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MEETING OF THE ADVISORY COMMITTEE

DIVISION OF BIOLOGY AND MEDICINE

UNITED STATES ATOMIC ENERGY COMMISSION

May 7-8, 1970

GENERAL INFORMATION

PROGRAM

AND

ABSTRACTS

Pacific Northwest Laboratory
Operated by Battelle Memorial Institute
Richland, Washington

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GENERAL INFORMATION

Hotel

Reservations for all members of the Advisory Committee have been made at the Hanford House. The hotel will bill you for your room.

Meals

Restaurant facilities are available in the Hanford House. Another convention is booked in the Hanford House for the same time as our meeting, and this may tend to crowd their dining rooms.

Lunch on May 7th will be catered in a large conference room at the Battelle-Northwest campus.

On the evening of May 7th there will be a social hour at the Rivershore Motor Inn beginning at 6:15 p.m. Out of town participants are invited to be guests of Battelle-Northwest for dinner at the Rivershore following the social hour. Transportation by private cars will be arranged to take you from and to the Hanford House.

A group luncheon has not been arranged for Friday, May 8th. There are several restaurants in or near Richland, and local people with private cars will be on hand to drive participants to lunch on this day.

Registration and Badges

There will be no formal registration, but a Hanford "badge" is needed for identification and access to some of the facilities. Please pick up your badge from our receptionist in the lobby of the Hanford House on the morning of May 7th between 8:00 and 8:15 a.m.

No "classified" information will be presented at this meeting.

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Transportation

A special bus will be available to take you from the Hanford House to the Battelle-Northwest Auditorium where the meetings will be held. The bus will leave the Hanford House at 8:15 a.m. on Thursday, May 7th, and at 8:00 a.m. on Friday, May 8th. The bus will make the return trip each day at about 5:00 p.m. Cars will be available for special transportation needs at other times.

The Kaymax Travel Agency is located in the Hanford House building and can provide assistance with travel arrangements. Phone 943-3124.

Incoming Messages

If you are expecting a telephone call, you can be reached at the meetings via (509) 942-1111, Extension 946-2208. (Dr. Alpen's office will relay the call to you.)

DOE ARCHIVES

MEMBERS OF ADVISORY COMMITTEE
DIVISION OF BIOLOGY AND MEDICINE
UNITED STATES ATOMIC ENERGY COMMISSION

Dr. Philip P. Cohen, Chairman; Professor and Chairman, Department of Physiological Chemistry, University of Wisconsin School of Medicine, Madison, Wisconsin.

Dr. Robert D. Moseley, Jr., Vice Chairman; Chairman, Department of Radiology, University of Chicago, Chicago, Illinois.

Dr. William F. Bale, Professor, Radiation Biology and Biophysics and Atomic Energy Project, University of Rochester School of Medicine and Dentistry, Rochester, New York.

Dr. Arie J. Haagen-Smit, Professor, Division of Biology, California Institute of Technology, Pasadena, California.

Dr. Perry R. Stout, Director, Kearney Foundation and Chairman, Department of Soils and Plant Nutrition, University of California, Davis, California.

Rosemary Elmo, Executive Secretary; Advisory Committee for Biology and Medicine, U.S. Atomic Energy Commission, Washington, D.C.

GUEST

Dr. Clement A. Finch, Professor, Department of Hematology, University of Washington, Seattle, Washington.

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AEC STAFF EXPECTED TO BE PRESENT

WASHINGTON, D.C.

Division of Biology and Medicine

Dr. John R. Totter	- Director, Division of Biology and Medicine
Dr. John Kirby-Smith	- Assistant Director for Biological Sciences
Dr. Charles W. Edington	- Chief, Biology Branch
Dr. Charles L. Osterberg	- Acting Chief, Environmental Sciences Branch
Mr. John C. Whitnah	- Chief, Program Coordination Branch
Dr. Roy V. Talmadge	- Medical Branch
Miss Rosemary Elmo	- Executive Secretary, Advisory Committee for Division of Biology and Medicine

Public Information Division

Mrs. Gail Bradshaw	- Public Information Officer

Division of Radiation Protection Standards

Mr. Robert E. Baker	- Program Assistance Branch

RICHLAND OPERATIONS OFFICE

Mr. Donald G. Williams	- General Manager

Laboratory and University Division

Mr. C. L. Robinson	- Director
Mr. C. Robert Qualheim	- Deputy Director
Mr. Michael W. Tiernan	- Health Physicist
Mr. Loviece C. Brazley	- Radiological Physicist

Health and Safety Division

Dr. William E. Lotz	- Director

BROOKHAVEN NATIONAL LABORATORY

Dr. Robert A. Conard	- Medical Department

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PROGRAM SCHEDULE

Thursday, May 7, 1970

8:00 a.m.	Issue badges in lobby of Hanford House
8:15	Bus to Battelle-Northwest Auditorium
8:40	Welcome - D. G. Williams, General Manager, Richland Operations Office, United States Atomic Energy Commission
8:50	Introductory Remarks - E. L. Alpen, Manager, Environmental and Life Sciences Division
9:00	Medical Findings in the People of the Marshall Islands Accidentally Exposed to Fallout - R. A. Conard (BNL)
9:30	Introduction to the Atmospheric Resources Programs - C. L. Simpson, Manager
9:35	Atmospheric Turbulence and Diffusion - C. E. Elderkin
10:05	Break
10:20	Precipitation Scavenging Studies - W. G. N. Slinn
10:50	Atmospheric Transfer Processes Over the Ocean - R. K. Woodruff
11:20	Introduction to the Radiological Sciences Programs - J. M. Nielsen, Manager
11:25	Cosmogenic and Fallout Radionuclides as Tracers of Atmospheric Phenomena - R. W. Perkins
11:50	Lunch, Research Operations Building, Northwest Room. Provided by Battelle-Northwest
1:00 p.m.	Physical Radiation Interactions and their Implications for Radiobiology - W. C. Roesch
1:30	New Techniques and Instrumentation for Use in Medical Research and Health Physics - H. E. Palmer
1:55	Trace Elements and Radionuclides in the Environment - L. A. Rancitelli
2:20	Break
2:35	Introduction to the Ecosystems Programs - B. E. Vaughan, Manager
2:40	Abiotic and Related Components of Natural Ecosystems - K. R. Price

