ADVANCED MONITORING DEVELOPMENT

The research program of the Advanced Monitoring Development Group involves multidisciplinary research efforts targeted toward three major areas: (1) cost-effective biochemical screening techniques, (2) biological and chemical sensors, and (3) basic technical advances of emerging monitoring technologies.

During this reporting period, we continued to develop new and simple types of substrates for surface-enhanced Raman scattering (SERS). The new substrates are based upon silver-coated microparticles on surfaces such as cellulose substrates, glass plates, or microscopic slides. Our studies have demonstrated the effectiveness and potential of SERS as a powerful spectrochemical technique to identify and quantify different compounds such as nitropolyaromatic hydrocarbons, drugs, organophosphorus chemicals, pesticides, and DNA adducts. Microparticles offer many advantages since they are easy to handle and commercially available at very low cost. The results demonstrate that the microparticle-based substrates are very efficient and produce large SERS enhancements.

Measurements with a variety of organic chemicals such as polyaromatic compounds demonstrated the usefulness of this new type of SERS substrates. The effectiveness of the SERS process has been found experimentally to be related to surfaces possessing some form of roughness. In general, it is difficult to produce microstructures with morphologies and defined surface roughness. For analytical purposes, the control of surface roughness is a critical factor which can strongly affect the SERS process. From this view point, microparticle materials provide a simple way to control and determine the surface roughness of the substrates by selecting the appropriate particle size and particle suspension

Our research program on biological monitors is aimed at developing sensitive and reliable tools to measure human exposure and biological response to hazardous chemicals. Research activities involve the development of novel biological-marker assays to detect early physiological responses to toxic pollutants. A new and potentially very broad-ranging monitor under development is the fiberoptic fluoroimmunosensor (FIS). This instrument is designed to measure internal doses of chemical pollutants by means of antibody-antigen recognition and to quantify these doses in microsamples of body fluids by fiberoptic technology and laser-induced fluorescence spectroscopy. The FIS was a recipient of a 1987 I·R 100 (currently R·D 100) award as one of the most significant

During this reporting period, we have developed a new type of sensor for the FIS and have used the device to measure DNA adducts of an important carcinogen, benzo(a)pyrene (BP). Studies have shown that BP is metabolically activated to electrophilic intermediates, which can bind covalently to DNA. Antibodies are contained at the membrane-based tip of the fiberoptic sensor for use in *in vitro* and *in vivo* fluorescence assays. The results of investigations employing a fiberoptic FIS designed to measure the BP-DNA adduct product, BP-tetrol (BPT), indicate that the FIS is capable of achieving a 40-attomole (10^{-18} mole) limit of detection for BPT. Since the carcinogenic activity of a compound might be associated with the degree to which it binds to DNA, there has been a great deal of interest in sensitive analytical techniques that are capable of detecting DNA-carcinogen interactions and thereby leading to a new approach to monitor human exposure

We have tested our synchronous luminescence (SL) technology for monitoring persistence of internal exposure leading to DNA-adduct formation by measuring the conversion of tritiated BP and BP-7,8-diol, injected subcutaneously into Fisher 344 rats, to metabolites and adducts in blood, urine, and feces. We demonstrated a good quantitative correlation between radioactivity and synchronous fluorescence measurements in urine after correction for metabolically released ^3H_2O.

A new research initiative involves the development of novel or improved detection technologies that will improve the efficiency, accuracy, and speed of DNA sequencing. Two approaches are under study. The first is an integrated instrument based on hybrid multiplexed systems combining various spectrochemical detection schemes under development. Several projects will be accomplished to develop (1) an improved fluorescent-label detection system, (2) a novel phosphorescence detection technique, (3) a postcolumn Raman detection technique, and (4) a real-time fiberoptic-multiplex/multichannel DNA sequence analyzer.

The second approach is an instrument that sequences DNA by a new procedure that, for the first time, unequivocally describes the sequence positions of modified bases. These modified bases are critical to expression of gene activity so that this sequence information can provide direct diagnostic information. Several projects are in progress including development of the chemistry for this procedure and the design of low cost instrumentation to perform the chemistry that will be modular and capable of incorporation into multiple units under robotic control. These advances will lead to a more accurate characterization of the human genome and a better understanding of the mutagenic and carcinogenic effects of energy-related environmental pollutants.

HEALTH EFFECTS AND EPIDEMIOLOGY

The objective of the Health Effects and Epidemiology Group is to draw together relevant laboratory and epidemiological data as well as other pertinent information necessary to develop methods for assessing health risks. Long-term objectives include: (1) placement of hazards from varying insults (e.g., chemicals, nonionizing electromagnetic energy, physical agents, ionizing radiation) on a common scale; (2) development of predictive tools for hazard analysis of complex chemical mixtures; and (3) development of methods for understanding technological hazards with respect to human activities generally regarded as safe. A variety of activities were engaged in during the reporting period, as described below.

Modeling of human mortality from protracted exposures to ionizing radiations is an area of high visibility to the North Atlantic Treaty Organization (NATO). British researchers have developed what is called an operational equivalent dose (OED) concept and are pushing to have this concept promulgated into NATO consideration. The OED concept is a simple two-coefficient mathematical formula which has no credible basis in human data or in radiation biology; it draws on a minuscule amount of the relevant animal information. The work at ORNL, supported by the Defense Nuclear Agency, has sought to improve the OED concept.

Improvements in the OED concept have been made by incorporating concepts of cellular mortality, repair, and repopulation. Because no reliable data are available on human mortality as a consequence of protracted exposures, different animal databases were assembled and used. The overall multicompartmental analytical approach is fed by statistical analyses of rate constants for cell injury, cell repair, cell killing, and cell repopulation-- processes implicit in the ORNL database on mortality from continuous exposure to a constant dose-rate source and from the split-dose and fractionated

studies. Efforts to date suggest that the British OED model cannot be correct, but the degree of inaccuracy is still unknown.

A combined group effort was made between the Health Effects and Epidemiology Group and the Biodosimetry Group (no longer in existence) in reporting on a three-year project carried out in the Biodosimetry Group. Funded by the Environmental Protection Agency (EPA) the activity sought to investigate the potential for using *in vitro* bioassays for assessing potential human hazards from the complex chemical mixtures present in wastewater. The document is intended for use in assisting decision making regarding the role of short-term bioassays in the regulatory process. Two bioassay systems were investigated for applicability: the Ames *Salmonella* test for mutagenicity and the CHO/HGPRT (XGPRT) tests for mutagenicity and cytotoxicity. Application of these test systems to environmental samples has shown the need for considerable research on sample strategy, sample preparation on increasing bioassay sensitivity, and on identifying a more complete battery of bioassays. The analytic framework used is based on a relative potency framework. Work to date has demonstrated that, in principle, a battery of short-term bioassays can be used to rank the relative hazard represented by chemicals which may be human carcinogens. The required number of assays and the specific tests composing a practical battery are yet undefined. Constraints of time and money will probably limit a future realistic battery to between three and six bioassays for most applications. This range is not inconsistent with work to date.

The Department of Defense Authorization Act of 1986 (PL 99-145) directed and authorized the Secretary of Defense to destroy the U.S. stockpile of lethal unitary chemical munitions and agents by September 30, 1994. Analyzing options for the disposal of these weapons required detailed toxicological analyses of the primary agents, GA, GB, and VX, as well as the vesicant (blister) agents H, HD, HT, and Lewisite. While each of the agents is lethal at sufficiently high concentrations, considerable interest was expressed by the Army as well as the scientific and host communities in evaluating potential delayed or latent effects of long-term, low-dose exposures. Detailed assessments, including consideration of variable human response effects, were performed for agent dose, agent antidotes, breakdown products, and postrelease decision criteria for safe reentry to potentially contaminated areas. In this regard, a detailed comparative analysis of potential latent effects was made for sulfur mustard, a recognized carcinogen and a principal component of the most plentiful vesicant agents. On the basis of this evaluation, sulfur mustard is considered to have approximately the same

The EPA proposes to regulate the combination of all man-made beta/gamma-emitting radionuclides in drinking water to a cumulative dose equivalent of 4 mrem/year; individual chemical carcinogens to a per capita lifetime risk of 10^{-5}; and chemicals not currently classified as carcinogens to concentrations below the "No Observed Adverse Effect Level" (NOAEL). Not only is there a remarkable lack of consistency in the way in which the three broad classes are evaluated and regulated, but there is also great variation in individual assessment and regulation within each of the three classes. To mediate this situation, members of the Health Effects and Epidemiology Group have worked in two pathways: (1) to attempt to provide a measure of stability with regard to the absolute decision-making process and (2) to provide an alternative to EPA's absolute processes with an internally calibrated method for relative decision making.

Assistance in the absolute process has been aided by the development of a method for ranking potencies of carcinogens, noncarcinogens, and radionuclides on a common scale. Then, by selecting a chemical for which the EPA has derived an allowable daily intake (ADI) (hopefully choosing one of the more accurate ones), the relative scale can be calibrated and ADIs for unregulated materials can be determined. The method for relative decision making compares toxicity levels inherent to foods, cooking practices, drinking of utility-processed but otherwise hypothetically pure water, and the natural radiation background exclusive of radon exposure. These two methods have been applied to hypothetical samples of a groundwater from ORNL remedial action sites.

METABOLISM AND DOSIMETRY RESEARCH

The main task of the Metabolism and Dosimetry Research Group is the development of radiation exposure-dose relationships through modeling the biokinetics of radionuclides within the body and modeling the deposition of ionizing energy within radiosensitive tissues from these radionuclides or from radiation externally incident upon the body. Such exposure-dose relationships are a cornerstone for the development of radiation protection and guidance and also serve an important role in the evaluation of diagnostic procedures involving radiopharmaceuticals and diagnostic X-ray machines.

The development of biokinetic models for "nonreference" humans has required a departure from the curve-fitting approach commonly used to represent the behavior of most radionuclides in adult man. We have found that a mechanistic approach permits supplementing the limited information on a particular radionuclide in man with more abundant physiological information, thus allowing consideration of the variability among

humans, more meaningful extrapolation of data from animal to man, better estimates of intake from measurements of excreta, and improved estimates of dose to tissues of the body.

In a collaborative effort with Children's Hospital National Medical Center in Washington D.C., routine diagnostic computerized axial tomography (CAT) scans are being used to develop a database of three-dimensional images of the body. The database will be used eventually to define the volumes, masses, shapes, and spatial relationships of body organs in an age-dependent manner. Current efforts have focused on determining the volume and density of the lung in children under normal conditions. Such information is part of our radon dosimetry research program. In the longer term, the database will lead to more realistic anatomical models for use in radiation transport calculations.

Members of the group are involved in work of various task groups of the National Council on Radiation Protection, the Medical Internal Radiation Dose Committee of the Society of Nuclear Medicine, and the International Commission on Radiological Protection (ICRP). Of particular relevance to our research interests is the task group of ICRP Committee 2 formed to revise Publication 23 on Reference Man. In the revision, Committee 2 not only is seeking an update of the report's content but also requesting that increased attention be given to variations in anatomical and physiological characteristics with age or sex or to natural differences that may occur for persons of the same age and

NUCLEAR MEDICINE

The Nuclear Medicine Program's research focuses on the design and development of new tissue-specific radiopharmaceuticals for diagnosis and therapy. In addition to the synthesis and testing of new radiopharmaceuticals for *in vivo* nuclear imaging, other activities include biochemical studies to determine the mechanism of tissue specificity of the radiolabeled agents and preclinical testing of new radiolabeled agents in laboratory animals and various *in vitro* systems. The major emphasis focuses on the development of agents for applications in cardiology, cerebral blood flow, oncology, and other nuclear medicine applications. In conjunction with the development of radiopharmaceuticals, new radiolabeling techniques are also developed to incorporate radionuclides into various tissue-specific agents for both diagnostic and therapeutic applications. New radiolabeled agents are distributed internationally to approximately twenty Medical Cooperative Programs at clinics, universities, and other research institutions for further collaborative preclinical testing and clinical evaluation. Our collaborative programs bridge the gap between the conception and development of agents at ORNL and interaction with a variety of extramural

programs with specific expertise in the areas of nuclear cardiology, cerebral metabolism, oncology, and other nuclear medicine applications.

Clinical testing in conjunction with several medical cooperative investigators is continuing with the ^{123}I-labeled methyl-branched fatty acids (BMIPP and DMIPP) developed in our program. These unique agents are important tools in cardiology research and are used for the evaluation of differences in regional myocardial blood flow (perfusion) and fatty acid energy substrate uptake by single photon computerized tomography (SPECT). We are pursuing a detailed biochemical evaluation of the distribution of radiolabeled fatty acid metabolites within the various lipid pools of heart tissue *in vivo* under various physiological conditions. The isolated perfused rat heart system allows an evaluation of the mechanism of localization and retention of these promising new agents for various interventions under carefully controlled conditions.

Potential utility of radiolabeled maleimide agents for labeling antibodies and other proteins for diagnostic and therapeutic applications has been demonstrated in laboratory experiments. Labeling studies with radioiodinated IMP in conjunction with medical cooperative investigators have demonstrated good labeling yield with a model monoclonal antibody and very low loss of radioiodide in tumor-bearing animals. Applications and optimization-evaluation of maleimide technology for labeling antibodies in conjunction with collaborators have continued. Various new structurally related maleimide analogues have been prepared for easy introduction of radioactive iodine to further evaluate the applications of this important project.

The development and use of radionuclide generator studies also continue to be a major focus of the program. The availability of ^{191m}Ir by rapid elution of the activated carbon ^{191}Os/^{191m}Ir generator system developed at ORNL has unique applications for the diagnosis of heart and vascular disease using "first-pass" nuclear medicine techniques. The ultrashort half-life of ^{191m}Ir (4.9 s) allows rapid, repeat studies with low-radiation exposure. Clinical trials are in progress through our Medical Cooperative Programs in Belgium and West Germany, and over 600 patient studies have been performed. Work on this generator at ORNL is now supported by NIH and is directed at optimizing generator fabrication and pursuing applications such as continuous elution. Studies with the ^{188}W/^{188}Re radionuclide generator system developed in our program are also continuing. Rhenium-188 decays with the emission of high-energy electrons and is obtained from our generator system in high yield. It is an excellent candidate for a variety of therapeutic applications, including antibody labeling and radionuclide treatment of rheumatoid arthritis of the knee joints where ^{188}Re would offer many advantages over the radioisotopes

A new area of research includes the development of radiolabeled nucleoside analogues for the localization and therapy of tumors. Nucleosides are important constituents of nucleic acids and can serve as attractive carriers of radioactivity to tumors because of the increased cell division. New methods have been developed for synthesizing bifunctional chelates for attaching radioisotopes of copper (^{64}Cu and ^{67}Cu) and rhenium (^{186}Re and ^{188}Re) to antibodies for therapy and diagnosis. Initial studies with ^{64}Cu have shown this method to work well with model proteins. Our studies with ^{64}Cu-chelate antibody complexes are directed at developing an agent for tumor detection with positron emission tomography (PET). The development of ^{188}Re chelates parallels our development of the new ^{188}W/^{188}Re radionuclide generator system. We are also developing new radiolabeled agents that bind to specific receptors in the brain for imaging

The transfer of our new technology to the commercial sector is progressing with both the ^{191}Os/^{191}Ir generator system and the maleimide protein radioiodination method. U.S. patents have been granted and licensing agreements are near completion for both technologies.

Beginning in FY 1989, a major new activity of our program will be support for radioisotope production development technology for biomedical applications. This new effort is closely related to our traditional radiopharmaceutical development efforts and involves development of production technology and radionuclide generator systems which have applications in nuclear medicine and related biomedical research.

