May 31, 1984

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of	)	
	)	
CAROLINA POWER & LIGHT COMPANY	)	Docket Nos. 50-400 OL
and NORTH CAROLINA EASTERN	)	50-401 OL
MUNICIPAL POWER AGENCY	)	
	)	
(Shearon Harris Nuclear Power	)	
Plant, Units 1 and 2)	)	

APPLICANTS' TESTIMONY OF LEONARD D. HAMILTON ON WELLS EDDLEMAN'S CONTENTION 8F(1) (TABLE S-3 COAL PARTICULATES)

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I. Introduction

My name is Leonard D. Hamilton. I am currently, and have been since its inception, the head of the Biomedical and Environmental Assessment Division in the National Center for Analysis of Energy Systems at Brookhaven National Laboratory, Associated Universities, Inc., Upton, New York 11973. The Biomedical and Environmental Assessment Division at Brookhaven National Laboratory is an interdisciplinary group that assesses the health and environmental impacts of all energy sources from exploration to end use. Much of our effort over the past ten years has focused on dose-response relationships for air pollution from fossil fuel combustion for electricity generation. A statement of my background and qualifications is provided in Attachment 1. Statements contained herein are my personal opinion and are not necessarily those of Brookhaven National Laboratory.

Eddleman Contention 8F(1) alleges that Appendix C of the Shearon Harris Final Environmental Statement (FES) underestimates the environmental impact of the effluents in Table S-3 because "the health effects of the coal particulates," quantified at 1,154 MT per year, "are not analyzed nor given sufficient weight" therein. In supporting his contention, Mr. Eddleman states that emissions which "are about two-tenths [sic] of one percent of U.S. emissions" may cause up to 10

deaths per year, a number which is "[n]ot trivial."1/ This testimony will demonstrate that Mr. Eddleman is incorrect and that the health effects of particulate effluents specified in Table S-3 were adequately assessed and given sufficient weight by the NRC Staff.

In the FES, the Staff found that the emissions specified in Table S-3 "constituted an extremely small additional atmospheric loading in comparison with the same emissions for the stationary fuel-combustion and transportation sectors in the U.S.; that is, about 0.02% of the annual national releases for each of these species. The staff believes that such small increases in releases of these pollutants are acceptable." FES, Appendix C at C-2. (Mr. Eddleman misquotes the FES in his statement of support for Contention 8F(1) in that the figure "two tenths of one percent" should actually be "two one hundredths of one percent" or two ten thousandths of the annual U.S. coal particulate emissions.)

II. Significance of Table S-3 Coal Particulates Issue

Before beginning my analysis of the possible health effects of 1,154 MT of coal particulates associated with the estimated electrical energy needed to support the uranium fuel

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1/ See Wells Eddleman's Response to Staff DEIS, June 20, 1983, at page 14.

cycle for one year, I would like to draw attention to the limited and therefore possibly misleading nature of such an assessment. Operation of a new nuclear power plant, such as the Shearon Harris Plant, will result in the retirement earlier than otherwise possible of old coal-fired plants with much higher rates of particulate emissions and, consequently, greater health and environmental impacts than the Shearon Harris Plant and associated fuel cycle activities. The net result of such a replacement is thus a considerable reduction in health and environmental impacts which is not included in Table S-3 or in my analysis here. With this caveat in mind, this testimony explains why the Staff succinctly and correctly concludes in the FES that there is a miniscule incremental environmental impact from the coal particulates identified in Table S-3.

III. Basis for Table S-3 Particulate Figure

The emission of 1,154 MT of particulates a year is a hypothetical attribution. It is used in Table S-3 in order to calculate a reasonable estimate of the particulate emissions that might be associated with the electrical energy produced by the equivalent of a hypothetical 45 MWe coal-fired power plant operating for one year; this is the estimated energy needed to support the uranium fuel cycle for one year of the Harris Plant's operation. Most of this energy is used in the uranium enrichment process at gaseous diffusion plants.