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3:05	Micro-environmental Climate and Community Structure of the ALE Reserve - W. H. Rickard
3:30	Factors Influencing Mammal Populations in the ALE Reserve Ecosystem *** Problem of Estimating Body Burdens in Alaska Chromosome Studies - T. P. O'Farrell
4:00	Food Chain Kinetics and Environmental Contamination - L. L. Eberhardt
4:20	Thermal Stress and Related Problems Affecting Aquatic Organisms - W. L. Templeton
5:00	Bus to Hanford House
6:15	Social Hour - Rivershore Motor Inn, Seville Room. (Transportation will be provided.)
7:00	Dinner - Rivershore Motor Inn - Battelle-Northwest host. "The New Look - E&LS" - E. L. Alpen

Friday, May 8, 1970

8:00 a.m.	Bus leaves Hanford House for BNW Auditorium
8:20	Introduction to Biology Programs - W. J. Bair, Manager
8:35	Malonaldehyde: A Radiolysis Product of Carbohydrates and Polynucleotides - D. B. Menzel
8:50	Regulation of Exocellular Enzyme Synthesis and Secretion - H. Drucker
9:10	The Role of Vascular Damage in the Gastrointestinal Radiation Syndrome - B. W. Wachholz
9:30	Age and Radiation Carcinogenesis - D. D. Mahlum
9:50	Break
10:05	Chronic ^{90}Sr Toxicity in Miniature Swine - W. J. Clarke
10:35	Development of a Blood Irradiator - F. P. Hungate
10:50	Toxicity of Inhaled Plutonium - J. F. Park
11:20	Co-carcinogenicity of Uranium Mine Air Contaminants - B. O. Stuart
11:55	Lunch - No host (Travel by cars to local restaurants)
1:30 p.m.	Executive Session, Advisory Committee, Division of Biology and Medicine. Northwest Room, BNW Research Operations Building
5:00	Bus to Hanford House

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A B S T R A C T S

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DOE ARCHIVES

MEDICAL FINDINGS IN THE PEOPLE OF THE MARSHALL ISLANDS ACCIDENTALLY EXPOSED TO FALLOUT

R. A. Conard, M.D.
Brookhaven National Laboratory

The medical status of the Marshallese people accidentally exposed to radioactive fallout in 1954 will be reviewed and updated to include results of the 16 year annual survey just completed in March. The acute effects of exposure of these people has been well documented. The most serious of the late effects has been the development of thyroid abnormalities resulting from exposure of the thyroid gland to radioactive iodines in the fallout. Of 82 people of Rongelap, 66 are now living, and of these 21 have developed thyroid abnormalities, 19 with nodularity and 2 with atrophy of the gland associated with hypothyroidism. Of 19 children exposed at less than 10 years of age (receiving doses of 700-1400 rad to the thyroid), 17 have developed thyroid abnormalities. Surgical exploration with thyroidectomy, partial to complete, in 18 Rongelap patients has revealed benign adenomatous nodules in 17 cases and malignant lesions in 3 cases. Cancer was noted in one girl exposed at 7 years of age and in 2 women exposed as young adults. The operated cases are all doing satisfactorily except for a 20 year old female who shows a suspicious enlargement of her thyroid remnant which will be further investigated. In addition one Utirik woman operated on during the past year had a thyroid malignancy, but the association with radiation exposure in this case seems unlikely in view of the low dose of radiation received by this population. Growth retardation noted in some Rongelap children has been correlated with hypothyroid tendency due to thyroid lesions and some of these children appear to be responding favorably to thyroid hormone treatment.

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Plans for radiological health monitoring of the Bikini people who are being returned to their home island will be briefly reviewed.

DOE ARCHIVES

ATMOSPHERIC TURBULENCE AND DIFFUSION

C. E. Elderkin
Atmospheric Resources Department

Recent atmospheric diffusion experiments for continuous releases from a number of heights up to 400 feet have provided data essential for evaluating the dependence of diffusion from elevated releases on the height of release and on a wide variety of meteorological conditions. A recently developed diffusion measurement network for sampling ^{85}Kr, utilized as a tracer, is also providing data for studying the diffusion of puffs of material released to the atmosphere instantaneously. The results obtainable from the ^{85}Kr system are useful not only for evaluating consequences of accidental releases of an instantaneous nature, but its inert characteristics offer the opportunity to study deposition by releasing simultaneously with krypton, materials which interact with the surface.

It is important in extending our understanding of diffusion, transport and flux of materials to the surface over tens and hundreds of miles to study the turbulent structure, growth, and decay of the atmospheric boundary layer within which transport, diffusion and removal are effected. Detailed turbulence measurements and analysis evaluating the turbulent energy budget and spectral structure are being conducted to define the properties of the boundary layer. Ongoing atmospheric tracer development work at Hanford must devise suitable tracers for studies over the larger distances of interest and ongoing aircraft meteorological measurements must include capabilities to be developed for sampling such tracers.

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DOE ARCHIVES

PRECIPITATION SCAVENGING STUDIES

W. G. N. Slinn
Atmospheric Resources Department

A review is made of current precipitation scavenging research being performed by the Atmospheric Resources Department. The objectives of these studies are to predict and to understand the removal by precipitation of particulate and gaseous pollution from the atmosphere. Major emphasis is placed on field work and pertinent theoretical analyses.

Important parameters which have been identified for the below-cloud, rain scavenging of particles are: raindrop size and electric charge, rainfall rate, and pollutant characteristics. Recent field experiments to determine the washout of rhodamine dye particles and to measure the electric charge on raindrops as well as some theoretical predictions of washout are described.

To understand the in-cloud scavenging of pollutants it is necessary to consider processes which range from the microphysical to the synoptic meteorological scales. Descriptions are given of the use of cosmogenic radionuclides as tracers and the numerical modeling of orographic, moisture-laden airflow. Plans for future research are described.

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ATMOSPHERIC TRANSFER PROCESSES OVER THE OCEAN

R. K. Woodruff
Atmospheric Resources Department

Turbulent eddies at the sea-air interface effect net transfers of heat, moisture, momentum, and mass between the sea and the atmosphere. These transfer processes are important to the accuracy of atmospheric models, the transport, diffusion and deposition of atmospheric pollutants, and the dispersion and diffusion of water pollutants. Their importance is emphasized when it is considered that 45 percent of the U.S. population resides along coastlines.