2. ENVIRONMENTAL MEASUREMENTS AND APPLICATIONS SECTION

B. A. Berven, Head

Staff

Research:

W. H. Casson
R. O. Chester
C. Clark, Jr.
S. J. Cotter[1]
W. D. Cottrell
M. T. Cristy
T. A. Cronk
C. S. Dudney
K. F. Eckerman
M. L. Espegren
D. E. Fields
R. D. Foley
R. B. Gammage
L. G. Greeley
L. M. Hively[2]
G. D. Kerr
G. G. Killough
D. C. Kocher
R. W. Leggett
C. A. Little
J. L. Marley
T. G. Matthews
J. E. Nyquist
F. R. O'Donnell
R. B. Ogle
J. L. Quillen
C. S. Sims
D. R. Smuin
R. E. Swaja
E. A. Wachter
J. P. Witherspoon
D. A. Witt
M. G. Yalcintas
E. A. Zeighami

Technical Support:

J. A. Atencio
A. C. Butler
K. S. Dickerson
B. S. Ellis
D. W. Greene
S. C. Hall
R. R. Knott
D. C. Landguth
R. P. Lenc
R. A. Mathis
C. A. Muhr
R. W. Oliver[3]
D. A. Pickering
E. M. Pilz
S. J. Ramos
D. A. Roberts
J. A. Roberts
A. S. Rood[3]
G. A. Smith
M. W. Smuin
S. A. Summers
T. R. Stewart
P. F. Tiner
G. H. Triplett
D. L. Wilson
W. Winton
K. M. Woynowskie

Clerical Support:

L. F. Amburn
D. K. Barslund
A. W. Brown[1]
D. E. Chavarria
L. E. Collins
D. F. Dickerson
A. G. Golliher
T. J. Graves
S. E. Huckaba
L. G. Jackson
O. V. Jennings[1]
M. K. Jensen
N. F. Lewis
S. R. Morris
M. J. Pitts
L. R. Pyles
C. D. Retolaza
C. J. Tyler
R. R. Weston
L. H. White[1]

Guest Scientists:

L. L. Cole
A. Moreno
N. Ozluoglu
H. Sabuncu
D. W. Shields
P. K. TerKonda
I. Uslu
P. S. Weng

Consultants:

G. P. Miller
G. S. Roessler
S. R. Sturm
M. L. Randolph

Students:

C. R. Berland
B. C. Gehrs
E. N. Lazo
K. Black
G. L. Goolsby
E. Y. Lee
R. L. Coleman
D. P. Harrison
C. J. Liu
T. A. Cristy
A. S. Hutchinson
L. A. Norman
M. E. Domroese
S. D. Jones
M. A. Puglisi
A. C. Eblen
D. S. Katz

Postdoctoral Fellow:

J. W. Haas, III

Subcontractors:

T. L. Bradford
C. Griffith
E. K. Roemer
W. H. Burke
T. D. Herrera
R. J. Saultz
S. E. Burns
S. S. Kilgore
E. P. Schlauger
M. J. Capacci
A. K. Klitz
R. M. Schlosser
J. M. Crenshaw
L. R. Lesperance
M. J. Silva
J. R. Davidson
J. C. McAninch
G. K. Stowe
J. C. DePriest
R. L. Meredith
J. E. Thate
D. B. Ertel
C. J. Miller
D. J. Thorne
D. A. Fenner
D. A. Over
C. L. Thomas
D. S. Foster
T. L. Owen
S. A. Tighe
W. L. Foutz
J. E. Peterson
K. V. Warthan
F. G. Gardner
D. T. Redding
T. M. Williams
D. L. Gillespie
J. A. Rice
J. L. Zutman
N. L. Glauner

Loanees from other divisions:

E. G. Bailiff[4]
L. B. Holland[4]
N. E. Korte[6]
M. S. Blair[5]
P. M. Kearl[6]
G. R. Patterson[7]

The major focus of the integrated groups in this section is in the area of environmental assessments as they impact human health. Specifically, this section develops, calibrates, and uses instrumentation to measure radiological and chemical environmental contaminants and evaluates the transport of these contaminants through the environment to assess potential exposure to humans. Resources exist in this section to measure or sample virtually any radiological or chemical contaminant in the environment, determine the magnitude and extent of that contaminant, model the movement of that

contaminant through the environment, and estimate potential human exposure from those agents. Current areas of capability and interest exist in the section in the areas of measurement and calibration of instrumentation and dosimeters in radiation detection, research and development of instrumentation to detect a variety of organic chemicals in the environment, and field investigations performed at federal facilities to develop new chemical and radiological survey methodologies and to test newly developed instrumentation. Education, training, and university interactions continue to be a major focus in the technology transfer process.

This section has several unique resources to enhance its research and development initiatives: (1) the Health Physics Research Reactor is an unshielded, unmoderated fast reactor suitable for mixed-field irradiation for research in health physics, radiobiology, biomedicine, component testing, and related fields; (2) the Radiation Calibration Laboratory is a facility with well-characterized radiation sources suitable to test radiation dosimeters to the requirements of national accreditation programs; (3) the Indoor Air Program is a nationally recognized effort to qualify and quantify a variety of indoor air contaminants including radon, formaldehyde, asbestos, and volatile organics; (4) a compilation of five high-purity germanium detectors are used for gamma spectroscopy of environmental samples; (5) four large mobile laboratories are used for extended survey support at off-site locations; and (6) a facility with laboratories and technical staff has been established in Grand Junction, Colorado, for more cost-effective response to environmental assessments

These collective resources enable this section to be a center-of-excellence in radiation measurement and calibration, development and application of chemical monitoring techniques, assessment of contaminants in the environment, and, collaboratively, determining the impacts to human health from these physical and chemical agents.

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[1]Part-time employee.
[2]Off-site assignment.
[3]Leave of absence.
[4]Research Reactors Division.
[5]Instrumentation and Controls Division.
[6]Environmental Sciences Division.
[7]Environmental and Health Protection Division.

MEASUREMENT APPLICATIONS AND DEVELOPMENT

The primary activities of the Measurement Applications and Development (MAD) Group are aimed at measuring radiological and chemical pollutants in the environment and assessing the impacts of these pollutants on the health and safety of potentially exposed individuals. In support of these objectives, the MAD Group performs three major activities: (1) identifies potential locations of environmental pollutants; (2) characterizes radiological or chemical pollutants with regard to location, type, and concentration; and (3) conducts research and development of instrumentation and techniques to advance survey capabilities. Based on existing expertise and equipment, the MAD Group has the capability to detect and characterize almost any radiological or chemical environmental pollutant of concern to the general public.

Most of the work performed during the report period was funded by the Department of Energy (DOE) Office of Remedial Action and Waste Technology through the Formerly Utilized Sites Remedial Action Project (FUSRAP) and Surplus Facilities Management Project (SFMP). Efforts in support of FUSRAP involved radiological surveying and identifying properties requiring remedial action in the vicinity of sites designated by DOE. Funding for this work has been almost constant over the last few years at a level of approximately $1.0 million each year. Full characterization surveys were completed for about 200 properties in Colonie, New York; 250 properties in Lodi/Maywood, New Jersey; and a large commercial property in Palmerton, Pennsylvania. Preliminary scoping surveys were completed for commercial properties in Schenectady, New York; Painesville, Ohio; Columbus, Ohio; West Chester, Pennsylvania; Hamilton, Ohio; Oak Ridge, Tennessee; and Warren, Ohio. Scoping surveys were also performed for private properties in Lodi/Maywood, New Jersey. In addition, full radiological surveys to assess the success of remedial actions at designated properties were conducted in Wayne, New Jersey. Recent directives by DOE indicate continuation of these scoping, characterization, and verification efforts for several years at FUSRAP and SFMP sites.

In addition to the DOE-funded FUSRAP work, the MAD Group conducted major programs in drinking-water monitoring for formaldehyde, radon monitoring at the Oak Ridge K-25 Plant, and radiological contaminant characterization at Oak Ridge National Laboratory (ORNL). The formaldehyde-monitoring program was funded by the Navy and consisted of sampling drinking water at about 50 houses in the San Diego area and analyzing the samples for formaldehyde concentrations relative to standards specified by the state of California. Radon monitoring at the K-25 Plant was conducted to detect the presence of radon in areas of buildings which are occasionally occupied by workers. The

radiological survey work at ORNL was funded by the Environmental Compliance and Health Protection Division and consisted of surveys at waste storage sites and suspected areas of contamination to determine the existence and nature of environmental pollutants. Results of these surveys are being used to identify and prioritize areas requiring remedial action at ORNL.

With regard to research and development efforts, projects were conducted to develop methods for evaluating ^{238}U concentrations without activation analysis, to develop data management systems and incorporate pattern recognition techniques for analyzing large sets of data obtained during environmental monitoring, and to improve the capabilities of a previously developed ultrasonic field survey system. In addition, MAD Group capabilities and efficiencies were improved by the construction of a larger gamma spectroscopy laboratory for analyzing environmental samples and the development and implementation of a computerized sample tracking/data analysis system for recording the status of environmental samples and preparing analysis data in report formats. This sample tracking system is the most efficient and comprehensive of any existing at organizations doing environmental surveys and characterization work.

Throughout the report period, MAD Group measurement and assessment capabilities for chemical pollutants were developed and exercised. Personnel were trained to sample almost all types of hazardous chemical pollutants, equipment was purchased for field monitoring and chemical survey operations, and staff members participated in chemical surveys with other organizations to gain experience. This capability and experience will be used to continue to advance methodology and instrumentation in environmental assessments and support technology transfer through publications, presentations, workshops, and symposia.

POLLUTANT ASSESSMENTS

The Pollutant Assessments Group (PAG) samples and measures contaminants in the environment to decide whether the contaminants are in excess of established limits, to assess the impact on human health, or to suggest appropriate methods of remedial action. The PAG is organized functionally into two branches (radiological and chemical assessments) and has experienced a large amount of growth in the last year in terms of the number of projects being conducted.

The major source of funding, the DOE Uranium Mill Tailings Remedial Action (UMTRA) Project, still continues with two major activities: inclusion surveys and independent verification surveys. The PAG involvement as the Inclusion Survey

Contractor (ISC) has been active in Grand Junction since 1983. Through FY 1988, the ISC has delivered to DOE over 10,000 recommendation reports that describe whether or not the surveyed properties exceed pertinent EPA standards for mill tailings contamination. The Independent Verification Contractor (IVC) verifies that properties cleaned up by the remedial action contractor no longer violate EPA standards. The PAG performs UMTRA surveys and also serves as an IVC for remedial actions being conducted at Monticello, Utah, by the Surplus Facility Management Program. Funding for the PAG's radiological activities was approximately $5 million during FY 1988 and will be approximately $2 million during FY 1989.

The radiological survey work largely consists of sampling of soil and air and measurement of *in situ* gamma exposure rates using portable instrumentation. Maps are prepared to indicate where contamination is located or where samples are taken. Soil samples are analyzed for radium concentration in an on-site laboratory. For verification surveys, samples taken by the remedial action coordinator (RAC) are split and analyzed by both the RAC and the IVC. A report is prepared for each surveyed property to describe the radiological condition of the property and whether or not it exceeds current standards.

The major growth in the PAG this last year occurred in the realm of chemical projects. Currently, the PAG is involved in site characterization studies at seven Department of Defense (DOD) facilities: Dyess Air Force Base, Abilene, Texas; Forbes Field Air National Guard Base, Topeka, Kansas; Fallon Naval Air Station, Fallon, Nevada; Tucson Air National Guard Base, Tucson, Arizona; Hill Air Force Base, Ogden, Utah; LeMoore Naval Air Station, LeMoore, California; and Corry Naval Air Station, Pensacola, Florida. In addition, the PAG is involved in characterization of the DOE Kansas City Plant and several contaminated sites at the Oak Ridge K-25 Plant. Similar work is being explored for the Department of the Interior (Bureau of Land Management and the Bureau of Reclamation). Funding for most of the chemical studies is multiple year; current total funding for those efforts is approximately $7 million with about $1.5 million being spent

Chemical projects range from simple soil sampling to full Remedial Investigation/Feasibility Study (RI/FS) projects. In noncomplex efforts, a project may require only that samples be taken from known outfalls or spill locations and sent to a laboratory for analysis. In more complex projects, multiple spill locations may contribute to a large or heterogenous plume in groundwater. Monitoring and sampling wells may need to be installed with some knowledge of the direction of groundwater flow relative to the source term. Subsurface soil samples may need to be taken from soil borings. Sampling of water may proceed for relatively long periods of time to produce data for use in

computer models which predict contaminant transport through plume flow. Reports are produced which describe the existing contaminant and make recommendations regarding further action. If the RI/FS process is followed, a feasibility study is written to suggest various remedial options, associated costs, and public risks.

Several new technologies have been developed by the PAG as a result of the types of work that are being done. The UltraSonic Ranging and Data System (USRADS) was created to allow collection of radiation data along with real-time position information of the person doing the surveying. Data are transmitted to a nearby personal computer which stores and analyzes the data. USRADS has been licensed to a private firm for use and

Another new scheme has been the development of a method of pumping multiple wells using a single inexpensive pump rather than a more expensive pump on each well. The system involves use of an elevated manifold and will retard contaminant flow, which may be an acceptable remedial action. The rate at which pollutant materials are transported via a plume is a function of the diffusivity of the medium through which transport is occurring. An *in situ* method of measuring diffusivity has been developed which should be much more accurate than previous methods. The method required a new derivation of the diffusivity equation and development of a downhole device which not only injects characteristic gases, but measures their concentrations as well. The new diffusivity derivation has been completed, and the downhole device has been designed but not manufactured.

MEASUREMENT SYSTEMS RESEARCH

In a major reorganization, the indoor air quality and chemical hazardous waste research activities have been brought together in a new group called Measurement Systems Research (MSR). A transfer has also taken place from the Health Studies Section to the Environmental Measurements and Applications Section. The new grouping is more capable of responding to a wide variety of research needs arising from increased hazardous waste activities at federal facilities.

The theme central to the group's activities is the development of improved and more cost-effective devices and techniques for monitoring and tracking radiological and especially hazardous chemical entities in the field.

Earlier research into a wide range of indoor pollutants has now become strongly focused on residential radon problems. An exhaustive study during FY 1987 was made of radon entry and mitigation inside seven homes in New Jersey. The work was sponsored jointly by DOE/Office of Health and Environmental Research (OHER), EPA, and

Tennessee Valley Authority. During FY 1988, the radon activities have transferred to Oak Ridge, Tennessee, and Huntsville, Alabama, where eight houses built over porous limestone formations are being studied. A major finding in Huntsville was the discovery of extreme seasonal changes in the concentrations of radon in subterranean fissures. Elevations in radon concentration occurred during the warm season and were communicated to the houses. This finding has important implications for guidance given to the public regarding the best time of the year to make screening measurements in their homes.

New directions to indoor environmental applied research are being provided by the Airborne Hazardous Materials Program (AIRHAS) component of the Martin Marietta Energy Systems, Inc., Hazardous Waste Remedial Action Program. The MSR Group is heavily involved with AIRHAS in the planning and conduct of QA/QC associated with the Navy Radon Mitigation Program, which aims at evaluating and fixing radon problems at their facilities worldwide. Other activities involve investigating traces of formaldehyde in drinking water at a military housing complex in San Diego and monitoring of exposures for a demonstration asbestos roofing demolition project.

Hazardous chemical waste projects are divided about equally into field activities and the development and evaluation of new monitoring devices and techniques. Field activities have largely been in support of the Air Force Installation Restoration Program. Pragmatic monitoring of soil gases from spilled jet fuel has been used to locate, map, and evaluate effectiveness of remediation at several Air Force bases. A similar study was conducted on the Oak Ridge Y-12 complex where a gasoline storage tank used for fueling automobiles had leaked.

An important component of the MSR Group's activities is the development of portable, remote-sensing devices for *in situ* screening measurements. An innovative project supported by EPA involves interfacing our USRADS with portable X-ray fluorescence (XRF) devices that have recently become commercially available. The objective of the USRADS/XRF project is demonstration of completely automated recording of data during walkover surveying for heavy metal surface contamination. Other portable survey devices, such as the hand-held photoionization detector (PID), were evaluated for interference problems. It was discovered that naturally produced methane seriously impairs the sensitivity of the PID when attempting to monitor coexisting pollutants such as fuel vapors and chlorinated degreasing solvents.

More basic research aims at developing new remote sensing devices employing fiber- optics. A portable derivative ultraviolet absorption spectrometer (DUVAS)

developed for the synfuels program is being upgraded for use with a fiberoptic probe. The aim is to conduct down-well remote monitoring of select aromatic compounds in part-per-million concentrations. Fiberoptic devices that employ principles of surface-enhanced Raman scattering are being developed for monitoring subparts per million concentrations of chlorinated organic solvents and industrial or agricultural wastes in groundwater. Both electrochemical and nonelectrochemical optrodes are being evaluated, together with significant surface chemical and submicron physical phenomena.

DOSIMETRY APPLICATIONS RESEARCH

The activities of the Dosimetry Applications Research (DOSAR) Group are focused on improving the quantification of the radiation dose received by individuals and on providing a better understanding of radiation effects. Such activities are in the mainstream of the HASRD mission of assessment of impacts of energy-related technologies on human health.

The Health Physics Research Reactor (HPRR) has been the primary research tool at DOSAR for more than two decades. The HPRR was shut down by DOE early in 1987 and remained shut down throughout the period covered by this report. Consequently, DOSAR attention was redirected toward the Radiation Calibration Laboratory (RADCAL).

The RADCAL building has been completed. It is in the process of being outfitted with the radiation sources necessary to perform dosimeter calibrations and performance testing as well as a variety of radiobiological experiments and materials irradiations. The RADCAL will feature computer-controlled source access, dose control, dose recording, interlock assurance, and environmental monitoring. Various gamma, beta, and neutron sources are currently in use at the facility but are not in their final configurations. An X-ray machine has been ordered and will be installed in the room being prepared for it.

The Thirteenth Personnel Dosimetry Intercomparison Study (PDIS) was conducted using radioisotopic neutron sources at RADCAL and at the University of Arkansas. A total of 48 organizations (34 - U.S. and 14 - foreign) participated in the study. Twenty-two of the 48 were associated with commercial nuclear power plants. The results of PDIS 13 provided up-to-date knowledge of the worldwide status of mixed field, neutron-gamma personnel dosimetry.

The DOSAR staff were involved in a number of activities important to the field of personnel dosimetry. The following three were among the most significant: (1) they organized the Second Conference on Radiation Protection and Dosimetry to be conducted

in Orlando, Florida, in November 1988; (2) they used radiation exposures at RADCAL to help quantify the response of the new Martin Marietta Energy Systems, Inc., corporate dosimeter; and (3) they chaired the Health Physics Society Committee charged with the responsibility of revising ANSI N13.11, the national personnel dosimeter test standard.