The three gaseous diffusion facilities used in the uranium enrichment process are located at (1) Paducah, Kentucky; (2) Oak Ridge, Tennessee; and (3) Portsmouth, Ohio. These facilities are supplied with electricity primarily from power grids. Thus, the impact of the particulates released from coal plants supporting the uranium fuel cycle in fact are distributed in small amounts over large areas. However, for purposes of my calculations to estimate an upper limit of health risks, I have made the following assumptions. From the TVA's grid system, I have assumed the Bull Run Plant to be the only plant serving Oak Ridge, and the Shawnee Plant to be serving Paducah, Kentucky. I have also assumed that the following facilities are dedicated to providing electric power to their respective locations: the Joppa Plant (in addition to the Shawnee Plant), supplying Paducah, Kentucky, and the Kyger and Clifty Plants, supplying Portsmouth, Ohio. I have also assigned the hypothetical 1,154 MT of particulates individually to each of these power plants on the basis of two different assumptions: first, that any one of these coal plants may be singly responsible for the electricity used to produce the entire enrichment of uranium needed to supply the Shearon Harris Nuclear Power Plant; and second, that the source of energy to support the uranium enrichment process may be divided equally among these coal plants (see Section IV.C).

IV. Particulate Concentration Levels and their Significance

A. Particulate Concentration Levels

In order to provide an understanding of the upper boundary of any possible risks to health, there are several different ways to analyze the impact of the coal emissions assumed in Table S-3. First, I have estimated the concentration of particulates in the atmosphere produced by the hypothetical 1,154 MT of emitted particulates. This calculation assumes that in the region (50-mile radius) near the coal plant supplying power for each enrichment facility, emissions are uniformly mixed in the volume of air contained in a cylinder with a radius of 50 miles and a height equal to the average height of the mixing layer of air (see Table 1, below). The concentration of particulates in the 50-mile region is a function of the quantity of emissions released by the coal plants and the wind speed. Thus, the total emissions mixed in this volume are related to the time it takes for the wind to blow the particles 50 miles from the stack to the edge of the cylinder. This calculation yields a rough estimate of the long-term average coal particulate exposure over the 50-mile radius area. Of course, on an individual basis, persons closer to the plant would receive greater exposures than those farther away. Similarly, individuals living downwind from the plant would receive larger exposures than those living upwind.

I have calculated the exposure to particulates in the area of each of the coal plants supplying energy for the enrichment facilities, assuming 1,154 MT/yr of particulate emissions and annual average daytime conditions as shown in Table 1.2/

Table 1

Annual Average Daytime Meteorological Conditions
(Holzworth, 1972)

	Wind Speed (m/sec)		Mixing Layer (m)	
	am	pm	am	pm
Paducah, KY				
Joppa Plant	5	6.5	450	1400
Shawnee Plant	5	6.5	450	1400
Oak Ridge, TN				
Bull Run Plant	5	6	450	1600
Portsmouth, OH				
Kyger Plant	5	6	520	1400
Clifty Plant	5	6.5	420	1400

2/ The small amount of particulates equivalent to the emissions of a hypothetical 45 MWe coal-fired plant actually attributable to the nuclear fuel cycle is in reality much smaller than the 1,154 MT/yr set forth in Table S-3. The allowable emission rate for three of the coal plants that supply power to the uranium enrichment facilities (Shawnee Plant, 0.11 lb/10E6 Btu; Bull Run Plant, 0.10 lb/10E6 Btu; and Kyger Plant, 0.10 lb/10E6 Btu) are roughly one-eighth of the figure given for the particulate emission rate in Table S-3. See 401 Ky. Admin. Reg. § 61:015 (Shawnee Plant); Tenn. Dept. Public Health, Div. of Air Pollu. Control Regs. Ch. 1200-3-16-.02 (Bull Run Plant); Ohio EPA Regs., § 3745-17 (Kyger Plant). The allowable emission rate for the Joppa Plant is 0.19 lb/10E6 Btu, which is roughly four times lower than the figure given for particulates in Table S-3, while the rate at the Clifty Plant of 0.236 lb/10E6 Btu is approximately three times lower. See Ill. Pollu. Control Bd. Rules & Regs., Ch. 2, Pt. II, Rule 203(g)(1)(C) (Joppa Plant); Ind. Control Bd. Regs., § 325 IAC 6-2 (Clifty Plant).