The Atmospheric Resources Department initiated studies of sea-air interaction processes through participation in the Barbados Oceanographic and Meteorological Experiment (BOMEX). Observations of eddy fluxes were made from a stable spar buoy for the purpose of determining dry deposition rates for radionuclides, determining the basic character of turbulence over the ocean, supporting BOMEX data requirements, and for evaluating the data acquisition system. Data processing software is being developed.

It is anticipated that future efforts will first be directed toward the refinement of the buoy, and data and sensor systems. Subsequent to demonstrating the system as a reliable and accurate tool, studies of radionuclide dry deposition rates over the ocean, thermal pollution, and the basic character of sea-air interaction processes will be conducted.

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PHYSICAL RADIATION INTERACTIONS AND THEIR IMPLICATIONS FOR RADIOBIOLOGY

W. C. Roesch
Radiological Sciences Department

Many characteristics of the phenomena of radiobiology are strongly influenced by the randomness in space and time of the physical and chemical events that lead to them. We are studying both of these sources of randomness. The study of randomness in time has been theoretical and has led to elaborations of classical hit theory that can explain dose-rate and fractionation effects as well as survival-curve shapes, etc. The studies of spatial effects have been mostly experimental. Part of them have been based on techniques, popularly known as microdosimetry, that permit simulating the ionization produced in a very small critical volume by that in a large volume of gas. We have recently been measuring ionization distributions that result from the randomness in space of the interactions of protons with matter. Theoretical studies of the spatial phenomena are limited at present by lack of knowledge of the distributions in energy and angle of the delta rays produced by charged particles. Therefore, another part of our experimental program is aimed at measurement of these distributions.

Among the actual physical and chemical events underlying radiobiological phenomena that we are studying are a number of free radical reactions. Rate constants for reactions between hydroxyl radicals and many biochemicals have been measured. Hydroxyl radicals were found to attack most rapidly sites of high electron density in small molecules; in more complex molecules, steric factors reduce the rate of interaction by an order of magnitude. A number of radicals formed from biochemical compounds have been identified and their rate

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constants measured. Strong oxidizing and reducing agents have been found among these radicals, and chain polymerization has been found to be a frequent result of their interactions. Compounds which react rapidly with hydroxyl radicals have been found to be effective protective agents against radiation damage in several model biochemical systems.

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NEW TECHNIQUES AND INSTRUMENTATION FOR USE IN MEDICAL RESEARCH AND HEALTH PHYSICS

H. E. Palmer
Radiological Sciences Department

The application of nuclear technology to medical science and to industry is increasing the frequency and nature of the encounters between man and a radiation environment. This requires continuing research on new nuclear instrument techniques and in health physics. This presentation describes some recent advances in nuclear technology for medical and health physics. Methods are being developed to measure the major elements of the human body by *in vivo* neutron activation analysis. A method for measuring the change in total body calcium is presently in use and measurements have been made on more than fifty patients suffering from a variety of diseases. A method for total body sodium measurement has been developed and is currently being tested on six normal subjects. Methods for determining total body phosphorus and nitrogen have been proven to be feasible and their development is now in progress. A method for accurately measuring the total body content of ^{59}Fe was recently developed for iron absorption and kinetics studies. Another method developed for iron absorption studies allows ^{55}Fe to be directly determined in a blood sample without the formerly required sample ashing, chemical separation and electrodeposition of the iron.

The feasibility of using low dose electron capture isotopes as tracers for metabolic parameters in humans was demonstrated. Techniques of external scanning and excreta analysis were used to measure retention and distribution parameters on 12 human volunteers injected intravenously with ^{143}Pm. The

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effect of DTPA in hastening removal was studied in some of these subjects. The potential for undertaking a similar approach in assessing body burdens of plutonium in workers accidentally exposed and who are undergoing chelation therapy is under examination. *In vivo* measurement techniques for promethium and plutonium in the lung, in wounds and in other body organs are being explored. Improvements in respiratory airway and radon daughter deposition modeling are also being investigated.

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COSMOGENIC AND FALLOUT RADIONUCLIDES AS TRACERS OF ATMOSPHERIC PHENOMENA

R. W. Perkins
Radiological Sciences Department

The atmosphere contains a wide spectrum of radionuclides from natural processes as well as from nuclear weapons testing. These include radon and thoron daughters which enter the atmosphere from the earth's surface, together with cosmogenic radionuclides which are produced throughout the atmosphere by cosmic-ray spallation of argon, nitrogen and oxygen. These radionuclides become attached to the natural atmospheric aerosols and can then serve as tracers of atmospheric mixing and precipitation scavenging rates. The development of very specialized technology for both their sampling and analysis allows very precise measurements of airborne radionuclides with half-lives of minutes to years.

Vertical gradients of these radionuclides from ground level through about 60,000 ft are establishing stratospheric and tropospheric residence times and mixing rates, and the magnitude of various depletion mechanisms. Measurements of their concentrations in the marine atmosphere relative to the underlying ocean water are providing the rates of air to sea exchange. Measurements of the rather short-lived cosmogenic radionuclides ^{38}Cl (38 min), ^{39}Cl (55 min), and ^{24}Na (15 hr) in rain have provided some of the first actual measurements of the rates and mechanisms involved in rain formation and precipitation scavenging. The use of existing airborne radionuclides as tracers can be expected to provide quantitative answers to many basic questions of atmospheric mixing and scavenging.

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TRACE ELEMENTS AND RADIONUCLIDES IN THE ENVIRONMENT

Louis A. Rancitelli
Radiological Sciences Department

Radionuclides injected into the biosphere by nuclear testing, power plant operations, and natural processes eventually mix with stable elements in the environment. To fully define the distribution, transport, mixing, and removal of these radionuclides or employ them as tracers of natural processes requires studies of both the stable and radioactive species. High-sensitivity and high selectivity gamma spectrometry systems combined with neutron activation techniques have made possible comprehensive studies of radionuclides and trace element behavior in the environment. Fourteen trace elements and seventeen radionuclides were measured in the Pacific salmon. The specific activity of ^{137}Cs was the same in the fish and seawater, indicating that the radionuclide was well mixed and behaved similarly to its stable isotope. Stable cesium was preferentially concentrated relative to potassium and rubidium. The specific activities of several other radionuclides, notably ^{60}Co, ^{65}Zn, and ^{110m}Ag, were found to be higher in certain biota than in seawater. Multielement analysis of Columbia River water has established the concentrations and their variation with seasons of over 20 trace elements. The normal concentrations of 14 elements in human lung tissue was established as well as differences in lungs from individuals with special occupational exposures, such as uranium mining. Comparisons of seven trace elements in the atmosphere with their concentrations in rainwater have established the origin, composition, and rate of removal of these materials from the atmosphere. Since these studies include measurements of the chemical species involved, an interpretation of the relationships between radionuclide and trace element pollution and their effect on man can be determined.