3. BIOLOGICAL AND RADIATION PHYSICS SECTION

H. A. Wright, Head

Staff

Research:

E. T. Arakawa
J. C. Ashley
T. A. Callcott[1]
J. G. Carter
L. G. Christophorou
O. H. Crawford
M. W. England
T. L. Ferrell
R. N. Hamm
B. E. Hingerty
S. R. Hunter
D. R. James
L. R. Painter[1]
R. H. Ritchie
I. Sauers
J. E. Turner
R. J. Warmack
H. Yoshida

Technical Support:

R. A. Mathis

Clerical Support:

J. E. Carrington
N. J. Kwaak
S. W. Masingo
S. S. Stockstill
B. R. Thomas

Guest Scientists:

G. Basbas
D. W. Bouldin
M. A. Breazeale
M. C. Buncick
M. S. Chung
P. M. Echenique
R. D. Edge
F. Flores
W. A. Garrison
W. Gibson
J. P. Goudonnet
A. Gras-Marti
T. L. Hayden
D. L. Hedden
H. H. Hubbell, Jr.
B. Illman
T. Inagaki
M. Kamada
B. N. Khare
K. Komaki
K. C. Mamola
J. R. Manson
J. G. Mantovani
D. L. McCorkle
M. O. Pace
M. C.
F. Sols
C. C. Sung
J. D. Todd
G. C. Wetsel
Y. Yamazaki

Students:

D. L. Bailey
B. K. Beatty
W. E. Bolch
W. T. Buller
K. L. Burchett
D. Chilcott
M. M. Clark
P. G. Datskos
M. H. Debrus
D. Dufrenois
T. M. Espy
S. Humphrey
D. Jacobson
J. G. Kreke
I. Lee
C. Martin
S. Meinel
C. G. Milne
M. A. Moore
E. Overton
J. E. Parks, II
R. C. Reddick
P. E. Rose
C. Rousculp
B. K. Russell
J. P. Sawyer
P. P. Shelby
M. L. Souleyrette
K. Swartz
J. R. Thompson
P. S. Tuminello
B. van de Sande
P. C. Votaw

J. D. Foust
H. J. Gill
G. H. Harman
G. F. Reinking
J. D. Richards
H. Rodriguez
S. P. Weaver
L. E. Williams

Postdoctoral Fellows:
M. J. Bloemer
H. Faidas
L. A. Pinnaduwage
V. Zabel

Loanees from other divisions:
D. P. Allison[2]
V. E. Anderson[3]
K. B. Jacobson[2]

Activities within this section consist primarily of basic physics research studies directed toward providing new scientific knowledge about the fundamental properties of matter in all phases (gas, liquid, and solid) and, in particular, of processes and mechanisms important in the interaction of pollutants with biological materials. The section also maintains a strong surface physics program. Both theoretical and experimental studies are included in the section's research activities, which involve state-of-the-art technology in many areas such as scanning tunneling microscopy, surface- enhanced Raman spectroscopy, soft X-ray emission spectroscopy, and microlithography. Some of the research highlights during this year in each of the four groups in the section are reported below.

The section continues to have significant interactions with many other research institutions, both in the United States and abroad. Eleven visiting scientists from foreign institutions, 20 visiting scientists from U.S. institutions, and 41 students worked within the section at various times during this reporting period.

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[1]Part-time employee.
[2]Biology Division.
[3]Computing and Telecommunications Division.

ATOMIC, MOLECULAR, AND HIGH VOLTAGE PHYSICS

This research program is devoted to the study of electron-molecule interactions and negative ion processes, electron-excited molecule interactions, interphase physics, and the coupling of basic and applied research for the advancement of new energy-related technologies.

In our studies of electron-excited molecule interactions we have discovered the first optically enhanced electron attachment involving electronically excited molecules. We have observed up to 10^6 times larger electron attachment cross sections to electronically excited states compared to ground states for thiophenol (C_6H_5SH) and thioanisole ($C_6H_5SCH_3$) molecules. The metastable (triplet) states responsible for the photoenhanced electron attachment were produced indirectly via internal conversion from higher excited singlet states which are strongly optically allowed and are reached by excimer laser excitation. Besides their basic significance these studies open up new technological possibilities such as the optical control of the impedance characteristics of (gaseous) matter and repetitive switching--or modulation--of the electronic conduction/insulation properties of matter at times in the microsecond to the nanosecond range.

The multiphoton ionization of fluoranthene in liquid tetramethylsilane (TMS) was studied as a function of laser intensity and wavelength. The ionization mechanisms operating at various laser wavelength regions were identified, and the ionization threshold (I_L) of fluoranthene in TMS was determined to be ~5.7 eV. It was found that a gradual transition from a direct two-photon to a three-photon (via the first, S_1, and second, S_2, singlet states) ionization mechanism takes place for $400 < \lambda < 440$ nm. This important observation was developed into a novel technique for determining the I_L of a molecule dissolved in a nonpolar liquid. Additionally, the multiphoton ionization of azulene in various nonpolar liquids, with V_0 values ranging from -0.7 to +0.21 eV, was studied, and its I_L was determined in each liquid utilizing the aforementioned technique. A linear relationship between the I_L in each liquid and the corresponding V_0 value was found.

A new program has been initiated to develop novel liquids (both cryogenic and room temperature) for liquid-filled particle/radiation detectors.

Interphase studies on electron motion, attachment, and ionization in dense gases continued with emphasis on the molecule TMPD in ethane and SF_6 in Xe and on atomic vapors in dense rare gases.

A strong negative effect of temperature, T, on the nondissociative electron attachment to molecules has been observed for a number of perfluorocarbons. The nondissociative attachment component of the total electron attachment to C_3F_8, n-C_4F_{10}, and n-C_6F_{14} extends from 0.4 to > 5 eV, increases with the size of the molecule, and decreases precipitously with increasing T above room temperature. Similarly, the rate constant for electron attachment to molecules such as c-C_4F_8 and c-C_4F_6, which below ~1.0 eV attach electrons exclusively nondissociatively, was found to decrease by two to three orders of magnitude when T was raised by 200 to 300 degrees above room temperature. Possible origins of the observed large negative effect of T on electron attachment have been investigated, and the significance of these novel findings for certain applications such as spark gap and diffuse discharge-closing switches has been established.

Electron attachment and ionization coefficients and electron drift velocities have been measured in several C_2F_6/Ar and C_2F_6/CH_4 gas mixtures over a wide range of E/N values [corresponding to mean electron energies $< \varepsilon >$ from thermal ($< \varepsilon > \simeq 0.04$ eV) to $< \varepsilon > \simeq 5$ eV] at gas temperatures T of $300\ K \leq T \leq 700\ K$. These measurements were performed to study the influence of elevated gas temperatures on the operation of diffuse discharge-opening switches. These results show that operation at those temperatures would have no deleterious effects on the performance of these switches, and may, in certain instances, be beneficial.

The uniform field breakdown strength of electronegative gaseous dielectrics has been shown to depend on T. It increases with T for those dielectric gases which attach electrons dissociatively, and their attachment cross section increases with T; and it decreases with T for those dielectric gases which attach electron nondissociatively, and their electron attachment cross section decreases with T.

Accurate values of the electron drift velocity w have been measured in the rare gases Ar, Kr, and Xe over a wide range of the density-normalized electric field strength ratio E/N and covering the mean electron energy $< \varepsilon >$ range from thermal energy $< \varepsilon > \sim 0.038$ eV to several eV. These measurements have been used in a Boltzmann equation analysis to determine the low-energy electron momentum transfer cross section σ_m, the transverse diffusion to electron mobility ratio D_T/μ, and $< \varepsilon >$ for these gases. The electron attachment rate constants $k_a(E/N)$ have been measured in SF_6/Xe gas mixtures, and these measurements along with the transport measurements in the pure rare gases are being used in analyses to calibrate the mean energy scale in rare gas liquids as a function of E/N.

The electron attachment coefficient η/N, ionization coefficient α/N, and w have been measured in SiF_4, BF_3, and several SiF_4/He gas mixtures over a wide E/N range. SiF_4 and BF_3 possess the highest known electron attachment thresholds ($\approx$10.5 eV), and these gases may be useful as constituents in gas mixtures for diffuse discharge-closing switch concepts which are of prime importance in many pulsed-power-switching applications.

PHYSICS OF SOLIDS AND MACROMOLECULES

This group concentrates on making basic measurements, by a variety of techniques, of the optical and electronic properties of solids, macromolecules, liquids, and thin films over a wide range of photon energies and temperatures. Other areas of research include resonance ionization spectroscopy, soft X-ray emission and absorption spectroscopy, photoacoustical measurements, and measurement and calculation of low-energy electron mean free paths in solids and macromolecules. Studies in this program should lead to a better understanding of biologically interesting materials and biological systems and to the development of new, low-level pollutant detectors.

We have measured the fluorescence intensity of solid solutions of anthracene dissolved in polymethylmethacrylate (PMMA) using photons in the energy range from 7 to 40 eV. A detailed investigation of the intensity as a function of the concentration of anthracene in PMMA allows one to determine the range of photoelectrons in PMMA. Using a random-walk model of the photoelectron and the given spatial distribution of the solute molecules, the distance traveled by the electron before exciting the anthracene molecule was determined to be between 18 Å and 22 Å for excitation energies between 20 eV and 40 eV.

Two-step resonance ionization of Ba atoms was carried out with a pulsed dye laser. A sensitivity was reached in the order of one in 10^6 atoms. The quantity of the sample (Ba impurities in Ag and Si) needed to perform this experiment was less than 100 µg. Femtogram quantities of a complex organic pesticide Dinoseb (2-sec-butyl-4, 6-dinitrophenol) in Ag were measured with multiphoton ionization and time-of-flight mass spectroscopy. A few parent ions were obtained in the mass spectra.

Sharp lines and broad bands have been observed in the optical spectra of electron-bombarded KCl:Tl and KBr:Tl. The broad bands are due to the characteristic Tl^+ emission. The sharp lines coincide in energy with emission lines from electronic transitions of isolated neutral potassium atoms. The intensity of these lines as a function of beam current had a linear, cubic, and greater-than-cubic dependence in the low-,

intermediate-, and high-current regions, respectively. It was concluded that excited-state potassium atoms are produced by direct electronic excitation and by secondary processes during electron bombardment in the low- and intermediate-current regions, respectively, while the excited atoms in the high-current region are due to gas-phase interaction with electrons.

Studies of light emission from targets bombarded by high-energy neutral and charged particles were conducted at the Argonne National Laboratory Neutral Particle Beam Test Stand. Negatively charged hydrogen ions were accelerated to 50-MeV energy by a LINAC and then passed through a thin carbon foil to produce H^+ and H^0 particles. Thin targets of Al, Ag, and Si were examined for emissions in the wavelength ranges from 1 to 50 nm and 50 to 160 nm, corresponding to the extreme ultraviolet (XUV) and vacuum ultraviolet (VUV), respectively. No emission was observed in the VUV using a vacuum monochromator. However, in the XUV using a channel electron multiplier only, detectable emissions were obtained. The observed signal could be attributed to soft X-ray emission and high-energy backscattered electrons. This experiment did not discriminate between the two processes, and, hence, the relative yields were not obtained.

A high-efficiency, soft X-ray emission spectrometer, designed for use with photon excitation from the National Synchrotron Light Source, completed its first year of regular operation in 1987. The spectrometer facility was upgraded by the installation of a transmission monochromator on the excitation beamline in June 1987. Studies of several materials were completed in 1987, with papers being submitted on dilute Al-Mg alloys, Al-Mn icosahedral alloys, $Al_xGa_{1-x}As$, LiAl, bonding in Al, and the $YBa_2Cu_3O_{7-x}$ superconducting compounds. Studies were initiated on multilayer structures, high-temperature superconductors, and impurities in organic materials.

LIQUID AND SUBMICRON PHYSICS

This group's research is devoted to the basic physics of liquids and submicron structures. Allied investigations leading to advances in microscopy, the response of materials to radiation, detection of organic compounds, and development of new surface probes are carried out.

New types of microscopy and microlithography have been developed. In particular, a new form of optical microscopy has been invented: the photon scanning-tunneling microscope. This unique instrument is capable of higher resolution than any other optical microscope and may be used to image insulating materials in air (unlike electron microscopes).

Well-controlled microstructures have been developed for use in detection of chemical compounds using surface-enhanced Raman scattering. The use of these microstructures on the exterior side of fiberoptic cables permits remote sensing of adsorbed compounds. This is particularly useful for testing for pollutants in ground- water and rapid, on-site identification of hazardous chemicals. A detailed program is underway to optimize the microstructures used for this system.

A scanning tunneling electron microscope (STM), which operates under ultrahigh vacuum at subatomic resolution, has been constructed and used to examine a variety of materials topographically and spectroscopically. Two other STMs operating in air have been used for examining conducting polymers, highly oriented pyrolytic graphite, and the tobacco mosaic virus (TMV). The TMV data are the first obtained on a virus in air and display fine details of the viral structure not seen before. The TMV structure was first examined years ago as part of the discovery of the double-helix structure of DNA and is closely related to our present efforts on the human genome project.

ANALYTIC DOSIMETRY AND SURFACE PHYSICS

This group concentrates on important basic problems in dosimetry, microdosimetry, and surface physics. Fundamental studies on the interaction of radiation with matter included a continuing development of the theory of electron and ion interactions with the excitation modes of condensed matter, the theory of track structure and high-energy sputtering from nonmetallic solids, and the theory of compound states of electrons and elementary excitations in condensed matter. New results for the energy-loss rates and transport mean free paths of subexcitation electrons in SiO_2 were incorporated in a Monte Carlo program to determine electron energy distributions which result when an electric field is applied to a layer of this material. A simple procedure was developed for calculating electron energy-loss rates and inelastic mean free paths in a condensed material from optical data for that material.

In the surface physics area, the goal is to elucidate the fundamental physical mechanisms involved in the interaction of microscopic and macroscopic bodies with condensed matter surfaces. Work done on the interaction of charged particles with surfaces includes a high-order perturbation theoretical evaluation of the complex image potential felt by an electron near a metallic surface and the binding energy of the surface polaron at a model insulator. We began evaluating numerically the image potential seen by an electron near a metal surface using a Coulombic basis set of wave functions in the self-energy perturbation theory of Manson and Ritchie. Studies of the binding energy of the surface

hydrated electron and of the geminate recombination process including the transient response of the medium were initiated. A new formulation of the impact parameter dependence of charged particle interactions in condensed media and the localization of initially unlocalized excitations was developed. A Monte Carlo study of the probability of multiple emission from a solid bombarded by swift protons is under way in order to evaluate the accuracy of our proposed, simplified analytical model for this process. Additional theoretical work on convoy electron production by swift, highly charged ions in solids was completed. Theory for the emission of continuum X rays from irradiated solids was developed; calculations were performed for X-ray emission from an aluminum target bombarded by 50-MeV hydrogen atoms. Theory was developed for the absorption, emission, and scattering of light by molecules adsorbed on a solid surface. From this theory we find the important, new result that the usual surface selection rules are broken as the adsorbed molecules form thin layers.

We have continued development of a model for Monte Carlo calculations of the detailed sequence of events in irradiated water with the ultimate goal of understanding the effects of radiation on DNA. In the first test of the model using an actual biological molecule, glycylglycine in water, the calculated production of free ammonia under X irradiation was in excellent agreement with that measured under the same conditions. A version of our optical charged-particle track detector suitable for neutron dosimetry is under construction. A proof-of-principle chamber in which alpha-particle tracks were visualized was constructed.

Work has been progressing on the ORNL initiatives in structural biology and the human genome. Initial work for the Human Genome Project was funded as a Laboratory Director's R&D project; continued support for this effort is being solicited through proposals to DOE. This collaborative effort with the Solid State and Instrumentation and Controls divisions is studying new DNA sequencing methods and instrument development as well as extending earlier work on DNA structure. A separate, more specific study involves determining the chemical structure of the complex carbohydrate cyclodextrin by X-ray and neutron diffraction. These studies will be extended to protein structure determinations. In collaboration with the Solid State Division, we are developing instrumentation and preparing experimental protocols for biological studies that will take advantage of the planned Advanced Neutron Source.

Collaborative studies with the Biology Division focus on the effects of chemicals on biologically relevant macromolecules and on live organisms. Detailed calculations were made of the binding of 24 different metal ions to the dinucleoside monophosphate, GpC.

These calculations yielded, for each metal ion, an energy related to the distortion of the GpC by the presence of the metal ion and, hence, an indicator of its toxicity at the molecular level. Using our previously obtained indicators of toxicity for CHO cells, *Drosophila*, and mice, a method was suggested for extrapolating indicators of metal-ion toxicity across species from the molecular level to man. Experiments were continued to help elucidate the properties of a low-molecular-weight, metal-binding protein which is induced in *Drosophila* in response to metal ions in their diet. In parallel experiments, genetics studies were continued to get closer to the location on the X chromosome of the allele associated with cadmium-ion toxicity in *Drosophila*. These experiments could lead to a better understanding of the basic mechanisms associated with metal-ion toxicity at the molecular level.

4. CHEMICAL PHYSICS SECTION

W. R. Garrett, Head

Staff

Research:
H. S. Carman, Jr.
C. H. Chen
R. N. Compton
J. P. Judish
C. E. Klots
S. D. Kramer[1]
J. C. Miller
M. G. Payne
J.A.D.

Technical Support:
S. L. Allman
R. C. Phillips

Clerical Support:
D. C. Crowell
N. S. Currence
B. F. Thomas

Consultants:
W. Christian!
C. S. Feigerle
G. S. Hurst
P. Lambropoulos
M. A. Moore
M. S. Pindzola
J. Tellinghuisen

Guests Scientists:
T. L. Bailey
H. C. Baker
D. Charalabidis
W. C. Cheng
W. M. Fairbanks, Jr.
C. Fotakis
H. B. Kinser
B. E. Lehmann
B. P. Pullen
S. A. Taylor
R. K.
D. Zei

Students:
J. H. Arps
S. J. Bajic
G. A. Barrera
I. Datskou
J. C. Day
S. A. Fischer
R. C. Hart
M. P. McCann
M. A. Moore
M. J. Shea
J. S. Thompson

Postdoctoral Fellows:
H. S. Carman, Jr.
M. P. McCann
D. B. Smith

Loanees from other divisions:
H. A. Barnett, Jr.[2]

The research conducted in the Chemical Physics Section relies heavily on laser-based spectroscopic techniques in studies of fundamental atomic and molecular processes relevant to energy-related problems in atmospheric physics and chemistry, radiation chemistry, advanced instrumentation technology, laser development, and advances in analytical methodology. In these efforts, laser-based resonance ionization spectroscopy (RIS) and RIS combined with mass spectrometry are used in developing ultrasensitive and/or highly selective techniques for chemical characterization and detection under a variety of circumstances. For problems requiring laser capabilities beyond those presently available, nonlinear optical processes are explored for their potential utilization in extending the ranges of tunable laser wavelengths. Picosecond laser techniques are being used to extend the range of accessible time scales for studies of fast photoinduced chemical and physical processes.