These data are used to calculate particulate concentration using the equation:

$$\text{Concentration } (ug/m^3) = \frac{\text{Emission Rate (ug/sec) x Radius(m)/Wind speed (m/sec)}}{\pi \times \text{Radius}^2(m^2) \times \text{Mixing Height(m)}}$$

(Where a 50-mile radius is 8×10^4m and 1154 MT particles/yr = 3.6×10^7 ug/sec.)

Estimated daytime concentrations for the five plants are shown in Table 2.

Table 2

Estimated Average Daytime Concentrations in a Cylinder of Radius 80 km and Height Equal to that of the Mixing Surface Layer of Air

Location	Concentration (ug/m^3)		
	am	pm	Average
Paducah, KY			
Joppa Plant	0.064	0.016	0.040
Shawnee Plant	0.064	0.016	0.040
Oak Ridge, TN			
Bull Run Plant	0.064	0.015	0.040
Portsmouth, OH			
Kyger Plant	0.055	0.017	0.036
Clifty Plant	0.068	0.016	0.042

These simplified concentration estimates depend on both wind speed and depth of the mixing surface layer, which are closely linked. The faster the wind blows, the deeper is the mixing surface layer. Also, faster wind results in reduced residence time, hence lower concentrations. (Holzworth, 1972).

B. Comparative Assessment of Impact of Particulate Concentration Levels

From an uncontrolled pulverized coal-fired power plant -- the type specified in WASH-1248 (see page D-16 at Table D-6), from which the annual particulate emission rate of 1,154 MT was derived -- the respirable particles (<10μm), called "thoracic particles" or "TP", constitute only about 40 percent of the mass of the total particulates (Fisher and Natusch, 1979).3/ Larger particles tend to be deposited in the nose or pharynx and do not reach the lung. Thus, only 40 percent of the particles released potentially are damaging to health. Using the above equation, this means that the concentration of TP that would penetrate the thoracic region, i.e., "both alveolar and tracheobronchial penetration,"4/ would be about

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3/ WASH-1248 states that the 1,154 MT of particulates per year was derived from a particulate emission rate of 22 lb/MT of coal with a heat value of coal of 13,000 Btu/lb. This represents the particulate emission rate of an uncontrolled plant, of which few remain.

4/ United States Environmental Protection Agency (EPA) Office of Air Quality Planning and Standards (OAQPS) Staff Paper in its "Review of the National Ambient Air Quality Standards for Particulate Matter: Assessment of Scientific and Technical Information," January 1982 EPA-450/5-82-001, at page 75.

0.014-0.017 ug/m^3. This concentration range is derived using the high and low average concentration estimates specified in Table 2.

For perspective, this concentration of TP (0.014-0.017 ug/m^3) should be compared with the EPA's estimate of potentially injurious concentrations of TP. In a critical review of the available scientific and technical information most relevant to the review of primary (health) National Ambient Air Quality Standards (NAAQS) for particulate matter, EPA states:

> Based on a staff assessment of the short-term epidemiological data, the range of 24-hour TP levels of interest are 150 to 350 [micrograms per cubic meter]. Under the conditions prevailing during the London studies, the upper end of the range represents levels at which effects are likely in the sensitive populations studied. Given the uncertainties in translating these results to U.S. conditions and the seriousness of the potential health effects, the upper end of the above range contains no identifiable margin of safety and should not be considered as an appropriate standards alternative. The uncertainties and the nature of the potential effects are important margin-of-safety considerations. Neither the studies used to derive the range nor more qualitative studies of effects in other sensitive population groups (e.g., asthmatics, children), or effects in controlled human or animal studies provide scientific support for health risks of consequence below 150 [micrograms per cubic meter]. . . <u>Based on a staff assessment of the long-term epidemiological data, the range of annual TP levels of interest are 55 to 110 [micrograms per cubic meter]</u>. The upper end of this range overlaps the somewhat uncertain "effects levels" derived from these studies. Due to these uncertainties, the upper end of the range (110 [micrograms per cubic meter]) may not include any margin of safety, and should not be considered as an appropriate standard

> alternative. The lower end (55 [micrograms per cubic meter]) represents a level where some risk of symptomatic effects might remain but no detectable differences in pulmonary function or marked increases in respiratory diseases are expected. Increases in symptomatic effects at the lower levels are uncertain and small in comparison to baseline rates (emphasis added).5/