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ABIOTIC AND RELATED COMPONENTS OF NATURAL ECOSYSTEMS

K. R. Price
Ecosystems Department

Many aspects of the physical environment are operative in natural ecosystems, and they can be categorized, roughly, as climatic, geologic, edaphic, and hydrologic factors. Overlap occurs among these factors and between abiotic and biotic components, for each organism has its particular set of environmental requirements. The 310 Km^2 Arid Land Ecology (ALE) Reserve increases 900 m in elevation, predominantly up a north-facing slope, from Cold Creek Valley to the crest of the Rattlesnake Hills. This physiography strongly influences local precipitation and temperature patterns, and it influences plant distribution and local phenologies. Geological investigations show that the perennial water flow at Rattlesnake Springs was caused by geological erosion and formation of a perched water table in lower Dry Creek. This perched water table is responsible for present-day community distributions of plants. Annual and diurnal cycles in the depth-to-water table were measured, and the plant influence on this cycling is under study. Water budget is being formulated from data on timing of transpiration and rates of surface and subsurface flow. Geologic studies also indicate that sodium salts accumulation in certain surface soils contributed toward present community distributions for these areas. Hydrologic studies are also being conducted in the Snively Watershed at the western edge of the ALE Reserve in an effort to establish the water budget for an arid region watershed. Waters from the natural springs are being carbon dated.

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MICROENVIRONMENTAL CLIMATE AND COMMUNITY STRUCTURE OF THE ALE RESERVE

W. H. Rickard
Ecosystems Department

Studies in plant ecology are here concerned with the structure and function of disturbed and undisturbed plant communities. Net primary production, mineral cycling, and energy flow are ecological processes to be determined in relation to abiotic and these biotic factors. On the ALE Reserve, agricultural perturbations 25 years ago have had lasting effects on the shrub-steppe communities. Although species composition of abandoned cultivated fields varies little from year to year, the harvest yield and botanical composition of the yield has varied according to total amount and seasonal distribution of precipitation. Generally speaking, available moisture was the limiting factor to primary production. However, data obtained in 1969 - a year of better than average moisture - showed that plant production was limited by available nitrogen. The rate of decomposition of dead plant material and of return of essential mineral nutrients to the soil were measured. Minerals included were N, P, Mg, Ca, Zn, Mo, and B. Caloric content of green forage, seeds, and litter were measured by oxygen bomb calorimetry. Artificially constructed earth mounds were used to study effects of contrasting microclimates on growth, mineral uptake, caloric content, and seed performance of the plant species colonizing these disturbed soils. Sixteen years ago, experimental plots were treated with long-lived radionuclides, ^{90}Sr and ^{137}Cs. Plots have become colonized naturally by plants characteristic of abandoned cultivated fields. Distribution, soil profile, and plant concentrations of these radionuclides are being studied to determine their transfer patterns, especially to herbivores of the shrub-steppe ecosystem.

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FACTORS INFLUENCING MAMMAL POPULATIONS IN THE ALE RESERVE ECOSYSTEM

T. P. O'Farrell
Ecosystems Department

Functional roles of important animal species of the ALE desert-steppe ecosystem are being characterized. Special emphasis is placed on relating population dynamics, physiological adaptations, and radiation sensitivity to environmental parameters, especially vegetative productivity, microclimatology, and the availability of water, minerals, and nutrients. Research efforts are also directed toward defining the fate of irradiated animals in the desert steppe. Free-ranging pocket mice, Perognathus parvus, irradiated in 1967, showed no synergistic effects between radiation and environmental stressors comparing $LD_{50/30}$ values derived from field and laboratory data. Field longevity, reproductive performance, and home-range utilization were measured, and population changes were modelled mathematically. Apart from radiation, the absence of seeds during years of poor germination of annual plants acted as part of a complex feed-back mechanism effectively reducing reproduction in the dominant mammals. Laboratory experiments were also designed to test the published hypothesis that native mammals are more resistant to acute radiation than their laboratory counterparts. There was 2-fold variation between sensitive and resistant species of the 14 small mammals tested (534 vs 1094 rad, $LD_{50/30}$), and no biologically significant difference between indigenous mammals and laboratory strains. No correlations could be made between radiation response and taxonomic affinities, karyotype, or adaptations to rigorous environments.

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PROBLEM OF ESTIMATING BODY BURDENS IN ALASKAN CHROMOSOME STUDIES

T. P. O'Farrell
Ecosystems Department

A new direction to the Alaskan studies was initiated cooperatively between Pacific Northwest Laboratory (PNL) and Oak Ridge National Laboratory (ORNL). The major objective was to determine whether Eskimos chronically ingesting radionuclides had a higher incidence of chromosomal aberrations in their circulating leukocytes as compared with Eskimos inhabiting the coast, who have different dietary regimes. Adult male inhabitants of Anaktuvuk Pass were sampled in February and July, while residents of Kotzebue were sampled in July only. No ring or dicentric formations were found in the chromosomes of cultured leukocytes from Kotzebue natives, but several such formations were found in cells of residents of Anaktuvuk Pass. Over 10,000 cells were scored; however, the significance of these findings is presently unknown. Major effort will be made to continue the program, taking advantage of the complementary capabilities of PNL and ORNL. PNL will continue to provide measurements of ^{137}Cs in the body. It will also provide dietary and modelling information for the determination of body burdens. Data for ^{55}Fe, ^{65}Zn, ^{90}Sr, and ^{210}Pb-^{210}Po are presently being evaluated at PNL, as potential dose contributors, with a view towards establishing possible dose dependence for the effects observed. ORNL (Human Cytogenetics Section) will continue to supply the expertise needed to collect, culture, score, and evaluate the karyological material.