Through the use of supersonic pulsed-nozzle expansions and a mass spectrometer arrangement with a cryogenically cooled laser ablation source, clusters of molecules and volatile liquids are studied with resonance ionization and mass spectroscopic analyses in research aimed toward achieving deeper understanding of radiation-induced chemical processes in liquids.

The following brief summaries of activities in the Molecular Physics and Photophysics groups provide general information on the accomplishments in the chemical physics program. More detailed information on all of the research can be found in the open-literature references at the end of this report.

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[1]Leave of absence.
[2]Instrumentation and Controls Division.

MOLECULAR PHYSICS

The invention of the pulsed tunable dye laser has created a revolution in our understanding of the interaction of light with matter. It has spawned the important new era of nonlinear optics--the simultaneous interaction of many photons with matter. The Molecular Physics Group has continued extensive experimental and theoretical contributions in this field through studies of multiphoton ionization (MPI), third harmonic generation (THG), stimulated electronic Raman scattering, and other nonlinear optical phenomena.

A major part of this effort is devoted to understanding molecular clusters as a bridge between the gaseous and liquid states. Recent experimental work has included MPI studies of simple van der Waals molecules and the autodetachment spectroscopy of helium negative ion dimers. Theoretical studies of evaporation dynamics in molecular clusters have uncovered important regularities, identified experimental tests of them, and shown how small "magical" properties may be magnified to macroscopic proportions. In a new experiment, reactions of highly excited Rydberg atoms with molecular clusters have been studied using crossed beams. These experiments are designed to examine the transition from an isolated negative ion to "solvation" in a liquid. The spectroscopic properties of such large clusters will provide direct tests of solvation phenomena in liquids.

In collaboration with the Physics Division, studies of the properties of atomic negative ions have continued. This program has been expanded to include laser photodetachment of negative ions. In addition to fundamental measurements of energy- and angle-resolved photoelectron detachment spectra of H^-, He^-, and B^-, a major discovery has resulted from studies of Ca^-. Laser photodetachment spectroscopy measurements on a fast beam of calcium negative ions show that Ca is bound into the $4s^24p$ state with a binding energy of 0.047 ± 0.005 eV. Previous to these studies, it was believed that none of the Group IIA metal atom negative ions would be stable.

In another experiment, studies of Rydberg atom reactions with rotationally and vibrationally cold molecules is providing unique new information on negative ions and the interaction of low-energy electrons with molecules. Specifically it is found that in many cases the presence of the ion core of the electron "donor" is necessary to stabilize a negative ion which is produced by low-energy electron attachment. An excellent example is the reaction $A^{**} + HI \rightarrow A^+ + HI^-$. In this interesting reaction, HI^- is formed only for alkali Rydberg atoms, A^{**}, at low principal quantum numbers where the HI^- ion is "close" enough to the A^+ ion to allow for stabilizations of HI^-. This is the first observation of a stable negative ion for a hydrogen halide.

A number of studies of high-power laser interaction with dense alkali vapors have been performed. The alkali vapors are contained in optical heat pipes. In addition to basic research into the mechanisms of MPI, harmonic generation, and stimulated Raman processes, which is the main focus of the work, applications of the tunable infrared (IR) radiation are being pursued. For example, detection techniques utilizing IR absorption due to gaseous impurities in the air (NO, HF, NO_2, etc.) are being developed with success. A more recent novel application of optical heat pipes has been in the area of dosimetry.

Studies are being directed toward the measurement of w values (energy required to produce an ion pair) for alkali vapors. A long-range goal of this research is to use lasers to study energy deposition mechanisms in the interaction of ionizing radiation with matter.

Our longstanding interest in THG in rare gases led to studies of the effect of a second strong, resonant laser on THG in xenon. We find that through coupling by the second laser, THG can occur in normally forbidden regions of a nonlinear medium. Even in normally allowed regions, the THG conversion is altered by the second laser. Excitation of strong two-photon resonances leading to stimulated emissions are currently under study in krypton and xenon.

A major new picosecond laser facility has recently become operational. The centerpiece of this new laboratory is a state-of-the-art Nd:YAG laser which pumps a novel short-cavity tunable dye laser. The high-peak power of such a system (10^{12} - 10^{14} W/cm^2) will make possible the observation of high-order multiphoton processes in dense atomic and molecular gases. The short pulse time (~ 5 x 10^{-12} s) will allow study of very fast chemical dynamics of liquids, solids, and clusters which are important in radiation chemistry and physics. In both cases, the ability to tune the wavelength of the laser will allow state specific studies.

Currently two investigations are yielding promising new results. In the first, it has been found that nonresonant, multiphoton processes are surprisingly efficient at producing ions of atomic and molecular clusters. Species such as Xe_n (n = 1 - 19), $(NO)_n$ (n = 1 - 5) and Ar_nNO (n = 1 - 10) have been observed. Detailed spectroscopic studies are beginning on nitric oxide dimers which are important parts of the NO_x pollution cycle in the upper atmosphere. Fast dissociative processes in $(NO)_2$ can only be studied with picosecond timing. The second study focuses on laser-matter interaction in metals and on surfaces. Short pulse lasers are required to minimize thermal effects which mask the interesting physics. Preliminary studies involve kinetic-energy-resolved detection of metal species and their clusters ablated by the laser. Both positive and negative ions, as well as electrons, are being studied.

PHOTOPHYSICS

In this reporting period, activities in the Photophysics Group fell into three broad categories: development of advanced analytical techniques for chemical analysis; studies of nonlinear optical phenomena relevant to laser frequency conversion techniques and to basic physics associated with RIS; and studies of laser-induced processes in liquids and solids.

We have implemented a novel two-photon excitation technique for accessing molecular states lying more than 10 eV above the ground state. The new method is based on the ability to drive two-photon transitions with a low-intensity, very-high-frequency laser beam combined with a high-intensity tunable beam of lower-frequency visible photons. The method offers very good spectral resolution for spectroscopic analysis of high-lying molecular states, with rather uncomplicated equipment. The work was featured in "Physics News in 1987" (*Physics Today*, January 1988, p. s-16).

Several studies of nonlinear optical phenomena and multiphoton ionization processes were conducted, with discoveries of a half-dozen new effects associated with generation of extended electromagnetic frequencies and with resonant ionization mechanisms. We discovered that an interference effect associated with hyper-Raman emission causes the process to occur only in the direction opposite to the laser beam which stimulates the atomic or molecular response. We showed that the effect also occurs for all higher-order odd photon Raman-type processes. The a.c. Stark effect caused by internally generated Raman emissions can act to strongly suppress two-photon resonant atomic excitation (scheme 3 RIS method). A new consequence of a three-photon interference effect was shown to lead to reduced conversion efficiencies for VUVgeneration by wave mixing in nonlinear media. Additionally, a two-photon resonance interference effect was shown to limit parametric four-wave mixing, which is a potentially important source of tunable infrared radiation for molecular spectroscopy.

In studies of laser-induced processes in liquids, new photoinduced reactions between organic and inorganic solutes were discovered and characterized. Finally, a new cryogenically cooled laser ablation source resonance ionization mass spectrometer system was used to show the presence of a mobile oxygen fraction in new high-temperature superconducting materials.

5. INFORMATION RESEARCH AND ANALYSIS SECTION

J. T. Ensminger, Head

Staff

Research:

W. J. Allen
L. J. Allison
K. J. Brown
M. M. Brown[1]
R. F. Carrier
G. M. Caton
S. S. Chang
B. D. Chilton
Z. Combs
N. S. Dailey
G. S. Danford
M. W. Daugherty
K. A. Davidson
M. C. Davidson[1]
A. R. Ehrenshaft
E. L. Etnier[1]
R. A. Faust[1]
J. M. Fielden
L. M. Floyd
C. S. Fore
M. W. Francis
R. M. Gove
R. T. Haas
J. A. Hall
C. L. Heckman
J. P. Hewins
F. M. Holland[1]
P. S. Hovatter
S. M. Hubner
M. P. Kertesz
D. G. Kilgore
B. W. Kline
E. B. Lewis
P. Y. Lu
F. M. Martin
K. H. Mavournin
D. C. Michelson
I. C. Miller
K. C. Miller
D. D. Moore
H. B. Morgan[1]
N. B. Munro
P. A. Noghrei-Nikbakht
C. J. Oen
P. S. Ogle
D. M. Opresko[1]
P. T. Owen
E. T. Owens[1]
B. C. Pal
H. A. Pfuderer
B. E. Ricci
L. M. Roseberry
R. H. Ross
M. G. Ryon
J. G. Smith
R. S. Stafford
S. S. Talmage[1]
R. K. Templeton
K. M. Thiessen[1]
S. Y. Uppuluri[1]
M. S. Uziel
C. K. Valentine
E. S. VonHalle
J. S. Wassom
R. S. Weaver
J. K. Williams
B. L. Whitfield
R. A. Young

Technical Support:

J. W. Crutcher
S. C. Daniels
M. E. Gillespie
L. F. Goins
J. P. Hutson
N. P. Knox
M. E. Langston
J. O. Mynatt
D. F. Pickel
J. H. Scott
C. C. Seaborn
D. M. Stokes
J. W. Taylor
C. J. Wear
J. M. Wyrick[1]

Clerical Support:

D. G. Arnwine
W. J. Barnard
G. E. Groover
B. S. Hayes
M. Phillips
D. B. Stinnett
L. E. Thurston
T. E. Watson
K. A. Weaver
P. J. Wenzel

Consultants:

C. R. Catlett
D. A. Douglas
N. P. Drago
S. M. Draime
S. E. Estepp
S. D. Ferguson
S. M. Ferrell
R. E. Gibson
P. S. Hammons
J. N. Hitchcock
J. A. Holland
L. M. Houlberg
G. J. Johnson
S. E. Kilgore
C. S. Lever
S. K. Maddux
W. L. McNabb
K. E. Mueller
J. E. Novick
K. S. Rao
P. L. Schumann
G. S. Thurmer
R. M. Zoz

Guest Scientists:

None

Students:

D. L. Blackburn
L. A. Bowles
C. E. Chase
T. L. Cox
J. E. DeHart
K. F. Goode
S. Gulati
M. K. Gustin
J. C. Haufe
J. W. Hodge
D. G. Jernigan
M. N. Kenney
T. D. King
J. A. Longmire
J. M. McClure
R. S. McDow
M. M. Mitchell
R. C. Moore
M. A. Phillips
P. A. Quiggins
L. C. Robert
M. M. Romines
W. J. Samples
G. G. Santore
B. J. Savary
G. D. Smith
S. E. Troy
C. W. Watson
G. M. Wells
L. A. Wilson
D. E. Wood

Postdoctoral Fellows:

None

Subcontractors:

G. Benke
C. Bergman
A. Colb
K. Cooper
J. Dragun
V. Freed
G. Lambert
P. Mirkes
J. Perkins
V. Rose
G. Stoner
G. Witz

Loanees from other divisions:

R. L. Schenley[2]

The Information Research and Analysis (IR&A) Section was organizationally moved from the Biology Division to the Health and Safety Research Division in October 1987. IR&A has been a part of the R&D environment of the laboratory since its inception as the Environmental Information Systems Office in 1971 and has historically maintained its major scientific strength in the area of health and environmental effects of hazardous

materials. The transition, which has been extremely smooth, presents new potential for interaction between the bench and information research aspects of new and ongoing research initiatives.

During the past year, the section continued work which has been under way for many years in the development of computerized health effects databases. Funded by the EPA and National Institute of Environmental Health Sciences/National Toxicology Program (NIEHS/NTP), the Environmental Mutagens and Teratogens databases now contain over 67,000 and 46,000 records, respectively, on approximately 21,000 total chemicals. The Environmental Mutagens Information Center has served as the focal point for the EPA Gene-Tox Program. The purpose of the Gene-Tox Program is to conduct a systematic review and validation of genetic toxicology studies to establish a registry of test results for chemicals evaluated in selected short-term bioassays. The peer-reviewed Hazardous Substances Data Bank now contains over 5000 records on individual chemicals. During the past year, section staff prepared and updated 1200 of these records which present a detailed profile of each substance. These resources, along with others, were used by the section staff for preparation of numerous hazard assessments and review documents in related areas for EPA and the Army.

A further application of these resources is the development of the computer searchable Materials Safety Data Sheet (MSDS) Database. With support from Martin Marietta Energy Systems, Inc., the database has been developed to inform employees at the Energy Systems facilities of hazardous materials with which they may come in contact. This was a critical factor in bringing Energy Systems into compliance with the Occupational Safety and Health Administration (OSHA) Hazard Communication Standard. The overriding need for high-quality health hazard data was the major factor in deciding to use the resources of the section, rather than the commercially available systems or chemical manufacturer's information. The work has now expanded to provide MSDS information to the Army, the Navy, the DOE Toxic Materials Advisory Committee, the Pittsburgh Energy Technology Center, and the Lawrence Livermore National Laboratory.

A new database is being constructed for the EPA Health and Environmental Research Laboratory in Cincinnati, Ohio. The database, which has been titled the Chemical Unit Risk Estimate (CURE), will contain all risk related values used by EPA, and will become the central data resource for carrying out EPA risk assessments.

In the energy and environmental areas, work has continued on development of computerized databases in support of hazardous waste management, transportation, disposal, and remedial actions. Additionally, the staff has participated in radiological

surveys of contaminated sites and has prepared numerous Remedial Actions Survey Assessment reports. Collaboration with other laboratory organizations includes acid deposition research and environmental regulation and compliance evaluation for DOE and DOD facilities with the Environmental Sciences Division; conservation and materials research with the Metals and Ceramics Division ; and fossil energy with the Fossil Energy Technology Environmental Program. In conjunction with the latter effort, a flexible information management system has been developed using the INQUIRE database management system. Features developed have proved transportable to other subject areas.

A relatively new initiative involves computer hardware and software evaluation and further development of data management systems for DOE and DOD. This type of effort was initiated in FY 1986 and should continue to grow in the coming years. Spinoffs from this work will provide benefits to several other section projects including the planned Human Genome Management Information system.

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[1]Part-time employee.
[2]Biology Division.

CHEMICAL HAZARD EVALUATION

Under various environmental regulations, such as the Toxic Substances Control Act (TSCA); Clean Air Act; Safe Drinking Water Act; Comprehensive Environmental Response, Compensation, and Liability Act of 1980 [CERCLA ("Superfund")]; and Superfund Amendment and Reauthorization Act of 1986 (SARA), federal and state governments are charged by Congressional mandate with protecting public health and preserving environmental quality. The staff members of the Chemical Hazard Evaluation Project (CHEP) have assisted the EPA, the Agency for Toxic Substances and Disease Registry (ATSDR), the Army, and the states of New York and Tennessee in developing scientific documents and technical reviews on chemicals potentially subject to these and other regulations. These reports facilitate the decision-making process of establishing permissible toxic levels for chemical regulation. Types of reports include: Toxicological Profiles, Chemical Hazard Information Profiles, Chemical Hazard Assessments, Tier-I Health Assessment Reports, Water Quality Criteria Documents, Reference Dose Profiles (oral and inhalation), Reportable Quantity Profiles, Air and Water Quality Standards,

Methodology Development for Occupational Health Criteria, and Problem Definition Studies.

In support of the Army's Installation Restoration Program (IRP), CHEP staff members are assisting the U.S. Toxic and Hazardous Materials Agency by providing guidance on scientific and regulatory issues and in defining cleanup criteria for hazardous waste sites. The Army has numerous waste sites that must be remediated in accordance with certain EPA policies and guidelines. CHEP scientists are using their knowledge of EPA's regulations and risk assessment strategies to define the necessary criteria.

The Hazardous Substances Data Bank (HSDB), formerly the Toxicology Data Bank, is an online interactive database providing peer-reviewed numeric/textual information on chemicals. The records include compounds that are toxic, produced in large volume, found in waste dumps, and/or have great potential for exposure to large populations. Each unit record has information on 10 categories and up to 145 data attributes. The end product is a "mini-encyclopedia" of useful data available to citizens, researchers, industry and government agencies, and international users. This year a total of 1200 records have been prepared and updated.

The CURE database is a research tool to be used by EPA scientists in the headquarters and regional offices supporting risk assessments of chemicals/mixtures. The database is composed of a series of subfiles which will contain the data pertinent for risk assessment [Q1*, NOEL, NOAEL, LOEL, LOAEL, ADI, RfD (oral), RfD (inhalation), DWEL, Hazard Ranking, and others] and derivation of estimated human cancer risk levels. The CURE files provide online interactive information in a variety of formats to meet the various EPA programmatic office needs as mandated by CERCLA/SARA. Phase-I activity, in file design and subfiles implementation, was completed in August 1988. Phase II activity, which includes (1) user friendly search script design (projected completion December 1988) and (2) data validation (projected completion December 1989), will allow limited access by a small group of EPA users to the completed subfiles.