In other words, EPA has concluded that from both short- and long-term exposures to particulates, the "bottom line" or lowest level of TP at which there may be some risk of health effects is approximately 55 ug/m^3. As stated above, the concentration of such particulates in the atmosphere, assuming a reasonable distribution of the entire 1154 MT in a 50-mile radius around a single coal plant, would be 0.014-0.017 ug/m^3. This means that even if the 1,154 MT was all distributed by a single coal plant in one place, which obviously is not the case since three different gaseous diffusion plants are used in the enrichment process, the concentration would be approximately 3,000 times smaller than the minimum concentration having some risk of symptomatic effects. While the 0.014-0.017 ug/m^3 of TP is an incremental concentration to a pre-existing background concentration of TP, its proportional responsibility for any biological effect is equally miniscule.

5/ EPA op. cit. pages 112-113.

C. Numerical Assessment of Impact of Particulate Concentration Levels

1. Fifty-Mile Population

In addition to the comparative analysis above, I have calculated some conservative estimates of possible health effects of coal emissions attributable to the Harris Plant's uranium fuel cycle needs. In this calculation, I have used a damage function for respirable particulates in a linear non-threshold way, thereby conservatively assuming that even the smallest incremental particulate dose has an incremental health effect. Moreover, to provide an understanding of the upper boundary of risk from coal particulates emitted in support of the uranium fuel cycle, I also have conservatively assumed that the entire hypothetical 1,154 MT of particulates are emitted and expose the 50-mile population around each of the fossil plants serving the three gaseous diffusion facilities.6/

The calculated health risk relies upon a damage function for fine particles developed recently by the Harvard University Energy and Environmental Policy Center.7/ This study recommends, for quantitative risk assessment, use of only a fine

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6/ This assumption ignores the fact that the 1,154 MT is roughly 3 to 8 times more than the actual particulates those plants emit per 45 MWe equivalent. See note 2, supra.

7/ See "Analysis of Health Effects Resulting from Population Exposures to Ambient Particulate Matter" October 1983 ("Harvard Report"), prepared for the Health and Environmental Risk Analysis Program of the U.S. Department of Energy.

particles (FP) risk coefficient, or particles smaller than 2.5 micrometers.8/ FP represent a small portion of the thoracic particles (TP) previously described. (Fine particles are about 10 percent of the total particulate emissions from an uncontrolled pulverized coal-burning power plant (Fisher and Natusch, 1979).) The FP damage function, which is 1.3 $\pm$ 0.6 deaths/year/10^5 persons per ug/m^3 FP, is derived from available cross-sectional mortality analyses.9/

Using this damage function, and the 10 percent FP function, I have calculated the expected excess deaths per year from population exposure to 1,154 MT/yr total particulate emissions around each of these plants (Table 3). These estimated excess deaths should be compared with the expected deaths from all causes in the population around each of these plants; this is also shown in Table 3. The estimated excess deaths from particulate exposure are indistinguishable from zero against the background of expected deaths from all causes. The upper limit of estimated expected deaths from particulate exposure corresponds to about one one-thousand of one percent of the mortality rate.

8/ See Harvard Report at page 8 and Table 1, page 5.

9/ Id. at page 45-50.

Table 3

Estimated excess deaths per year from population exposure to 1,154 MT/yr total particulate emissions and total deaths from all causes.

Location	Excess Mortality (deaths/yr)		
	Expected from particulate exposure*	95% range	Expected from all causes
Paducah, KY			
Joppa Plant	0.014	0.001-0.027	2,400
Shawnee Plant	0.017	0.0015-0.032	2,800
Oak Ridge, TN			
Bull Run Plant	0.044	0.004-0.080	7,400
Portsmouth, OH			
Kyger Plant	0.014	0.001-0.027	2,600
Clifty Plant	0.068	0.006-0.13	11,000

* In my original affidavit I conservatively assumed that respirable particles ($< 10\mu m$) or "TP" constituted about one half the mass of the total particulates, while in fact they constitute only about 40% of the mass of the total particulates. I also overly conservatively assumed that the fine particles ($< 25\mu m$) or "FP", as used in the Harvard damage function, were the same as the TP, while in fact FP constitute only 10% of the mass of the total particulate emissions from an uncontrolled pulverized coal-burning power plant (Fisher and Natusch, 1979).