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FOOD-CHAIN KINETICS AND ENVIRONMENTAL CONTAMINATION

L. L. Eberhardt
Ecosystems Department

Transforming current popular interest in the environment into real improvements in human welfare requires that we convert many ecological concepts into operating manuals. The food-chain concept serves well enough for safety factors in orders of magnitude, but it has little utility at the point of trade-offs between starvation and pest control, or, malaria and DDT. Our present study of food-chain kinetics is designed to serve the needs of continuing research on radioactive substances and to translate experience from that area to apply to other contaminants, including pesticides. We have necessarily to deal with different areas; these include: 1) Basic principles - These include the formal structure of possible mathematical models and such aspects as the relationship of retention-time to metabolic rate. 2) Case histories - We have assembled computer-simulation models for several sets of actual data involving both radionuclides and pesticides. Main effort concerns ^{137}Cs movement in the Alaskan lichen-caribou-Eskimo food chain. Although we have a good working model, it continues to provide both surprises and unresolved anomalies. To evaluate new phenomena in the system, e.g., chromosome abnormalities, requires an uninterrupted flow of field data. 3) Statistical problems - Variability is part and parcel of an ecosystem. Using standardized animals in a laboratory system often destroys the objective of a study. Consequently, a major part of our present effort concerns statistical methods for appraising variability. We have established some principles and constructed working models and will turn next to the stochastic aspects. 4) Further questions - We have thus far been mainly concerned with tracing

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substances through systems. There is urgent need to consider the effects of, for example, pesticides. For ecosystems, this means a study of population dynamics. As we approach the stage of providing "blueprints" for measuring and managing ecosystem contamination, there will be an urgent need to do specific field experiments to test our predictive capabilities.

DOE ARCHIVES

THERMAL STRESS AND RELATED PROBLEMS AFFECTING AQUATIC ORGANISMS

W. L. Templeton
Ecosystems Department

The major objective of these programs is to determine effects on aquatic ecosystems, particularly of "man-made stress", e.g., radioactivity and thermal increments caused by reactor cooling water. One of the least understood is determination of the effects of a thermal increment in the mixing zone immediately below a discharge point in the stream. Research is concerned with physical modelling and with the interaction of migratory fish and other organisms in the intermediate zone of mixing. These studies embrace all of the life stages of salmon, including the eggs, the fry, the juveniles, and the adults. New technology has been developed to evaluate the risks to young salmon as they pass the reactor discharges enroute to the sea. Field and laboratory data were combined to create a hybrid computer model that predicts the hazards to young fish in the mixing zones. Apart from mortality criteria, behavior was studied, with the use of sonic tags, for adult salmon and trout on their spawning migration upstream past the reactor discharges. Studies also were made on fish diseases known to be aggravated by increases in temperature, e.g., the bacterial disease, columnaris, and "gas bubble" disease, resulting from supersaturation by nitrogen gas. In addition to investigating direct effects on fish, tracer studies were made on key elements of the river ecosystem. These include possible thermal effects on the dynamics of the periphyton community, the development of bottom dwelling invertebrate organisms, and the long-term changes in the size of the chinook salmon population that spawns in the near vicinity of the reactors. Laboratory models

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were constructed of the natural system for periphyton productivity and simple food webs (water → periphyton → fish). These models are permitting control and identification of various environmental parameters, particularly the role of suspended materials which affect productivity.

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MALONALDEHYDE: A RADIOLYSIS PRODUCT OF CARBOHYDRATES AND POLYNUCLEOTIDES

D. B. Menzel
Biology Department

Controversy exists over the safety of irradiated foods. Cytotoxic effects have been ascribed to irradiated solutions of pure carbohydrates, yet the nature of the toxic radioalysis products remains obscure. We have shown that irradiation of a number of carbohydrates and of DNA and RNA produces malonaldehyde. Malonaldehyde appears to arise from a deoxy sugar intermediate via a solvated electron reaction; hence, the radiolytic production of malonaldehyde is pH-dependent, higher yields occurring at physiological than at more acidic pH ranges. The identity of malonaldehyde was established by u.v.spectra, by column chromatography and by formation of the 2-thiobarbituric acid derivative. Irradiation of DNA or RNA produced both malonaldehyde and a malonaldehyde-nucleic acid reaction product. This latter product was fluorescent and could be dissociated only by hot acid hydrolysis. Fluorescent reaction products of nucleosides with malonaldehyde show the u.v. absorption spectra and fluorescence excitation and emission spectra characteristic of the 1-amino-3-iminopropene crosslink.

The identification of malonaldehyde as a major radiolysis product of carbohydrates and polynucleotides places the evaluation of the safety of irradiated foods on a more scientific footing. The production of malonaldehyde and its reaction with DNA suggests that the biochemistry of malonaldehyde may be important to an understanding of the long-term effects of radiation damage as well as the safety of irradiated foods. Since malonaldehyde is also a product of lipid oxidation, it may be of general importance to such problems as aging and carcinogenesis.

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REGULATION OF EXOCELLULAR ENZYME SYNTHESIS AND SECRETION

H. Drucker
Biology Department

Cultures of Neurospora secrete a proteolytic activity when grown in a medium containing calcium, bovine serum albumin and a trace of sucrose. The secretion or synthesis of the proteolytic activity is catabolically repressed when substrate quantities of sucrose are present. In a comparable bacterial system, streptomyces fradiae, calcium appears to be required for either the synthesis or secretion of this proteolytic activity.

Examination of the effect of calcium on the activity of a representative bacterial protease, thermolysin, from Bacillus thermoproteolyticus, showed that the kinetic parameters K_m and V_{max}, determined for the substrate furylacryloylglycine leucinamide, vary with calcium concentration. In a complex fashion, K_m and V_{max} peak at calcium concentrations between 3×10^{-4} M and 7×10^{-5} M at all temperatures investigated. These results imply that calcium does not behave as a simple catalytic cofactor.

A model is proposed which suggests that there is a calcium dependant structural change which causes molecule X with kinetic properties A to become molecule Y, with different kinetic properties B. This transition occurs at a calcium ion concentration of about 7×10^{-5} M. At this low calcium concentration, molecule Y is autodigested resulting in an irreversible reaction.

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ROLE OF VASCULAR DAMAGE IN THE GASTROINTESTINAL RADIATION SYNDROME

B. W. Wachholz
Biology Department

The gastrointestinal epithelium and vasculature was studied in the rat, mouse, guinea pig, rabbit and miniature swine following whole-body or lower-body ^{60}Co-gamma, or x-ray exposures. Histopathologic changes were qualitatively similar but maximum injury occurred at different times postexposure in the several species. Gross vascular changes were particularly evident in the pig. Microscopically, there was partial or complete occlusion of the fine vasculature, usually coincident with epithelial injury. Additional evidence of endothelial changes and capillary congestion was obtained using electron microscopy. Infarction was observed in the pig as early as 6 days postexposure, coinciding with the period of maximum epithelial injury. The evolution of radiation ulceration was apparent in the pig from its early development to the later chronic stage that resembled the late radiation ulcer seen in man.