With the promulgation of the Hazard Communication Standard by OSHA and SARA, Title III, 14 million workers at more than 320,000 manufacturing facilities and private citizens were given the right to obtain chemical safety information about the hazardous chemicals in their surroundings. To assist Energy Systems in complying with the law, CHEP has developed an online, interactive retrieval system for Material Safety Data Sheets (MSDS). Data contents of MSDS come from ORNL in-house peer-reviewed databases (HSDB and Gene-Tox) and handbooks, as well as MSDS sheets from

manufacturers/distributors. High data quality is assured by having an external peer-review committee assure information content and provide input on current practices in "real world" situations. The menu-driven system uses the INQUIRE database management system which resides on the IBM 3033. The system can be accessed through TSO on-site or off-site and is available to all Energy Systems' employees and Toxic Material Advisory Committee members/DOE. Currently, the database contains information on 2180 pure chemicals and 2824 trade name products. This project has expanded to assist the Air Force, Army, and Navy in implementation of their hazard communication programs.

ENERGY INFORMATION ANALYSIS

The environmental regulations and compliance work in support of DOE and DOD has expanded by adding state regulations, site-specific regulatory evaluations under CERCLA, and environmental auditing. An assessment of the state air and water regulations pertaining to coal-burning power plants for military bases was completed, and a program to conduct site-specific evaluations of Applicable or Relevant and Appropriate Regulations (ARARs) under CERCLA for the Army has been initiated. Staff participated in several environmental auditing teams for DOD sites and completed the Natural and Historic Resources Management audit for three Space Command Air Force sites, as well as the Spill Prevention and Countermeasures Plan and the Oil Spill Pollution Contingency Plan for five Air Force sites. Related to this work, we have proposed and initiated a desktop publishing capability to enhance, improve, and make more efficient the preparation of printed information resources for several programs.

The Fossil Energy Environmental, Health, and Safety Information System is an online, menu-driven database containing data on chemical emissions and health data of emerging coal conversion technologies that are of interest to DOE. Recent efforts have centered on environmental and permitting requirements for DOE's Great Plains Coal Gasification Plant. The inclusion of gasification, shale oil, enhanced oil recovery, integrated combined cycle technologies, and the publication of documentation reports and presentations signal the maturation of this information product for use by DOE, its contractors, and industry.

A program to provide to the Pittsburgh Energy Technology Center (PETC) technical support in developing occupational safety and health programs for PETC and its subcontractors has started. This includes a project to develop an information system that could provide MSDS in a relational VAX computing environment. The database design

was implemented using ORACLE, C programming for manipulation of large text fields, and standard query language (SQL).

A research program addressing the human health issues in chemical exposure and risk assessment has continued. As part of the ORNL task force, staff contributed to the programmatic environmental impact statement for the chemical stockpile disposal program of the Army. Manuscripts on DNA adduct formation by target chemicals and radon's contribution to indoor air pollution have been prepared.

A multifaceted project with the DOE national program for energy conversion and utilization technology was initiated. All scientific, technical, and management information aspects are covered. In addition, the responsibility for the technical management of the lightweight materials (polymers) part of the program has been undertaken. Communication of developments in ceramic technology for advanced heat engines to over one thousand U.S. and foreign interested persons is being accomplished through the *Ceramic Technology Newsletter*. New computer technologies were applied to this project, and the coverage was expanded significantly.

A comprehensive inventory of federal and state supported research on acid deposition has been developed and maintained for the National Acid Precipitation Assessment Program (NAPAP), a twelve-government agency organization. New front-end interfaces were developed for the online computer users of the information and a separate database of principal investigators and project officers within NAPAP was developed in the INQUIRE database management system. This multiyear program was completed and records were archived during this reporting period.

For the National Atmospheric and Oceanic Administration, an inventory was completed of research sponsored by states, regions, or other nonfederal sources and relevant to marine pollution research, development, and monitoring on the West Coast. In support of the DOE Biomass Production Program, a comprehensive dataset of ten-year research results was completed. It is a key tool in assessing the potential energy that could be gained from woody crops and in enhancing that production through biomass enhancement techniques and crop management emphases. A biomass reference system was designed to provide online access to relevant information from the literature. For the Feed Materials Production Center at Fernald, Ohio, which processes uranium for DOE, a tracking system was developed for their environmental, health, and safety projects. Additionally, support was provided for Department of Transportation efforts to survey off-highway use of gasoline in the United States.

ENVIRONMENTAL INFORMATION ANALYSIS

In the Nuclear Facility Decommissioning and Site Remedial Actions area, a focal point has been established for technical information exchange among participants in DOE's Remedial Act on Program. Significant accomplishments for this activity include: building a database on 995 documents for the program and responding to 1477 requests for assistance from program staff and contractors. An information management activity has also been established for the ORNL Remedial Action Program including two databases: (1) a bibliographic database that contains all reports generated by program staff and (2) a records control database that contains all program documentation. An information transfer activity has also been developed for the RI/FS project. Additionally, technical information analysis and evaluation are provided for radioactive waste management activities at ORNL. An online data management system was developed to support site characterization and site selection activities. The data system is used as a resource in the preparation of analytical and evaluative reports related to a proposed high-level radioactive waste repository.

Technical information support is also being provided to the Nuclear Regulatory Commission Office of Nuclear Material Safety and Safeguards to assist in its effort to approve licensing of a geological repository for high-level radioactive waste and spent fuel. To support these activities, a computerized data management system was developed for selected geological, geochemical, petrological, and hydrological data on the candidate repository sites.

For the past 15 years, the group has been part of a multidisciplinary research team studying the ecology of transuranics in the desert environment of the Nevada Test Site. This year, studies were in the area of analysis of methods used to clean up and to treat radioactively contaminated sites. An ORNL report has been completed and a journal article is in progress.

In collaboration with the Environmental Measurements and Applications Section, site surveys have been conducted for both the FUSRAP and the UMTRA Project. Group members analyzed radiological data and wrote assessment reports on potentially radiologically contaminated sites.

Staff members are assisting the Navy with projects-related information analysis and computing. A personal computer-based Engineering Approval Tracking System has been designed to meet the needs of major acquisition programs where approval status is crucial. This system, designed for the Airborne Self Protection Jammer Program, automates, accelerates, and increases the accuracy of tracking approvals. For another Navy project,

information architecture studies are under way. Organizational goals and objectives have been identified, analyzed, and defined as individual data items, and the role of these items in the information system has been determined.

ENVIRONMENTAL MUTAGEN, CARCINOGEN, AND TERATOGEN INFORMATION

Three thousand papers from the published worldwide literature on genetic toxicology were collected and analyzed during FY 1988. These included papers on mutagenesis and related areas such as the effects of chemicals on DNA synthesis, DNA and synthetic polynucleotides, the processes of mitosis and meiosis, and reproduction. The information extracted from these papers was entered into the Environmental Mutagen Information Center's (EMIC) searchable database and made available to persons in research, government agencies, and medical or educational institutions. These additions brought the center's record holdings to over 67,299. Each record processed contains both bibliographic data and a wide range of technical data allowing investigators to search according to specific research interests. The following types of information are indexed and entered in the EMIC database: (1) taxonomic, common name, strain, cell line, and sex of text object, (2) genetic end point examined in either germ or somatic cells, (3) assay system employed, (4) inducers used in metabolic activation studies, (5) chemical names or abbreviations of agents tested, (6) chemical abstracts service registry number(s) of agents tested, (7) keywords involved, and (8) text abstracts (added on a selected basis).

This indexing scheme provides more complete and more readily accessible information than is possible with conventional text abstracting plus the flexibility to respond to the needs of our users. As of September 30, 1988, the file contained information on more than 20,808 unique chemicals (plus about 2500 unknowns).

The EMIC database is accessible online through the National Library of Medicine's TOXLINE system. In addition to requesters' use of EMIC's online files, the EMIC staff responded to 900 information requests made directly to the center during FY 1988.

The information file for teratology, reproductive toxicology, and developmental toxicology is maintained by Environmental Teratology Information Center (ETIC). Information in the ETIC database is obtained from reports in the open literature relating to the testing of chemical, biological, and physical agents in animals for teratogenic, reproductive, or developmental effects. The main focus is on the administration of an agent

to a pregnant animal and examination of the offspring at or near birth for structural or functional anomalies.

As of September 30, 1988, the ETIC file contained 46,199 (3505 added in FY 1988) entries from 3803 sources, approximately 16% of which are in languages other than English. There is information on approximately 9000 unique chemicals. The database contains both bibliographic and technical information which is indexed so that the file may be searched in a variety of ways according to the needs of its users. The types of information include: (1) taxonomic and common name and strain of text object, (2) organ type or embryo cultured, (3) end point examined in offspring, (4) chemical names or abbreviations, (5) Chemical Abstracts Service registry number(s), (6) text abstracts (added only on a selective basis), (7) stage treated in cold-blooded and invertebrate animals, and (8) sex treated. This method of indexing is thorough, flexible, easily searchable, and facilitates adding new fields as the need arises.

Work with the EPA on the Gene-Tox Program continued. The objective of Gene-Tox is to conduct a systematic review, analysis, and evaluation of the genetic toxicology literature and to establish a registry of test results for chemicals evaluated in selected short-term bioassays. The Gene-Tox Program was initiated in 1979 and to date has accumulated a peer-reviewed registry of test results on 4400 chemicals (1080 added in FY 1988). A software system called CHEMBASE was acquired for the entry of the structures of the chemicals evaluated by Gene-Tox. The resultant file, managed on an IBM personal computer, contains structures on 3700 chemicals and will be used to conduct structure-activity relationship studies. A total of three papers have been published as part of the Gene-Tox Program during FY 1988, and this number brings to 41 the total number of papers published by Gene-Tox since 1979.

Work was initiated with EPA's Health Effects Research Laboratory (HERL) at Research Triangle Park, North Carolina, in the development of computer programs that graph the genotoxic and teratogenic activity of chemicals as a function of dose within a specific assay or assay group as well as by end point. These profiles provide a quick and easy means to ascertain or depict the activity of a specific chemical. Profiles on the genotoxicity of over 80 Superfund chemicals have been completed.

INFORMATION SCIENCES AND OPERATIONS OFFICE

The Information Sciences and Operations Office has installed a MicroVAX II workstation and Local Area VAX cluster software to the VAX 11/785 computer located in

the IR&A computer room in Building 2001. Long-range plans for this cluster are to add additional workstations to distribute the computing load based on type of application. Software additions to the cluster include adding the ORACLE relational database management system to the MicroVAX II, adding TEX typesetting software to the 11/785, and adding FOCUS fourth-generation language software to both the 11/785 and the MicroVAX II.

A coaxial cable, personal computer (PC)-based local area network (LAN) was also installed in 2001. Long-range plans include installation of additional thin-wire Ethernet LANs among our work groups. The network version of FOCUS was also installed on the PC-LAN. Approximately 20 PCs including 3 lap-tops were purchased, as well as a liquid crystal display device to use with an overhead viewer that projects an image of the PC screen.

6. OFFICE OF RISK ANALYSIS

C. C. Travis, Coordinator

The Office of Risk Analysis (ORA) was organized to assist in the coordination of risk-related activities at ORNL. The office is involved in a variety of risk-related activities ranging from development of theoretical models to actual field work characterizing risk at hazardous waste sites.

For the EPA, ORA is evaluating the use of pharmacokinetic models in risk assessment. ORA has developed pharmacokinetic models in mice, rats, and humans for tetrachloroethylene, methylene chloride, methyl chloroform, and benzene. The ability of physiologically based pharmacokinetic models to extrapolate between species provides a major tool for improving the estimation of human cancer risk based on animal cancer bioassays. ORA is also evaluating the use of pharmacodynamic models in the risk assessment process. These models relate fundamental cellular processes to the epidemiology of cancer in animal and human populations. They are based on the assumption that cancer is a two-stage process and incorporate data on genetic mutation frequencies and cell turnover dynamics. These models appear to have excellent possibilities of producing more realistic estimates of risk associated with hazardous substances. For DOE, the ORA is evaluating rapid methods for prioritizing chemicals with respect to their potential threat to human health. Attributes of these methods are that they provide estimates of the potential human toxicity of organic chemicals for which little toxicological data exist, and they work equally well for carcinogens and noncarcinogens. ORA is also performing health evaluations at hazardous waste sites throughout the United

7. CONTRIBUTIONS TO NATIONAL AND LEAD LABORATORY PROGRAMS AND ASSIGNMENTS

CHEMICAL HAZARDOUS WASTE AND RADIOACTIVE WASTE MANAGEMENT PROGRAMS

R. B. Gammage and D. C. Kocher

An intersectional effort was initiated three years ago to promote HASRD's entry into chemical hazardous waste programs. There are three principal tasks and objectives of the chemical hazardous waste initiative. The first objective is to couple the products of basic and applied research with field surveying. This is a cross-fertilization exercise for ensuring that field activities are conducted with devices and techniques that are cutting-edge, state-of-the-art. The second objective is to identify and fill niches whose needs are not being adequately met by others. Thirdly, there is the task of prioritizing proposals and coordinating tasks that involve different research groups and sections.

The newly formed Measurement Systems Research Group is helping the Pollutant Assessments and the Measurement Applications and Development groups of the Environmental Measurements and Applications Section realize the first objective. A good example is the codevelopment and application of the USRADS for radiological and now heavy-metal field surveying. Transfer of formaldehyde experience and personnel from the indoor air quality program has also been directly valuable in field studies of formaldehyde in the drinking water at a Navy housing site.

An unfilled niche well suited to address by HASRD researchers is remote sensing of chemical pollutants by fiberoptic and laser devices. Director's R&D funding is in its second year to develop portable fiberoptic devices employing lasers and surface-enhanced Raman scattering as the spectroscopic measurement technique. This large project involves a cooperative and coordinated effort among three groups in three sections of HASRD. Other fiberoptic devices under development involve techniques of derivative ultraviolet-absorption, fluorescence, and light-scattering from suspended colloidal particles. Each of these sensors will have applications in the down-well monitoring of groundwater poliutants and their movement.

The hazardous waste remedial action program (HAZWRAP) managed in Oak Ridge is having major impacts on the division's chemical hazardous waste initiative. There is

direct involvement in large projects such as the Air Force Installation Restoration Program and the Navy Radon Assessments and Mitigation Program. We have helped to identify and provide personnel suitable for setting up fledgling programs such as the AIRHAS component of HAZWRAP which addresses indoor environmental quality in federal facilities. Our initiative also has assisted in prioritizing ideas and field task proposals for an orderly and effective response to solicitations from HAZWRAP for R&D proposals.

The Metabolism and Dosimetry Research Group has been involved in two major projects within the laboratory's radioactive waste management program. In the first project, which was supported by DOE's Defense Programs and involved a cooperative effort with the Chemical Technology Division, a new system for classifying radioactive wastes was developed. Definitions for high-level waste, transuranic waste and equivalent, and low-level waste were proposed which are quantitative, generally applicable to any radioactive waste regardless of its source, and based on considerations of risks to radiation workers and the public from waste management and disposal. The proposed waste classification system permits an unambiguous identification of all radioactive wastes on the basis of concentrations of radionuclides. This work has provided a technical basis for the DOE's responses to proposed NRC rulemakings on the definition of high-level waste and on requirements for disposal of low-level wastes that are not generally acceptable for near-surface land disposal. In the second project, the group has continued to support the laboratory's Remedial Action Program by developing a proposed regulatory framework for evaluating the need for and acceptability of remedial actions at radioactively contaminated sites, which includes criteria for limitation of radiation dose to off-site individuals and to inadvertent intruders who may receive radiation exposure following loss of active institutional controls, and developing realistic exposure scenarios and dose assessment models for inadvertent intruders at contaminated sites on the Oak Ridge Reservation, which could be applied to a variety of conditions of disposal and environmental contamination.