The above estimates are based on the assumption that any one of these plants may be singly responsible for the electricity which supplies the entire enrichment of uranium needed to supply the Shearon Harris plant. Using this assumption, the greatest health risk posed by the coal used to supply uranium enrichment facilities is 0.068 deaths annually for the 50-mile population around the Clifty Plant.

An equally plausible assumption is that uranium enrichment services are being supplied equally by all three facilities to produce fuel for the Shearon Harris plant. Using this assumption, the amount of coal generated for each facility would be divide. by three and health risks associated with each site would be similarly reduced.10/ This would result in a worst case health risk of 0.023 deaths annually.

These calculations are conservative estimates. The actual numbers could be zero. As the Harvard Report states:

> [T]he FP coefficient is most representative for an "average" urban aerosol composition and will, to some extent, be subject to the biases noted for sulfates when applied to aerosols having a makeup very different from from the mean composition . . . Although the use of a fine particle mortality coefficient should provide an improvement over previously used cross-sectional indices of particle air pollution, we must emphasize the large uncertainties surrounding any such damage coefficient. Indeed, despite the fact that the coefficient is statistically greater than zero, uncertainties not considered by such analyses (e.g., errors in the measurement of the exposure variable) make it possible that the mortality risk might in fact be zero.

Harvard Report at pages 8, 50 (emphasis added).

10/ This calculation does not account for different quantities of energy being supplied by more than one coal plant in the vicinity of the uranium enrichment plant.

2. U.S. Population

An alternative way to calculate the health (mortality) effects of coal particulate emissions attributable to the uranium fuel cycle is to consider the health risk for the entire United States due to the long-range transport of these particulates. Based on the Brookhaven National Laboratory's Biomedical and Environmental Assessment Division's matrix results (Rowe, 1981), it is estimated that the average total U.S. exposure to fine particles from all coal power plants is 90 person-ug/m^3 per MT emissions. Using the FP damage function cited above,11/ the calculated additional deaths in the entire U.S. population from coal particulates associated with the uranium fuel cycle would be 0.13, with a 95 percent statistical range 0.013-0.26. In the entire U.S., roughly 2 million die annually from all causes.

In assessing the 50-mile and U.S. population risk estimates described above, it is important to keep in mind that linear dose-response functions are not able to distinguish between large doses to a few persons and small doses to many persons. The estimates for health effects of long-range transport are based on exceedingly small exposures to millions of persons. Since the human body has many defenses against low-level exposure to particles, these small doses are probably less harmful per unit exposure than higher doses. The long-range

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11/ The calculation is (90 person-ug/m^3 per MT) (1154 MT) (0.1 FP/total emissions) (1.3E-05 deaths-m^3/person/ug).

transport health effects estimates therefore probably are biased on the high side.

It also must be recognized that the health-damage function described above links annual average fine particle exposure to increased annual mortality rate. It does not represent the acute effects of exposure but, rather, the long-term impact on the population of a continuing (chronic) environmental exposure. The mortality rates calculated above are based on the assumption that, although the sequence of events leading to its impact on the population is unknown, long-term exposure to fine particles, particularly in childhood, presumably increases the susceptibility to respiratory infection. A history of repeated respiratory infection, possibly coupled with continued fine particle exposure, increases the prevalence of chronic respiratory disease. This leads to more deaths from a broad range of cardiopulmonary diseases. Implicit in this hypothesis, therefore, is the assumption that the exposure to fine particles that eventually is reflected in mortality rate is continuous and long-standing.