A further indication of vascular injury is the increase in the leakage of plasma protein into the irradiated intestine which we have measured in rats and pigs. The mechanism by which this leakage occurs, whether by a direct or an indirect means, is not yet clear, and may be similar to that responsible for the protein loss that occurs in patients with protein-losing enteropathy. Our experimental data suggests that the lymphatic system may be a significant factor in this increased protein leakage.

1071342

DOE ARCHIVES

AGE AND RADIATION CARCINOGENESIS

D. D. Mahlum
Biology Department

The carcinogenicity of radiation relative to age at exposure has been an important facet of our studies to define the influence of maturation on the response of animals to radiation. Two typical yet rather different experiments will illustrate our approach to this problem.

Newborn, weanling and adult rats were injected with 0.25, 0.5 or 1.0 μCi/g of ^{144}Ce. Randomly-selected animals were killed periodically for determination of radiation dose and of short-term morphologic and functional alterations. Radiation doses to the skeleton during the first 45 days after injection were similar for the weanlings and adults but were much less for the newborns. Osteogenic sarcomas have developed in animals injected as weanlings with 0.5 or 1.0 μCi/g. Adults injected with 1.0 μCi/g did not develop bone tumors although those that received 0.5 or 0.25 μCi/g did. No tumors were observed after any dose injected neonatally.

The relationships between the size of an irradiated skin area, age of the animal, radiation dose and carcinogenic response are being examined in another experiment. The skin of newborn, weanling and adult rats was exposed to doses of 1 to 10 krad of β-radiation from ^{204}Tl plaques of 0.01, 0.5 or 1.0 cm^2 area. At 15 months postexposure of male rats, tumors had developed at 25 of 94 sites irradiated in the newborn, at 9 of 79 sites irradiated in the weanlings, and at none of 191 sites in the adult group. The early responses (erythema, ulceration and scabbing), as seen in this experiment and in companion studies with miniature swine, were markedly greater in the immature animal. The size of the scarred area at maturity was inversely proportional to the age at exposure.

1071343

ARCHIVES

CHRONIC ^{90}Sr TOXICITY IN MINIATURE SWINE

W. J. Clarke
Biology Department

Since 1958 over 780 female Pitman-Moore miniature swine, representing three generations, have been fed daily doses of ^{90}Sr ranging from 1 to 3100 μCi/day, while 194 of their untreated littermates have served as controls. Sixty-nine of the ^{90}Sr swine have thus far developed hematopoietic disorders, 40 of which were neoplastic and 29 metaplastic, as compared to 2 cases of myeloid metaplasia in the controls. Significant increases in these disorders have occurred only in the 125 and 625 μCi/day groups; bone tumors have also been seen in 7 animals of these groups. There have been no significant changes in litter size, percent stillborn, birth weight, weaning weight, or sex ratios occasioned by the feeding of up to 625 μCi ^{90}Sr/day. This feeding level (625 μCi/day) is the equivalent of more than a million times the peak levels of ^{90}Sr ever reported in the American diet.

Special emphasis is now being placed on the isolation, identification, and adaption to tissue culture systems of viruses from some of the pigs with ^{90}Sr-induced leukemia. These viruses will be passed to immunologically depressed unirradiated animals in an attempt to transmit the leukemias.

A small number of cats are being exposed to ^{90}Sr to complement and augment the study in swine. Cats are particularly sensitive to bone marrow dysfunctions and resulting stem cell leukemias, and their shorter gestation period and smaller size is an advantage in these studies.

1071344

DOE ARCHIVES

DEVELOPMENT OF A BLOOD IRRADIATOR

F. P. Hungate
Biology Department

Blood irradiation to control diseases associated with high lymphocyte levels is known to be effective under conditions of acute radiation. Our laboratory animals with internally deposited radionuclides are often observed to have leukopenia, suggesting that chronic low-level irradiation of blood may be an effective treatment method. We are now developing an irradiator capable of being implanted and providing low-level continuous irraidation of the blood.

It was clear from calculations of internal and external dose rates that isotopes emitting photons with energies less than 50 kv would be most satisfactory. Four irradiators each less than 10 g in weight, were made using ^{55}Fe (5.9 kv) as the source. Two of these are now implanted in the thoracic aortas of dogs. Material selection and design of irradiators was facilitated by experience gained in the NCI-sponsored project on heat dissipation into blood.

Effects from chronic irradiation will be compared with those reported for acute exposures. Combinations of long with short half-life sources will be tested. Studies combining irradiation with drugs and application of these techniques to leukemic animals will be included in future plans.

1071345

DOE ARCHIVES

TOXICITY OF INHALED PLUTONIUM

J. F. Park
Biology Department

Studies were initiated 8 to 10 years ago to determine the biological effects of inhaled plutonium. Sixty-five beagle dogs inhaled $^{239}PuO_2$ and were held for life-span observations. Of 60 dogs that have come to autopsy, 58 died or were euthanized due to plutonium induced pulmonary fibrosis and/or neoplasia 2 to 110 months postexposure. Twenty-two of the dogs had primary pulmonary neoplasia including 18 of the 19 dogs that survived at least 4.5 years postexposure. The estimated initial alveolar deposition in the dogs with plutonium induced tumors ranged from 0.5 to 3.3 μCi. Five to 50% of the alveolar deposited plutonium was retained in the lungs. Twenty to 50% of the plutonium was translocated to lymphatic tissue, 2 to 25% to the liver and 2 to 10% to the skeleton. The highest plutonium concentration occurred in the lymph nodes, followed in descending order by lungs, liver and skeleton. Respiratory insufficiency and lymphopenia were the primary clinical signs associated with the fibrotic metaplastic and neoplastic changes in the lungs and fibrosis of the lymph nodes.