APPENDICES

APPENDIX A. SOURCES OF FUNDING

	FY 1987 ($K)	FY
DEPARTMENT OF ENERGY		
Remedial Action and Waste Technology	$ 6,521	$ 5,585
Environmental Research and Development	4,769	5,617
Electric Energy Systems	494	590
Defense Waste and Environmental Restoration	152	
Magnetic Fusion	115	64
Multiprogram - Facilities Support	229	444
Administrative Services	113	24
Fossil Energy - Coal		289
Solar Energy		85
Transportation		30
Multi-Sector		81
DEPARTMENT OF DEFENSE		
Air Force (including HAZWRAP)	598	1,584
Navy (including DSRD)	321	525
Army	290	436
National Security Agency	143	86
Defense Nuclear Agency	172	328
OTHER FEDERAL AGENCIES		
Environmental Protection Agency	1,244	2,358
Consumer Products Safety Commission	254	69
Nuclear Regulatory Commission	119	133
National Institutes of Health		
National Heart, Lung and Blood Institute	198	305
National Institute of General Medical Sciences	34	160
National Institute of Environmental Health Sciences		343
National Cancer Institute		126
National Science Foundation	24	40
National Library of Medicine		1,032

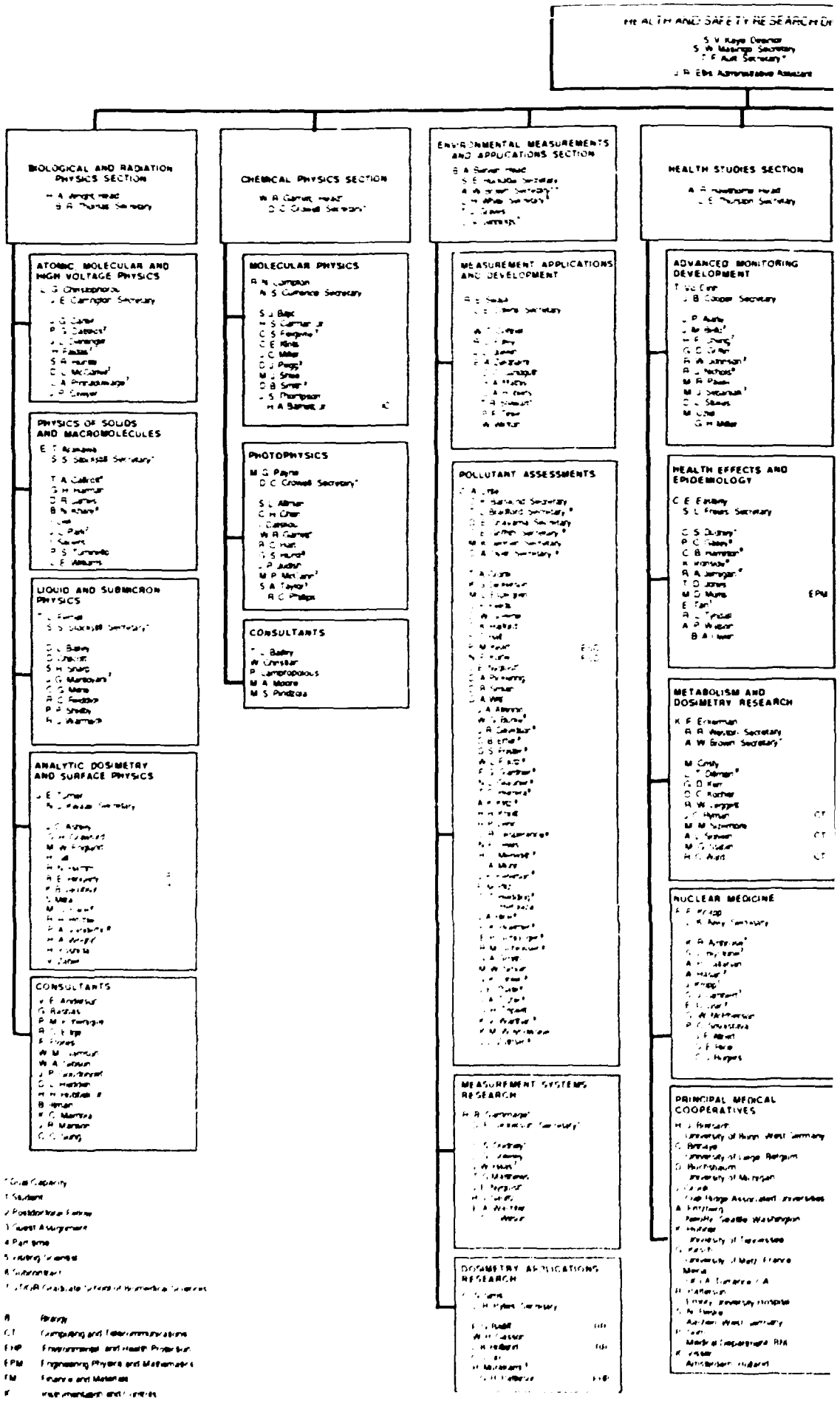
Agency for Toxic Substances and Disease Registry		301
Tennessee Valley Authority		91
Department of Treasury		53
Office of the Inspector Generai		30
OTHER DOE		
Battelle Pacific Northwest Laboratory	92	138
Lawrence Livermore National Laboratory	30	21
Westinghouse Materials Corporation	88	12
Bechtel	75	
Sandia National Laboratory		41
Bendix		297
Y-12	532	513
K-25		30
ORO	9	
PRIVATE, STATE AND LOCAL GOVERNMENT		
Universities		
University of Tennessee	78	115
University of Southern California	130	3
New York University	9	31
Harvard University	24	
University of New Jersey		5
Children's Hospital	94	84
Electric Power Research Institute	63	36
Alabama Power Company	50	
Tetra Tech	25	
National Academy of Sciences	146	
American Petroleum Institute		72
TOTAL Division	$ 17,235	$ 22,207

*Includes addition of the Information Research and Analysis Section to the Health and Safety Research Division effective October 1, 1987.

APPENDIX B. PERSONNEL SUMMARY

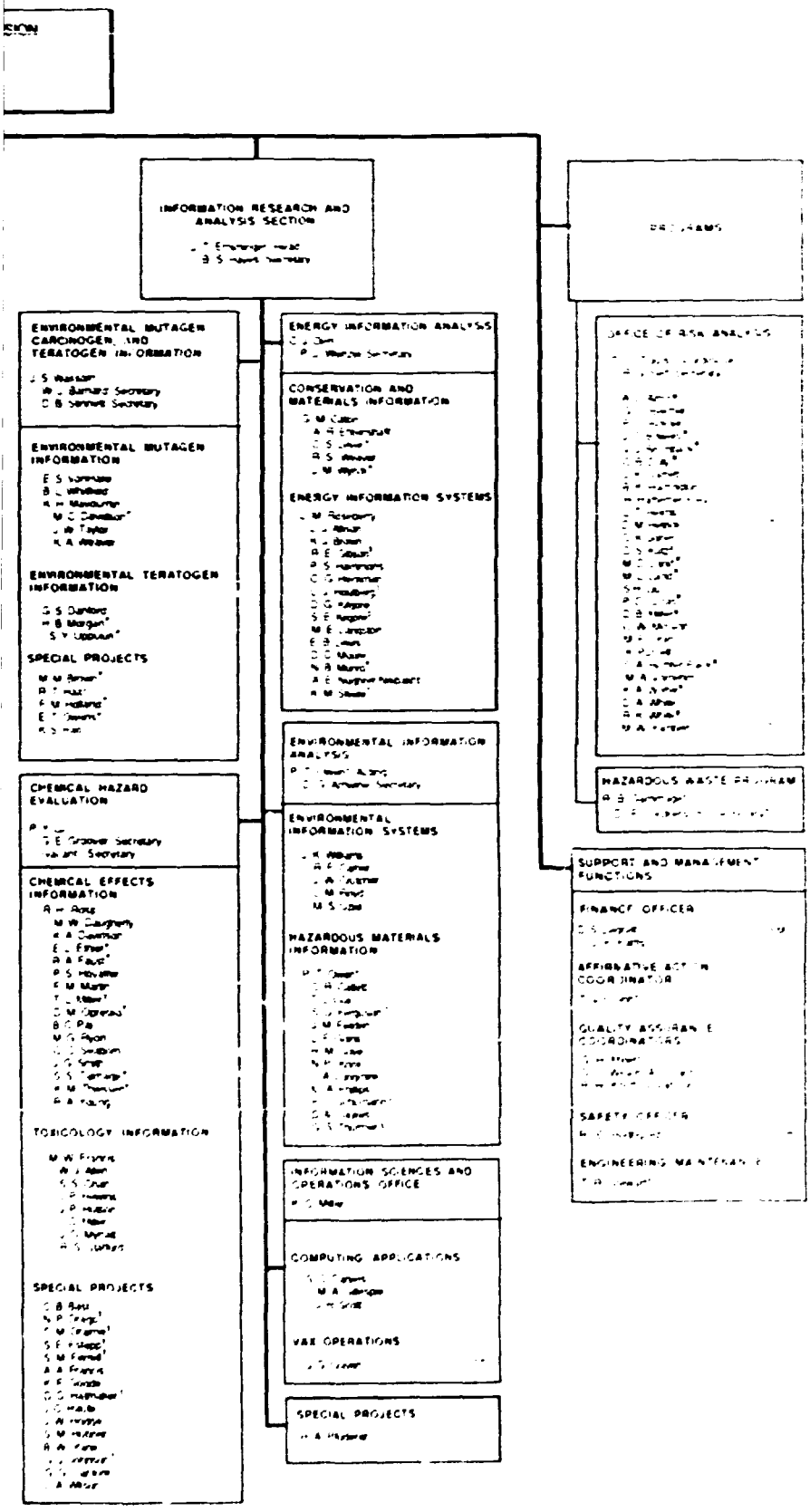
	Professional	Technical Support	Administrative Support	Total
Permanent	103	35	24	162
Temporary	11	10	4	25
Part-time	14	1	4	19
Leave of absence	1	0	0	1
Off-site assignment	1	2	0	3
Division-supported loanees	18	3	0	21

Many types of employees are required to run the division effectively and efficiently. Several sources are used to staff the division to maintain the high standards. During this reporting period, we have had a total of 325 assignments to the division in the following categories: consultants; subcontractors; guests from universities; visiting scientists from other laboratories as well as private companies; postdoctoral fellows; and students who come to us under several different programs. Assignment terms vary in duration from a few months to a year or more. We view this as a very economical way to bring different and diversified talents to the division.



Guest Scientist
Student
Postdoctoral Fellow
Guest Assignment
Part time
Visiting Scientist
Subcontract
Graduate Student in Biomedical Sciences

A	Atomic
CT	Computing and Telecommunications
EHP	Environmental and Health Protection
EPM	Engineering Physics and Mathematics
FM	Fusion and Materials
IF	Instrumentation and Controls
HH	Research Reactors


INFORMATION RESEARCH AND ANALYSIS SECTION
ENVIRONMENTAL MUTAGEN CARCINOGEN, AND TERATOGEN INFORMATION
ENVIRONMENTAL MUTAGEN INFORMATION
ENVIRONMENTAL TERATOGEN INFORMATION
SPECIAL PROJECTS
CHEMICAL HAZARD EVALUATION
CHEMICAL EFFECTS INFORMATION
TOXICOLOGY INFORMATION
SPECIAL PROJECTS
ENERGY INFORMATION ANALYSIS
CONSERVATION AND MATERIALS INFORMATION
ENERGY INFORMATION SYSTEMS
ENVIRONMENTAL INFORMATION ANALYSIS
ENVIRONMENTAL INFORMATION SYSTEMS
HAZARDOUS MATERIALS INFORMATION
INFORMATION SCIENCES AND OPERATIONS OFFICE
COMPUTING APPLICATIONS
VAX OPERATIONS
SPECIAL PROJECTS
OFFICE OF RISK ANALYSIS
HAZARDOUS WASTE PROGRAM
SUPPORT AND MANAGEMENT FUNCTIONS
FINANCE OFFICER
AFFIRMATIVE ACTION COORDINATOR
QUALITY ASSURANCE COORDINATOR
SAFETY OFFICER
ENGINEERING MANAGEMENT

APPENDIX D. SEMINAR PROGRAM

P. C. Srivastava

The coordinator of the Health and Safety Research Division's seminar program works with division staff to identify distinguished seminar speakers from various disciplines of research interest to the division.

During the period April 1, 1987, through September 30, 1988, the Health and Safety Research Division has hosted 14 seminar speakers representing industry, research institutions, and universities. The following is a list of the seminar speakers and their topics.

I. Winkelmann

Institute for Radiation Hygiene, Federal Health Office, Neuherberg, West Germany, "Fallout Measurements in the Federal Republic of Germany after the Chernobyl Accident," April 15, 1987.

Kenneth Black

Department of Geology, Southern Illinois University, Carbondale, Illinois, "The Geological Factors Influencing Indoor Radon Levels," August 7, 1987.

Larry L. Cole

Department of Chemistry, Prairie View A&M University, DOE-OHER Faculty Research Participant, Health and Safety Research Division, "The Chemistry of Carbon from 100°C to Graphitization Temperatures," August 19, 1987.

Albert P. Li

Section Head, Cellular and Genetic Toxicology, Environmental Health Laboratory, Monsanto Company, St. Louis, Missouri, "Present Status of the Use of Short-Term Tests in the Evaluation of Chemical Carcinogenicity," October 9, 1987.

Richard P. Van Duyne

Department of Chemistry, Northwestern University, Evanston, Illinois, "Surface Enhanced Raman Scattering," October 13, 1987.

Henry C. Pitot

McArdle Laboratory for Cancer Research, University of Wisconsin, Madison, Wisconsin, "Quantitative Studies of the Stages of Initiation, Promotion, and Progression in Hepatocarcinogenesis in the Rat," December 17, 1987.

Christian Betzel

European Molecular Biology Laboratory, DESY, Hamburg, West Germany, "Structure of the Enzyme Proteinase K at High Resolution Using Synchrotron Radiation," January 19, 1988.

Gary Stein

Centers for Disease Control, Atlanta, Georgia, "Disease Surveillance by the Centers for Disease Control," February 25, 1988.

Richard Irons

CIIT, Research Triangle Park, North Carolina, "Benzene and 1,3-Butadiene; Comparing and Contrasting Potentially Different Mechanisms of Leukemogenesis," May 27, 1988.

William H. Farland

USEPA, Washington, D.C., "Future Directions of Risk Assessment at the U.S. EPA," June 22, 1988.

Joe W. Grisham

Department of Pathology, University of North Carolina, Chapel Hill, North Carolina, "Clonal Analysis of Tumorigenicity and Paratumorigenic Phenotypes and Genotypes in Cultured Hepatic Epithelial Cells," July 27, 1988.

William D. Nichols

Clemson University, Clemson, South Carolina, "Mercury Mobilization in a Newly-Impounded Reservoir," August 4, 1988.

G. M. Williams

Division of Pathology and Toxicology, American Health Foundation, Valhalla, New York, "Risk Assessment of Chemical Carcinogens Based on Mechanism of Action," August 16, 1988.

Michael J. Schlosser

Thomas Jefferson University, Philadelphia, Pennsylvania, "A Role for Prostaglandin Synthase in Benzene Toxicity," August 22, 1988.

APPENDIX E. LIST OF HONORS AND AWARDS FOR STAFF MEMBERS

SPECIAL HONORS

K. C. Miller

Received recognition at the President's Luncheon as a project team member of the Performance Improvement Process Project entitled "Relocation of Biology Division Computer Facilities"

P. C. Srivastava

Chosen to serve as a member of the Developmental Therapeutics Contracts Review Committee, National Cancer Institute, funded by a Scientific Review and Evaluation Award. This committee is advisory to the Institute Director, with primary responsibility for the Division of Cancer Treatment. His term will be from July 1, 1988 to June 30, 1992

P. C. Srivastava

Recipient of the United Nations Development Distinguished Scientist Award. Invited by the Council of Scientific and Industrial Research (CSIR) to participate in the Transfer of Knowledge Through Expatriate Nationals (TOKTEN) Project in India for a period of eight weeks beginning in November 1987

T. Vo-Dinh

Recipient of the New York Society for Applied Spectroscopy (SAS) Gold Medal Award

I·R 100 AWARDS

T. Vo-Dinh, M. J. Sepaniak, B. J. Tromberg, G. D. Griffin, and K. R. Ambrose, "Fiber-Optics Fluoroimmuno Sensor"

C-H. Chen, S. D Kramer, and M. P. McCann
"Crystal Laser Monitor"

SPECIAL AWARDS

S. R. Hunter and Loucas G. Christophorou

Martin Marietta Energy Systems 1987 Inventor Award for development of gas mixtures that possess temperature-enhanced glow discharge characteristics for use in repetitive pulsed-power closing switches.

C. E. Klots
Health and Safety Research Division Excellence in Research Award for 1987

J. E. Turner
Corporate Fellow, 1988

PUBLICATION AWARDS

L. G. Christophorou, S. R. Hunter, L. A. Pinnaduwage, J. G. Carter, A. Christodoulides, and S. M. Spyrou
Martin Marietta Energy Systems 1987 Publications Award for "Optically Enhanced Electron Attachment"

R. E. Swaja and S. Yeh (Institute of Nuclear Energy Research)
Recipients of Editor's Award from Radiation Protection Management for their paper entitled "Potential Problems with Using Sphere Ratios to Determine Neutron Albedo Dosimetry Correction Factors"

Sylvia S. Talmage
Recipient of a second place award from the Society of Environmental Toxicology and Chemistry (SETAC) for her presentation at the annual meeting entitled, "Small Mammals as Monitors of Environmental Contaminants"

T. Vo-Dinh, B. J. Tromberg, G. D. Griffin, K. R. Ambrose, M. J. Sepaniak, and E. M. Gardenhire
Martin Marietta Energy Systems 1987 Publications Award for "Antibody-Based Fiberoptics Biosensor for the Carcinogen Benzo(a)pyrene"

COMMITTEE APPOINTMENTS

E. T. Arakawa
Member, International Advisory Board, Vacuum Ultraviolet Radiation Physics Group, 1986 - 1989

B. A. Berven
Chairman, Environmental Section of the Health Physics Society Standards Committee, 1985 - present

R. N. Compton
Member, Executive Committee, Atomic, Molecular, and Optical Physics Division, American Physical Society, 1983 - 1986

Member, Executive Committee, Division of Electron and Atomic Physics, American Physical Society, 1984 - 1987

M. Cristy

Member, Task Group on Dose Calculations, Committee 2 on Secondary Limits, International Commission on Radiological Protection, 1985 - present

Vice-chairman, Task Group on Revision of Reference Man, Committee 2 on Secondary Limits, International Commission on Radiological Protection, 1985 - present

C. E. Easterly

Member, Electromagnetics Subpanel of the Free-Electron Hazards Advisory Panel, U.S. Army Environmental Hygiene Agency, 1988 - present

K. F. Eckerman

Member, Task Group on Modeling and Scaling to Humans, DOE, 1985 - present

Member, Committee 2 on Secondary Limits, International Commission on Radiological Protection, 1982 - present

Chairman, Task Group on Dose Calculations, Committee 2 on Secondary Limits, International Commission on Radiological Protection, 1982 - present

Member, Scientific Committee 57, Internal Emitter Standards, National Council on Radiation Protection and Measurements, 1979 - present

Member, Scientific Committee 64, Task Group 5, Public Exposure from Nuclear Power, National Council on Radiation Protection and Measurements, 1979 - present

Member, Scientific Committee 64, Task Group 6, Screening Models, National Council on Radiation Protection and Measurements, 1979 - present

Member, ASTM Committee 10-E on Nuclear Technology and Applications Subcommittee on Radiation Risk, 1984 - present

Member, Advisory Group, Health Effects Model Revision, Nuclear Regulatory Commission, 1980 - present

D. E. Fields

Member, Executive Committee, Tennessee Academy of Science, 1986 - 1988

R. B. Gammage

Chairman, Indoor Air Quality Committee, American Industrial Hygiene Association, 1987 - 1988