V. Conclusions

In summary, the 1,154 MT of annual particulates referenced in Table S-3 is a hypothetical figure for the sole purpose of calculation of estimates of the level of particulate emissions that might be emitted from a 45 MWe coal-fired plant. This figure essentially is based on the annual quantity of energy

from coal plants needed to support the uranium enrichment facilities that are part of the uranium fuel cycle. Conservative calculations of the upper limit of health risk which may be associated with the 1,154 MT figure indicate that atmospheric concentrations of the amount of particulates attributable to a 45 MWe coal-fired plant reasonably distributed over a 50-mile radius would be 3,000 times smaller than the minimum concentration determined by the EPA to present some health risk. Moreover, conservative calculations of the upper limits of risk of those particulates distributed among the populations around the five fossil plants supplying the uranium enrichment facilities indicate that, at most, a tiny fraction of a death, each year those plants are in operation, could be attributed to the particulate emissions. This quantity is extremely small, particularly when compared to the deaths one would expect in those same populations from all causes. This upper limit of risk is confirmed by an alternative calculation of the impact of the Table S-3 particulates over the population of the entire United States. Moreover, these calculations assume that exposure from particulates is long standing; otherwise, the calculated impact is inapplicable.

Attachment 1

DR. L. D. HAMILTON

PERSONAL QUALIFICATIONS

My name is Leonard D. Hamilton. My address is: 6 Childs Lane, Setauket, New York, 11733. I am, among other responsibilities, Head of the Biomedical and Environmental Assessment Division in the National Center for Analysis of Energy Systems at Brookhaven National Laboratory, Associated Universities, Inc., Upton, New York, 11973. The Biomedical and Environmental Assessment Division is jointly sponsored by the Department of Energy and Environment and Medical Department at Brookhaven. The Biomedical and Environmental Assessment Division (BEAD) aims at developing a realistic assessment of biomedical and environmental effects of energy production and use. All forms of energy, including electric power generation using fossil fuels, hydro, nuclear, and new technologies, are assessed. The Biomedical Environmental Assessment Division is the lead group in the Health and Environmental Risk Analysis Program, Human Health and Assessment Division, Office of Health and Environmental Research, Office of Energy Research, U. S. Department of Energy, assessing the health and environmental effects of energy production and use and among other responsibilities is charged with producing a comparative health and environmental effects assessment of the different energy systems. The Biomedical and Environmental Assessment Division also has substantial support from the U.S. Environmental Protection Agency and is the lead group for assessing the health effects of complex technologies. The Division is designated a World Health Organization and United Nations Environment Program [WHO & UNEP] Collaborating Centre for the Assessment of Health and Environmental Effects of Energy Systems.

I have been involved in assessing the risks of radiation for man for 37 years, specifically the health effects of nuclear energy for electric power generation for 22 years, and the assessment of the comparative health effects from various energy sources, for the past 10 years. The Biomedical and Environmental Assessment activity formally began in July, 1973; for the past and present year our level of effort is 204 man-months annually.

I received my Bachelor of Arts in 1943 and qualified in medicine from Oxford University in 1945. I am a registered medical practitioner in the United Kingdom and licensed physician in New York State. After several positions in University hospitals, which included a position as Resident Medical Officer at the Radiotherapeutic Centre, Addenbrooke's Hospital, Cambridge, during which time I was concerned with the management of cancer patients undergoing treatment with radiation, I proceeded to research at Cambridge University on histological studies of the mechanism of the action of therapeutic doses of ionizing radiation for which I received my Ph.D. in experimental pathology in 1952. In the meanwhile, in 1951, I had received my Doctor of Medicine degree from Oxford; this is a senior medical qualification in the United Kingdom, roughly equivalent to Diplomate in Internal Medicine in the United States. I am also a Diplomate of the American Board of Pathology (Hematology).

From 1950-1964 I spent 14 years on the research staff of the Sloan-Kettering Institute for Cancer Research and on the clinical staff of Memorial Hospital in New York being Associate Member and Head, Isotope Studies Section at the Institute and Assistant Attending Physician,

Department of Medicine at Memorial. During this time I was also a member of the faculty of Cornell University Medical College and a Visiting Physician, Cornell Division, Bellevue Hospital. Since then I have maintained a continuing association with the Sloan-Kettering Institute as Associate Scientist.

At the Institute my laboratory research was on the molecular structure of the genetic material (DNA) and the cells in man concerned with the immune mechanism. I provided the DNA on which the proof of the double-helical structure of DNA is based, and was one of the first to establish the long life of the immune cells in man. My clinical work in Memorial Hospital involved research on the treatment of patients afflicted with cancer and leukemia with new chemical agents and also with new applications of radiation therapy.