Experiments were initiated in 1970 to expose 200 dogs to $^{239}PuO_2$ and $^{238}PuO_2$ aerosols, depositing 3.0 to 0.002 μCi. The lowest level corresponds to the presently established maximum permissible average dose of 15 rem/year to the lungs. Comparison of effects will provide data on the influence of specific activity, since ^{238}Pu has a specific activity 280 times ^{239}Pu. This study should help to establish the critical tissues after inhalation of plutonium which will depend on the translocation rates from the lungs to lymph nodes, liver, and skeleton, and on the relative radiosensitivity of these tissues at the low exposure levels to be investigated.

1071346

DOE ARCHIVES

CO-CARCINOGENICITY OF URANIUM MINE AIR CONTAMINANTS

B. O. Stuart
Biology Department

In response to the growing national concern over the increased incidence of lung cancer among uranium miners of the Colorado Plateau, an experimental program was undertaken involving life-span daily inhalation exposures of dogs and hamsters to determine the biological effects of several potentially carcinogenic uranium mine air contaminants. In order to determine the possible synergistic actions of radon daughters, uranium ore dust, and diesel engine exhaust fumes in the production of respiratory tract and systemic organ pathology, six groups of 100 hamsters each are being exposed for 6 hours daily to the following aerosols: (1) 30 Working Levels of radon daughters, (2) 600 Working Levels of radon daughters, (3) 600 Working Levels of radon daughters with 20 mg of uranium ore dust/m^3, (4) diesel exhaust fumes, (5) diesel exhaust with 600 Working Levels of radon daughters and ore dust, and (6) laboratory air (controls).

Because only 3 to 4% of the uranium miners that developed lung cancer have not had histories of cigarette smoking, experiments were initiated using beagle dogs that receive daily exposures to radon daughters and uranium ore and/or cigarette smoking in a manner closely simulating the patterns of human exposure. Three groups of twenty dogs each are receiving daily inhalation exposures consisting of: (1) 4 hours of 600 Working Levels of radon daughters with uranium ore dust plus the smoke of 10 cigarettes over a 16-hour period, (2) 600 Working Levels of radon daughters with ore dust, and (3) cigarette smoking alone. A group of 9 dogs receive sham exposures. The current status of these studies will be discussed.

DOE ARCHIVES

A P P E N D I X

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BATTELLE-NORTHWEST STAFF EXPECTED TO PARTICIPATE

ENVIRONMENTAL AND LIFE SCIENCES DIVISION

Dr. Edward L. Alpen - Manager
Dr. Richard F. Foster - Associate Manager
Mr. James J. Fuquay - Associate Manager
Dr. Dennis W. Pearce - Technical Staff
Mr. Carl M. Unruh - Technical Staff

ATMOSPHERIC RESOURCES DEPARTMENT

Mr. Charles L. Simpson - Manager
Dr. Charles E. Elderkin - Manager, Atmospheric Physics Section
Mr. Roger K. Woodruff - Research Scientist
Mr. Lysle C. Schwendiman - Manager, Air Pollution Chemistry Section
Dr. W. George N. Slinn - Manager, Precipitation Physics Section

BIOLOGY DEPARTMENT

Dr. William J. Bair - Manager
Dr. Frank P. Hungate - Senior Research Associate
Mr. Carlos E. Newton, Jr. - Research Associate
Dr. Roy C. Thompson - Senior Research Associate
Dr. William J. Clarke - Manager, Pathology Section
Dr. James C. Hampton - Manager, Cytology Section
Dr. Maurice F. Sullivan - Manager, Physiology Section
Dr. D. Dennis Mahlum - Senior Research Scientist
Dr. Bruce W. Wachholz - Senior Research Scientist

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BIOLOGY DEPARTMENT (CONTD)

Dr. James F. Park	- Manager, Inhalation Toxicology Section
Dr. Bruce O. Stuart	- Senior Research Scientist
Dr. William Wiley	- Manager, Cellular and Molecular Biology Section
Dr. Harvey Drucker	- Senior Research Scientist
Dr. Daniel B. Menzel	- Manager, Nutrition and Food Technology Section

ECOSYSTEMS DEPARTMENT

Dr. Burton E. Vaughan - Manager

Mr. William L. Templeton	- Manager, Aquatic Ecology Section
Dr. Thomas P. O'Farrell	- Manager, Terrestrial Ecology Section
Dr. Lee L. Eberhardt	- Senior Research Scientist
Dr. William H. Rickard	- Senior Research Scientist
Dr. Keith R. Price	- Manager, Soil Relationships Section

RADIOLOGICAL SCIENCES DEPARTMENT

Dr. Julian M. Nielsen - Manager

Dr. A. Judd Haverfield	- Manager, Radiological Physics Section
Dr. William C. Roesch	- Senior Research Associate
Mr. H. Earl Palmer	- Senior Research Scientist
Dr. Ned A. Wogman	- Manager, Radiological Chemistry Section

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RADIOLOGICAL SCIENCES DEPARTMENT (CONTD)

Mr. Richard W. Perkins	- Research Associate
Dr. Louis A. Rancitelli	- Senior Research Scientist
Dr. Lynn J. Kirby	- Manager, Technical Analysis Section