Member, Workplace Environmental Exposure Level Committee, American Industrial Hygiene Association, 1982 - 1988

G. D. Kerr

Member, Task Group on Revision of Reference Man, Committee 2 on Secondary Limits, International Commission on Radiological Protection, 1985 - present

Member, Ad Hoc Committee on Neutron Quality Factors, DOE, 1987

Member, DOE working group on Reassessment of A-bomb radiation dosimetry in Hiroshima and Nagasaki, 1982 - present

Member, ANSI/ANS Standards Committee on Neutron and Gamma-Ray Fluence-to-Dose Factors, 1985 - present

Member, NRC Health Physics Research Overview Committee, 1988 - present

D. C. Kocher
Member, Standards Committee, Health Physics Society, 1987 -

R. W. Leggett
Member, Task Group on Dose Calculations, Committee 2 on Secondary Limits, International Commission on Radiological Protection, 1985 - present

C. A. Little
Chairman, Public Information Committee, Environmental Radiation Section, Health Physics Society, 1988 -

Member, DOE Division of Remedial Action Programs Ad Hoc Committee on Hazardous and Mixed Wastes, 1987 - present

Member, DOE Division of Remedial Action Programs Ad Hoc Committee on Property Verification and Certification, 1987

P. Y. Lu
Member, National Safety Council, Executive Committee Chemical Section, 1985 - present

C. J. Oen
Member, Advisory Committee on Continuing Education, University of Tennessee, 1984 - present

Vice-chairman, Sponsors' Committee, WATTec 89, 1988 - 1989

Member, WATTEC 89 Executive Committee, 1988 - 1989

R. H. Ritchie
Member, Executive Council, Southeastern Section, American Physical Society, 1986 - present

I. Sauers
Subcommittee Chairman, IEEE Gaseous Dielectrics Committee S-32-11, 1986 - present

C. S. Sims
Chairman, Technical Committee on Procedures and Data for the Intercomparison of Personnel Dosimeters, IAEA, 1984 - present

Chairman, Technical Committee on Assessment of Occupational Exposure to External Radiation for Monitoring Purposes, IAEA, 1985 - present

Chairman, ANSI N13.11 Review Working Group, Health Physics Society, 1987 - present

R. E. Swaja

Member, ANSI N319 Committee on Personnel Neutron Dosimetry, Health Physics Society, 1986 - present

Chairman, ASTM E10.04 Committee on Criticality Accident Dosimetry, 1986 - present

C. C. Travis

Chairman, Scientific Bases for Risk Assessment Assumptions, Office of Science and Technology Policy, 1986 - present

Member, Science Advisory Board, Food and Drug Administration, 1987 - present

Member, Delivered Dose Work Group, American Industrial Health Council, 1987 - present

Member, State of New Jersey Governor's Science Advisory Board on Health and Environmental Issues, 1988 - present

Member, New Jersey State Department of Health Advisory Panel on Superfund Sites, 1988 - present

Member, State of Maryland Advisory Panel on the Maryland Power Plant Research Program, 1988 - present

J. E. Turner

Member, Comprehensive Certification Panel of Examiners, American Board of Health Physics, 1987 - present

Member, RERF Advisory Dosimetry Subcommittee, National Research Council, 1988 - present

Consociate Member, National Council on Radiation Protection and Measurements, 1983 - present.

T. Vo-Dinh

Co-chairman, International Committee on Polycyclic Aromatic Compounds, 1985 - present

Secretary, Technical Committee TT-6 on Energy-Environmental Interactions, Air Pollution Control Association, 1984 - present

Member, Technical Committee on Indoor Air Quality, American Industrial Hygiene Society, 1984 - present

Chairman, Program Committee, Air Pollution Control Association, East Tennessee Chapter, 1986 - present

E. S. VonHalle
Chairman, Membership Committee, Environmental Mutagen Society, 1986 - present

J. S. Wassom
Chairman, Communication and Archives Committee, Environmental Mutagen Society, 1982 - present

Councilor, Environmental Mutagen Society, 1987 - present

M. G. Yalcintas
Chairman, Organ Dose Committee, Biology and Medicine Division, American Nuclear Society, 1980 - present

Chairman, Program Committee, Biology and and Medicine Division, American Nuclear Society, 1984 - present

JOURNAL ACKNOWLEDGMENTS

K. F. Eckerman
Member, Editorial Board, *Radiation Protection Dosimetry Journal*, 1980 - present

R. N. Hamm
Associate Editor, *Radiation Research*, 1985 - 1989

G. G. Killough
Editor, *Mathematics and Computer Science Journal*, Tennesee Academy of Science, 1984 - present

C. E. Klots
Associate Editor, *Journal of Mass Spectrometry and Ion Physics*, 1983 - present

K. H. Mavournin
Member, Editorial Board, *Environmental and Molecular Mutagenesis*, 1985 - present

C. C. Travis
Editor-in-Chief, *Risk Analysis*, 1983 - present

T. Vo-Dinh
Member, Editorial Board, *Applied Spectroscopy*, 1988 - present

E. S. VonHalle
Member, Editorial Board, *Environmental and Molecular Mutagenesis*, 1980 - present

Member, Editorial Board, *Mutation Research*, 1985 - present

Member, Editorial Board, *Registry of the Toxic Effects of Chemical Substances*, 1984 - present

J. S. Wassom
Member, Board of Managing Editors, *Mutation Research*, 1975 - present

A. P. Watson
Book Review Editor, *Environmental Management*, 1986- present

Member, Editorial Board, *Environmental Management*

J. P. Witherspoon
Editor, Environmental Effects, *Nuclear Safety*, 1983 - present

M. G. Yalcintas
Editor, *Biology and Medicine Division Newsletter*, American Nuclear Society, 1985 - present

UNIVERSITY APPOINTMENTS

T. E. Aldrich
Assistant Professor of Public Health, The University of Tennessee, 1985 -present

Adjunct Professor of Epidemiology, The University of Miami. 1984 - present

Adjunct Professor of Epidemiology, The University of Texas, 1985 - present

Adjunct Professor of Epidemiology, The University of Utah, 1986 - present

E. T. Arakawa
Adjunct Professor of Physics, The University of Tennessee, 1982 - present

L. G. Christophorou
Professor of Physics, The University of Tennessee, 1969 - present

R. N. Compton
Adjunct Professor of Physics, Vanderbilt University, 1983 - present

Professor of Chemistry, The University of Tennessee, 1985 - present

T. L. Ferrell
Professor of Physics, The University of Tennessee, 1979 - present

C. A. Little
Adjunct Professor of Radiology and Radiation Biology, Colorado State University, 1987 - present

J. C. Miller
Professor (part-time) of Chemistry, The University of Tennessee, 1986 - present

R. H. Ritchie
Professor of Physics, The University of Tennessee, 1965 - present

J. E. Turner
Professor of Physics, The University of Tennessee, 1981 - present

Adjunct Professor of Environmental Engineering Sciences, University of Florida, 1986 - 1988

M. Uziel
Professor of Biomedical Sciences (part-time), The University of Tennessee, 1968 - present

T. Vo-Dinh
Professor of Biomedical Sciences (part-time), The University of Tennessee, 1987 - present

R. J. Warmack
Professor of Physics, The University of Tennessee, 1983 - present

J. P. Witherspoon
Professor of Ecology, The University of Tennessee, 1979 - present

M G. Yalcintas
Adjunct Professor of Radiation Biology, Tennessee Technological University, 1985 - present

OTHER

B. A. Berven
Secretary, Oak Ridge Chapter of Sigma Xi, 1988

K. F. Eckerman
Consultant, Sloan-Kettering Memorial Medical Center, 1981 - present

L. M. Hively
Full-time Advisor to Office of Energy Research, Office of Fusion Energy,DOE, 1986 - 1987

S. V. Kaye
Consultant, Environmental Protection Agency Science Advisory Board, 1986 - 1987

Member of the Technical Advisory Committee for Florida Institute of Phosphate Research, 1987

G. D. Kerr

Visiting Scientist, Radiation Effects Research Foundation, Japan, September 1986 - August 1987

Consultant, Radiation Effects Research Foundation, Japan, 1975 - present

R. H. Ritchie

Recipient, NATO Research Grant, 1987 - 1988

Recipient, Research Grant, US-Spain Joint Committee for Scientific and Technological Cooperation, 1988 - 1989

Recipient, Grant from National Science Foundation for US-Japan Collaborative Research, 1988 - 1990

Member, Board of Directors, Pellissippi International, Inc., 1987 - present

C. S. Sims

U.S. Dosimetry Contact for the Joint Standing Committee for Civil Nuclear Cooperation with Taiwan, Republic of China, 1985 - present

C. C. Travis

President, Society for Risk Analysis, East Tennessee Chapter, 1988

T. Vo-Dinh

Elected Fellow, American Institute of Chemists, 1987

A. P. Watson

Member, Admissions Committee, Oak Ridge Chapter of Sigma Xi, 1988 - present

APPENDIX F. PATENTS GRANTED TO STAFF MEMBERS

PATENTS ISSUED

Loucas G. Christophorou and Scott R. Hunter, "Ternary Gas Mixture for Diffuse Discharge Switch," U. S. Patent No. 4,751,428, June 1988

Loucas G. Christophorou and Scott R. Hunter, "Laser Activated Diffuse Discharge Switch," U. S. Patent No. 4,743,807, May 1988

Furn F. Knapp, Jr. and Thomas A. Butler, "Osmium-191/Indium-191m Radionuclide," U.S. Patent No. 4,683,123, July 28, 1987

Furn F. Knapp, Jr., Mark M. Goodman, and Gilbert Kirsch, "Radiolabeled Dimethyl Branched Long Chain Fatty Acid for Heart Imaging," U. S. Patent No. 4,764,358, August 16, 1988

Marvin G. Payne, Norbert Thonnard, and George S. Hurst, "Double Pulsed Time-of-Flight Mass Spectrometer," U.S. Patent No. 4,694,167, September 15, 1987

Prem C. Srivastava, "Radioiodinated Maleimides and Use as Agents for Radiolabeling Antibodies," U. S. Patent No. 4,735,792, April 5, 1988

Prem C. Srivastava and Furn F. Knapp, Jr., "Precursors to Radiopharmaceutical Agents for Tissue Imaging," U. S. Patent No. 4,764,598, August 16, 1988

Tuan Vo-Dinh, "Practical Substrate and Apparatus for Static and Continuous Monitoring by Surface-Enhanced Raman Spectroscopy," U.S. Patent No. 4,674,878, June 23, 1987

PATENT APPLICATIONS

S. R. Hunter and L. G. Christophorou, "Glow Discharge Closing Switches," 1987

L. G. Christophorou and S. R. Hunter, "Binary and Ternary Gas Mixtures with Temperature Enhanced Diffuse Glow Discharge Characteristics for Use in Closing Switches," 1988

P. C. Srivastava, "Radioiodinated Maleimides - Broadened Scope," 1988

INVENTION DISCLOSURES

Chung-Hsuan Chen, Steve L. Allman and Ronald C. Phillips, "Liquid Resonance Ionization Mass Spectrometer (LRIMS)," 1987

C. H. Chen, R. C. Phillips, S. L. Allman, M. G. Payne, and M. P. McCann (UT), "Portable Photoionization Mass Spectrometer," 1988

R. N. Compton, "High Brillance Negative Ion and Neutral Beam Source," 1988

T. L. Ferrell, Mark J. Bloemer (ORAU), and Robert J. Warmack, "Method for Preparing Improved STM Probe Tip," 1987

Thomas L. Ferrell, Mark J. Bloemer, Jean-Pierre Goudonnet, David R. James, and Edward T. Arakawa, "Fiber Optic Substrate for Surface-Enhanced Raman Scattering (SERS)," 1988

T. L. Ferrell, Robert J. Warmack, and Robin C. Reddick, "Photon Scanning-Tunneling Microscope (PSTM)," 1988

M. M. Goodman and F. F. Knapp, Jr., "Radiohalogenated 4,4-DMIPP," 1987

M. M. Goodman and F. F. Knapp, Jr., "Radiohalogenated Thienylethylamine Derivatives for Evaluating Local Cerebral Blood Flow," 1987

D. R. James, I. Sauers, and E. T. Arakawa, "High Energy Particle Beam Profile Monitor," 1987

P. C. Srivastava, "Radioiodinated Maleimides and Use as Agents for Radiolabeling Antibodies," 1987

Tuan Vo-Dinh, "New Substrates for SERS," 1987

Tuan Vo-Dinh, "Fiber Optic Substrate for Surface-Enhanced Raman Scattering (SERS)," 1987

Tuan Vo-Dinh, "Surface-Enhanced Raman Optical Data Storage (SERODS) System," 1988

APPENDIX G. MEETINGS AND CONFERENCES APRIL 1, 1987 - SEPTEMBER 30, 1988

Fifth International Symposium on Gaseous Dielectrics, Knoxville, Tennessee, May 3-7, 1987. Chairperson: L. G. Christophorou. Sponsor: Department of Energy/ Electric Power Research Institute.

Population Exposure, Oak Ridge, Tennessee, September 13-18, 1987. Chairperson: R. O. Chester. Sponsor: American Nuclear Society.

Eighth Life Sciences Symposium - An International Conference on Bioindicators: Exposure and Effects, Knoxville, Tennessee, November 10-12, 1987. Co-Chairmen, Organizing Committee: C. Gehrs, P. J. Walsh, and W. Generoso. Sponsor: Department of Energy/Oak Ridge National Laboratory

11th Werner Brandt Workshop on Charged Particle Penetration Phenomena, Oak Ridge, Tennessee, April 14-15, 1988. Chairperson: R. H. Ritchie. Sponsor: Department of Energy.

Ceramic Fiber Information Meeting, Oak Ridge, Tennessee, April 25-26, 1988. Organized by the Health Effects and Epidemiology Group, Health and Safety Research Division. Sponsored by ORNL and the U.S. Advanced Ceramics Association (USACA).

Third International Workshop on Quantitative Structure-Activity Relationships (QSAR) in Environmental Toxicology, Knoxville, Tennessee, May 9-13, 1988. Chairperson: M. W. England. Sponsor: University of Tennessee, Knoxville, and Oak Ridge National Laboratory.

DOE/CEC Workshop on Critical Evaluation of Radiobiological Data for Biophysical Modeling, Oak Ridge, Tennessee, June 22-25, 1988. Chairpersons: Matesh Varma, DOE, and George Gerber, CEC. Host: H. A. Wright. Sponsor: Department of Energy and Commission of European Communities.

APPENDIX H. ADVISORY COMMITTEE

1987-1988

J. Norman Bardsley, Ph.D. Lawrence Livermore National Laboratory P. O. Box 808, MS L-296 Livermore, California 94550	Atomic Physics and Quantum Chemistry
A. Welford Castleman, Ph.D. Pennsylvania State University College of Science 152 Davey Laboratory University Park, Pennsylvania 16802	Chemical Physics
William A. Mills, Ph.D. Senior Technical Advisor ORAU/CIRRPC 1019 19th Street NW E700 Washington, D. C. 20036	Health Physics and Risk Analysis
John M. Palms, Ph.D. Vice-President for Academic Affairs and Professor of Physics Emory University Atlanta, Georgia 30322	Radiological Physics and Instrumentation

APPENDIX I. PUBLICATIONS AND PRESENTATIONS

Alak, A. M.

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

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

Aldrich, T. E.

Easterly, C. E., Aldrich, T. E., and Morris, M. D., "ELF Bioeffects: Use of Negative Data in a Structured Argument," presented at the 23rd Hanford Life Sciences Symp., Richland, WA, Oct.2-4,1984, and published in the *Proc. 23rd Hanford Life Sciences Symp.*, Richland, WA, Oct.2-4, 1984, Pacific Northwest Lab., CONF-841041, 1987, pp. 543-50.