In 1964 I joined the scientific staff of Brookhaven National Laboratory as Senior Scientist and Head, Division of Microbiology, and Attending Physician, Hospital of the Medical Research Center. Since 1973 I have been Head of the Biomedical and Environmental Assessment Group which in 1976 became a Division of the National Center of Analysis of Energy Systems.

At Brookhaven I continued my laboratory research begun at Sloan-Kettering. In addition since my Visiting Fellowship at St. Catherine's College, Oxford 1972-73, I have been concerned with placing all risks in life in perspective; and since becoming Head of the Biomedical and Environmental Assessment activity in 1973, particularly with the assessment of the hazards associated with different energy sources and their use. Our group has the lead responsiblity to DOE for

the assessment of health and environmental effects from various energy systems, and of coordinating such assessments in national laboratories, universities and research institutes in the United States.

My interest in the risks of radiation for man began with my Ph.D. work in Cambridge in 1946 and, since DNA and the immune system are prime targets of radiation damage has continued throughout my laboratory research. I was associated informally with the United Nations Scientific Committee on Effects of Atomic Radiation (UNSCEAR) almost since its inception in 1957, served as Consultant, Office of the Under-Secretaries for Special Political Affairs (UNSCEAR), 1960-62, and was responsible for the first draft of the somatic effects of radiation in the 1962 report. This section covers the effects of radiation in inducing leukemia and cancer in man. I have reviewed most of the working papers of UNSCEAR since then. I was a member of the National Research Council-National Academy of Sciences (NAS-NAS) Committee on Biological Effects of Atomic Radiation, Subcommittee on Hematologic Effects, 1960-64, the NRC-NAS Solar Energy Research Institute Workshop, 1975, the NRC-NAS Committee on Environmental Decision Making, Steering Committee on Environmental Monitoring, Panel on Effects Monitoring 1975-76, the NRC-NAS Health Effects Resource Group, Risk Impact Panel of the Committee on Nuclear and Alternative Energy Systems (CONAES) 1975-80, the NRC-NAS Panel on the Trace Element Geochemistry of Coal Resource Development Related to Health 1976-80, and the NAS-NRC Committee on Research Needs on the Health Effects of Fossil Fuel Combustion Products, 1976-80.

I was a member of the Mayor's Technical Advisory Committee on Radiation, New York City, since 1963 until its end, December, 1977 and

have been a member of the Technical Advisory Committee on Radiation to the Commissioner of Health of the City of New York since August, 1978.

Since 1972, I was a Consultant to the Environment Directorate, Organization for Economic Co-operation and Development; since 1976 served as DOE (formerly ERDA) Representative in the U. S. Delegation to the Environment Committee and U. S. delegate to the Joint Environment-Energy Steering Group. I was a member of the United Nations Environment Programme (UNEP) International Panels of Experts on the Environmental Impacts of Production, Transportation, and Use of Fossil Fuel 1978, on the Environmental Impacts of Nuclear Energy 1978-79, on Renewable Sources of Energy and the Environment 1980, and on the Comparative Assessment of Environmental Impacts of Different Sources of Energy, 1980. I was a member of the Beijer Institute, UNEP, and USSR Commission for UNEP International Workshop on Environmental Implications and Strategies for Expanded Coal Utilization, 1980.

I am currently a member of the U. S. Department of Health and Human Services, Public Health Service Centers for Disease Control, National Institute for Occupational Safety & Health group of consultants advising on the epidemiological study of the employees at the Portsmouth Naval Shipyard where an alleged increase in leukemia was reported by Najarian and Colton in 1978, and a Consultant to the Division of Environmental Health, World Health Organization and the United Nations Environment Programme on the comparative health effects of different energy sources.

I have been Professor of Medicine, Department of Medicine, Health Sciences Center, State University of New York at Stony Brook, New York since 1968 and I am currently a member of the American Association for

Cancer Research, American Society for Clinical Investigation (emeritus), American Association of Pathologists, Inc., the Harvey Society, and the British Medical Association.

I have published more than 150 scientific papers, including many reports assessing the hazards of various energy sources.

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