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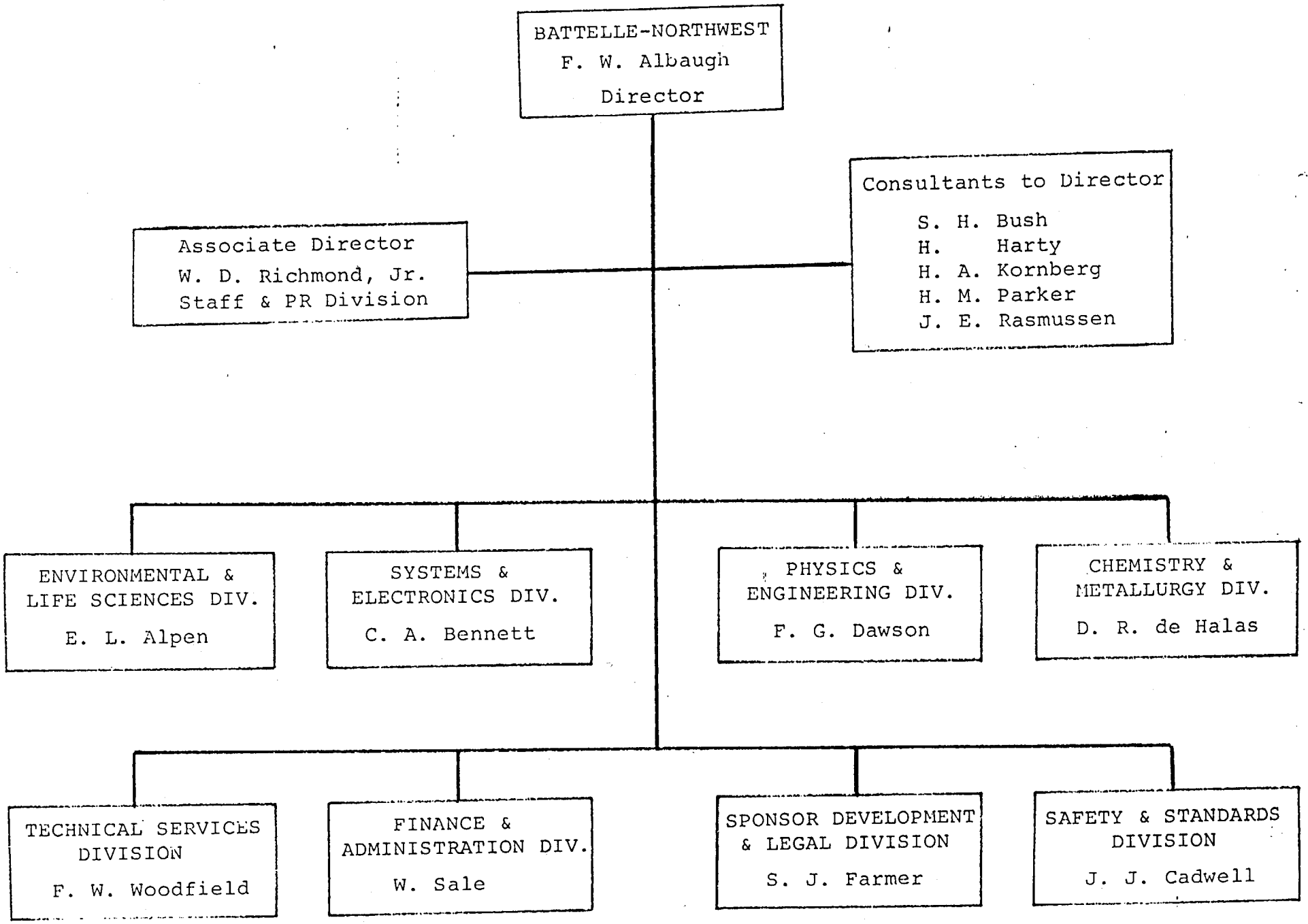

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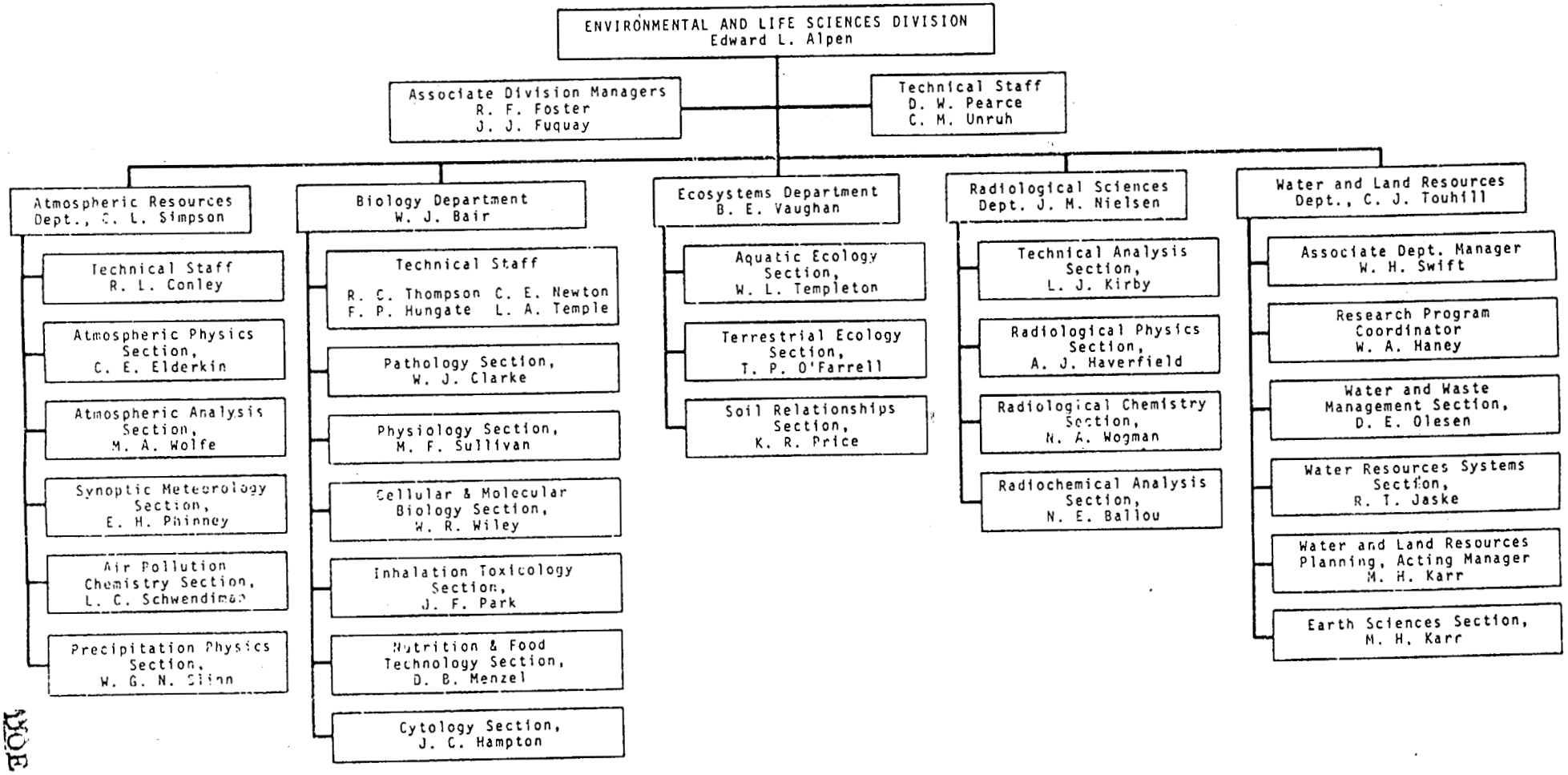

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