Aldrich, T. E., Easterly, C. E., McGuire, J. L., and Wells, S. M., "Safeguarding Occupational Health: Surveillance of Work-Related Disease Clusters," presented at the Annu. Meet. of Conf. of Government Industrial Hygienists (ACGIH), Montreal, Quebec, Canada, May 1987

Aldrich, T. E. and Easterly, C. E., "Strategies for Epidemiology Studies of Electromagnetic (EM) Fields," presented at the 9th Annu. Meet. Bioelectromagn. Soc., Portland, OR, June 21-25, 1987

Kimball, K. T., Morris, M. D., Easterly, C. E., and Aldrich, T. E., "Statistical Approach for Combining Results of Similar Experiments with Application to the Hematologic Effects of ELF Field Exposures," presented at the 9th Annu. Meet. Bioelectromagn. Soc., Portland, OR, June 21-25, 1987

Baes, C. F., III, Mrochek, J. E., Aldrich, T. E., and Glatthaar, C. L., *A Brief Summary of the OSHA Interim Final Rule on "Hazardous Waste Operations and Emergency Response and Implications for Federal Facilities,"* ORNL/TM-10443

Easterly, C. E. and Aldrich, T. E., "Support for Health Risk Assessment: Human Studies," presented at the DOE-EPRI Contractor's Review, Kansas City, MO, Nov.2-5, 1987

Brown, J. L., Burns, S. E., Aldrich, T. E., and Easterly, C. E., "Potential Health Effects of Silicon Carbide Fibers," presented at the American Industrial Hygiene Assoc. East Tennessee Conf., Tennessee Valley Chapter, Knoxville, TN, Oct.1, 1987

Aldrich, T. E. and Easterly, C. E., "Space-Time Clusters of Adverse Health Events as a Means of Early Detection of Departure from Planned Containment," presented at the Oak Ridge Model Conf., Oak Ridge, TN, Oct.14-16, 1987

Brown, J. L., Burns, S. E., and Aldrich, T. E., "A Justification for Study of Silicon Carbide Whiskers," presented at the American Industrial Hygiene Convention, San Francisco, May 15-20, 1988

Aldrich, T. E., Easterly, C. E., Buffler, P. A., Brown, J. L., Pickle, L. W., and Mason, T. J., "Assessing Occupational Risk of Lung Cancer in the Petroleum Industry," presented at the American Industrial Hygiene Conf., San Francisco, May 15-20, 1988

Aldrich, T. E., Easterly, C. E., Gailey, P. C., and Hamilton, C. B., *Bioelectromagnetic Effects of EMP: Preliminary Findings*, ORNL/TM-10784

Aldrich, T. E. and Easterly, C. E., "Space-Time Clusters of Adverse Health Events as a Means of Early Detection of Departure from Planned Containment," *Proc. Oak Ridge Model Conf.*, Oak Ridge, TN, Oct.14-16, 1987, CONF-871075, 1987, v. 3, pp. 253-62

Hawthorne, A. R., Aldrich, T. E., Vo-Dinh, T., Uziel, M., Cohen, M. A., Hamilton, C. B., Orebaugh, C. T., Miller, G. H., Ironsides, K., Monar, K. P., Dudney, C. S., Tyndall, R. L., Matthews, T. G., Daffron, C. R., Bull, L. A., White, D. A., Jernigan, R., Wilson, D. L., Meyer, R. E., and Newport, T. H., *Indoor Air Quality in 300 Homes in Kingston/Harriman, Tennessee*, ORNL-6401

Aldrich, T. E. and Easterly, C. E., "Public Health Risk from ELF Exposure--Can It Be Assessed?" presented at the Int. Agency for Research on Cancer, Lyon, France, May 2-3, 1988

Aldrich, T. E. and Easterly, C. E., "Extremely Low Frequency Electromagnetic Fields and Public Health," presented at the WHO Conf. on Use of Sentinel Health Indicators for the Purpose of Identifying Possible Environmental Health Hazards, Lyon, France, May 2-3, 1988

Aldrich, T. E., Meyer, R. E., Newport, T. N., and Easterly, C. E., "An Epidemiologic Analog to the Ames Carcinogen Bioassay," presented at the World Health Organization Conf. on Use of Sentinel Health Indicators for the Purpose of Identifying Possible Environmental Health Hazards, Paris, France, May 4-6, 1988

Aldrich, T. E., Meyer, R. E., Newport, T. H., and Easterly, C. E., "Research Methods Using Population-Based Disease Surveillance Data," presented at the 3rd Natl. Environmental Health Conf., New Orleans, Feb.1-5, 1988

Aldrich, T. E., Meyer, R. E., Newport, T. H., and Easterly, C. E., "Research Methods Using Population-Based Disease Surveillance Data," presented at the Centers for Disease Control, Atlanta, Feb.11, 1988

Allison, L. J.

Olson, R. J., Allison, L. J., and McCollough, I. L., *ADDNET Notebook: Documentation of the Acid Deposition Data Network (ADDNET) Data Base Supporting the National Acid Precipitation Asssessment Program*, ORNL/TM-10086

Sale, M. J., Kornegay, F. C., and Allison, L. J., "Trends and Environmental Impacts of Hydroelectric Development in the United States," presented at the 4th Int. Symp. on Regulated Streams, Loughborough, Great Britain, Aug.15-19, 1988

Allison, L. J. and Olson, R. J., Editors, *Piecing the Puzzle Together: A Conference on Integrating Data for Decisionmaking, May 1987*, CONF-8705147

Allman, S. L.

Judish, J. P., Allman, S. L., Garrett, W. R., and Payne, M. G., "Experimental Studies of Self-Suppression of Vacuum Ultraviolet Generation in Xe," *Bull Am. Phys. Soc.* **33**, 1657 (1988)

Allred, J. F.

Srivastava, P. C., Knapp, F. F., Jr., Dickson, D. R., and Allred, J. F., "Design and Synthesis of a New N-(p-[^{125}I]Iodophenyl)-Maleimide ([^{125}I]IPM) 'Kit' for Labeling of Antibodies with ^{131}I and ^{123}I," presented at the 34th Annu. Meet. Soc. Nucl. Med., Toronto, June 2-5, 1987 and published in *J. Nucl. Med.* **28**, 726 (1987)

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Srivastava, P. C., Suggs, J. A., and Allred, J. F., "Synthesis and Biodistribution of a P-[^{125}I]Iodophenyl Analogue of a Naturally Occurring Imidazole Ribonucleoside," presented at the 35th Annu. Meet. Soc. Nucl. Med., San Francisco, June 14-17, 1988

Srivastava, P. C. and Allred, J. F., "Synthesis and Biodistribution of Para-Iodophenyl Analogue of a Naturally Occurring Imidazole Ribonucleoside," presented at the 7th Int. Symp. on Radiopharmaceutical Chemistry, Groningen, The Netherlands, July 4-8, 1988

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Ambrose, K. R.

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Watson, A. P., Ambrose, K. R., Griffin, G. D., Munro, N. B., and Waters, L. C., "Toxicity Evaluation in Support of Chemical Stockpile Disposal Program," presented at the Health and Safety Research Div. Information Meet., ORNL, Oak Ridge, TN, Oct.27-28, 1987

Vo-Dinh, T., Sepaniak, M. J., Tromberg, B. J., Griffin, G. D., and Ambrose, K. R., "Development and Applications of a Fiberoptics Fluoroimmuno-Sensor (FIS)," presented at the Health and Safety Research Div. Information Meet., ORNL, Oak Ridge, TN, Oct.27-28, 1987

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Anderson, V. E.

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Arakawa, E. T.

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215. W. Bair, Pacific-Northwest Laboratory, Battelle Boulevard, P. O. Box 999, Richland, WA 99352

216. J. N. Bardsley, Lawrence Livermore National Laboratory, MS L-296, Livermore, CA 94550

217. N. F. Barr, Office of Energy Research, U.S. Department of Energy, Washington, DC 20545

218. J. E. Baublitz, Division of Facility and Site Decommissioning Projects, NE-24, U.S. Department of Energy, Washington, DC 20545

219. J. M. Becker, Microbiology Department, University of Tennessee, Knoxville, TN 37916

220. V. P. Bond, Associate Director of Life Sciences, Brookhaven National Laboratory, Upton, NY 11973

221. H. M. Borella, EG&G, Inc., Santa Barbara Operations, 130 Robin Hill Road, Goleta, CA 93117

222. J. N. Bradford, RADC/ESR, Hanscom AFB, MA 01731

223. L. C. Brazley, U.S. Department of Energy, MS NE-24, Washington, DC 20545

224. A. B. Brill, University of Massachusetts Medical School, Department of Nuclear Medicine, Worcester, MA 01605

225. Jon Broadway, U.S. Environmental Protection Agency, P. O. Box 3009, Montgomery, AL 36109

226. A. Brodsky, Office of Standards Development, U.S. Nuclear Regulatory Commission, MS-1130SS, Washington, DC 20555

227. Patricia A. Buffler, Professor of Epidemiology and Associate Dean for Research, University of Texas at Houston, School of Public Health, P.O. Box 20186, Houston, TX 77025

228. G. Burger, Gesellschaft fur Strahlen und Unweltforschung, 8042 Neuherberg, Post Oberschleissheim, Ingolstadter Landstrasse 1, Munich, Federal Republic of Germany

229. T. A. Butler, 119 Dana Drive, Oak Ridge, TN 37830

230. J. R. Cameron, University of Wisconsin Medical Center, Department of Radiology, 1300 University Avenue, Madison, WI 53706

231. A. W. Castleman, Pennsylvania State University, College of Science, 152 Davey Laboratory, University Park, PA 16802

232. M. Cha, Naval Surface Weapons Laboratory, Silver Spring, MD 20910

233. A. Chatterjee, Lawrence Berkeley Laboratory, University of California, Berkeley, CA 94720

234. P. Cho, Office of Health and Environmental Research, ER-73, GTN, U.S. Department of Energy, Washington, DC 20545

235. R. J. Cloutier, Manpower, Educational Research Training, Oak Ridge Associated Universities, Oak Ridge, TN 37830

236. C. B. Coburn, Jr., Biology Department, Tennessee Technological University, Campus Box 5127, Cookeville, TN 38501

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239. T. W. Crawford, Savannah River Laboratory, Aiken, SC 29801

240. J. L. Davis, Department of Physics, University of Tennessee at Chattanooga, Chattanooga, TN 37403

241. C. DeRosa, U.S. Environmental Protection Agency, 26 W. St. Clair, Cincinnati, OH 45268

242. L. T. Dillman, 184 West Lincoln Avenue, Delaware, OH 43015

243. L. J Doemeny, Deputy Director, Physical Sciences and Engineering Division, NIOSH, 4676 Columbia Parkway, Cincinnati, OH 45266

244. P. A. Duhamel, Office of Health and Environmental Research, ER-74, E-223, Department of Energy, Washington, DC 20545

245. P. M. Echenique, Departmento de Fisica de Materiales, Universidad del Pais Vasco, 20080 San Sebastian, Spain

246. G. G. Eichholz, School of Nuclear Engineering, Georgia Institute of Technology, Atlanta, GA 30332

247. W. H. Farland, Health and Environmental Review Division, Carcinogen Assessment Group, MS TS-796, U. S. Environmental Protection Agency, 401 M Street, SW, Washington, DC 20460

248. D. J. Fehringer, U.S. Nuclear Regulatory Commission, MS 623-SS, Washington, DC 20555

249. C. Feldman, Office of Standards Development, U.S. Nuclear Regulatory Commission, MS-1130SS, Washington, DC 20555

250. J. J. Fiore, U.S. Department of Energy, MS NE-24, Washington, DC 20545

251. D. R. Fisher, Pacific-Northwest Laboratory, Battelle Boulevard, P.O. Box 999, Richland, WA 99352

252. F. N. Flakus, International Atomic Energy Agency, Wagramersstrausse 5, P. O. Box 100, A-1400, Vienna, Austria

253. F. Flores, Departmento de Fisica del Estado Solido, Universidad Autonoma de Madrid Cantoblanco, Madrid, Spain

254. R. Geiger, U.S. Department of Energy, 3G092 Forrestal Building, Washington, DC 20585

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257. M. M. Goodman, Radiology Department, U.T. Memorial Hospital, 1924 Alcoa Highway, Knoxville, TN 37920

258. R. Goyer, Deputy Director, National Institute of Environmental Health Sciences, P.O. Box 12233, Research Triangle Park, NC 27709

259. D. Greathouse, U.S. Environmental Protection Agency, 26 W. St. Clair, Cincinnati, OH 45268

260. R. A. Griesemer, National Institute of Environmental Health Sciences. P. O. Box 12233, Research Triangle Park, NC 27709

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262. G. Heuter, U.S. Environmental Protection Agency, Research Triangle Park, NC 27711

263. A. Howie, Cavendish Laboratory, Madingley Road, Cambridge CB30HE, England

264. J. H. Hubbell, Center for Radiation Research, National Bureau of Standards, Washington, DC 20434

265. S. R. Hunter, GTE - Sylvania Lighting Design Center, 100 Endicott Street, Danvers, MA 01923

266. G. S. Hurst, Consultec Scientific, Inc., Pellissippi Center, Suite 110, 725 Pellissippi Parkway, Knoxville, TN 37932-3300

267. T. Inagaki, Department of Physics, Osaka Kyoiku University, Tennoji, Osaka, 543 Japan

268. B. Jinkerson, University Programs Division, Oak Ridge Associated Universities, P.O. Box 117, Oak Ridge, TN 37831

269. R. Katz, Department of Physics, University of Nebraska, Lincoln, NE 68588

270. T. W. Kerlin, Department of Nuclear Engineering, 315 Pasqua Building, University of Tennessee, Knoxville, TN 37996

271. G. Killough, 105 Netherland Rd, Oak Ridge, TN 37830

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274. E. Lin, Director, Atomic Power Department, Taiwan Power Company, 242 Roosevelt Road, 3rd Section, Taipei, Taiwan, ROC

275. W. C. Lineberger, Department of Chemistry and Joint Institute for Laboratory Astrophysics, University of Colorado, Boulder, CO 80302

276. J. N. Maddox, Office of Health and Environmental Research, EV-12, U.S. Department of Energy, Washington, DC 20545

277. D. T. Mage, Senior Scientific Advisor, Data Management and Analysis Division (MD-56), USEPA/EMSL, Research Triangle Park, NC 27711

278. J. L. Magee, Biology and Medicine Department, University of California, Berkeley, CA 94720

279. J. R. Manson, Department of Physics, Clemson University, Clemson, SC 29631

280. T. G. Matthews, 7250 Zuni Drive, Dallas, TX 75236

281. C. W. Mays, Jr., Radiobiology Laboratory, University of Utah, Salt Lake City, UT 84112

282. T J. McKenna, Office of Inspection and Enforcement, MS EW-359, U.S. Nuclear Regulatory Commission, Washington, DC 20555

283. W. A. Mills, ORAU/CIRRPC, 1019 19th Street NW, #700, Washington, DC 20036

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288. D. Nelson, Department of Energy, DH 331.2, Washington, DC 20545

289. J. M. Palms, Vice President for Academic Affairs, Emory University, Atlanta, GA 30322

290. B. Parks, Office of Radiation Programs (ANR-460), U.S. Environmental Protection Agency, Washington, DC 20460

291. R. Perhac, Electric Power Research Institute. 3412 Hillview Avenue, P. O. Box 10412, Palo Alto, CA 94303

292. J. W. Poston, Department of Nuclear Engineering, Texas A&M, College Station, TX 77843

293. C. J. Powell, Electron Physics Section, National Bureau of Standards, Washington, DC 20234

294. P. W. Preuss, U.S. Environmental Protection Agency, 401 M Street, SW, RD672, Washington, DC 20460

295. G. Purcell, Director, GGSLIS, The University of Tennessee, 804 Volunteer Boulevard, Knoxville, TN 37996-4330

296. D. P. Rall, Director, National Institute of Environmental Health Sciences, P. O. Box 12233, Research Triangle Park, NC 27709

297. A. Richardson, Office of Radiation Programs, U.S. Environmental Protection Agency, Crystal Mall #2, 1921 Jefferson Davis Hwy., Crystal City, VA 22202

298. R. Rieger, Appalachian Regional Laboratory, NIOSH, Morgantown, WV 26505

299. J. A Robertson, Director, Human Health and Assessments Division, Office of Health and Environmental Research, ER-73, GTN, U.S. Department of Energy, Washington, DC 20545

300. B. A. Schwetz, Chief, Systemic Toxicology Branch, NIEHS, P. O. Box 12233, Research Triangle Park, NC 27709

301. K. Sexton, Director, Office of Health Research, RD-683, U. S. Environmental Protection Agency, 402 M Street, SW, Washington, DC 20460

302. G. L. Sherwood, NE 52, Office of Nuclear Energy, MS-B107, U.S. Department of Energy, Washington, DC 20545

303. C. M. Shy, School of Public Health, University of North Carolina, Chapel Hill, NC 27514

304. W. K. Sinclair, President NCRP, 7910 Woodmont Avenue, Suite 800, Bethesda, MD 20814

305. A. Sinkankas, The University of Tennessee, 804 Volunteer Boulevard, Knoxville, TN 37996-4330

306. R. Snelling, U.S. Environmental Protection Agency, Las Vegas, NV 89193-3478

307. J. K. Soldat, Energy System Sigma, Pacific-Northwest Laboratory, Battelle Boulevard, Richland, WA 99352

308. D. Straw, W. J. Schafer Associates, Inc., 1600 Randolph Court SE, #2, Albuquerque, NM 87106

309. J. R. Stetter, Pollutant Analysis and Geochemistry Section, Energy and Environmental Systems Division, Argonne National Laboratory, 9700 Cass Avenue, Argonne, IL 60439

310. R. E. Sullivan, Office of Radiation Programs (AHR-460), U.S. Environmental Protection Agency, Crystal City, VA 22202

311. J. W. Thiessen, Radiation Effects Research Foundation, 5-2 Hijiyama Park, Minani-ku, Hiroshima 732, Japan

312. L. H. Toburen, Pacific-Northwest Laboratory, Battelle Boulevard, P.O. Box 999, Richland, WA 99352

313. A. Ulsamer, U.S. Consumer Product Safety Commission, 5401 Westbard Avenue, Washington, DC 20207

314. M.Varma, Pollutant Characterization and Safety, Office of Health and Environmental Research, ER-74, U.S. Department of Energy, Washington, DC 20545

315. J. Villforth, Bureau of Radiological Health, U.S. Public Health Service, 5600 Fishers Lane, Parklawn Building, Rockville, MD 20582

316. P. Voytek, Office of Health and Environmental Assessment, U.S. Environmental Protection Agency, 401 M Street SW, Washington, DC 20460

317. B. Wallace, Appalachian Regional Laboratory, NIOSH, Morgantown, WV 26505

318. P. J. Walsh, H & R Technical Associates, Inc., 575 Oak Ridge Turnpike, Oak Ridge, TN 37830.

319. W. L. Ward, American Petroleum Institute, 1220 L Street NW, Washington, DC 20005

320. M. D. Waters, Director, Genetic Toxicology Division, U. S. Environmental Protection Agency, Health Effects Research Laboratory, Research Triangle Park, NC 27711

321. J. E. Watson, 517 Yorktown Drive, Chapel Hill, NC 27514

322. W. Weyzen, Electric Power Research Institute, 3412 Hillview Avenue, P.O. Box 10412, Palo Alto, CA 94303

323. G. H. Whipple, 3301 Rutland Loop, Tallahassee, FL 32312

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