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RECEIVED MAR 12 1981 U.S. NUCLEAR REGULATORY COMMISSION

MAR 1 1 1981

Ms. Mary Sinclair
5711 Summerset Drive
Midland, Michigan 48640

Dear Ms. Sinclair:

I am writing in response to your letter of February 6, 1981 to Chairman Ahearne.

Dr. Gotchy is a well known and respected professional in the national community of individuals who are called upon to evaluate the risks associated with energy production. His talk at the annual meeting of American Association for the Advancement of Science was well received, and I am sorry to learn of your reaction that it was a whitewash of the risks of nuclear power. His analyses have been reviewed by his peers and occasionally challenged in adjudicatory proceedings and have been improved by and withstood the implications of those challenges. With regard to risks of radiation and radioactivity, much more is known than for risks associated with other potential pollutants, so that analyses such as Dr. Gotchy's can be carried out with relative accuracy and authenticity. To put his reported results in perspective, I'm enclosing recent summaries of comparative risks from the Congressional Research Service of the Library of Congress and the Health and Safety Executive for the United Kingdom.

You are concerned that Dr. Gotchy did not mention plutonium. However, plutonium is in the source term for releases from reprocessing plants and the radiological impact or risk of plutonium is therefore included in the risk analysis of his paper as part of reprocessing risks. You also characterize the comparison of Three Mile Island doses with Denver doses as misleading. Only inplant and effluent monitors at Three Mile Island were "going off scale." It is accurate to compare the doses that the people off site nearest to the plant received during the course of the accident with the increase in annual background dose that people get by living at the high altitude of Denver because the doses were about equivalent. Although potassium iodide was considered for distribution at TMI when it was feared that radioactive iodine might be a major release from the plant, the actual radioiodine release was very small and potassium iodide distribution would not have significantly changed the collective doses to the thyroids of people in the area. The enclosed report, "Population Dose and Health Impact of the Accident at the Three Mile Island Nuclear Station," NUREG-0558, describes the actual doses from the accident.

We have read the material you enclosed with your letter. Much has been done by NRC and by state and local governments to improve response mechanisms in the areas around all nuclear power plants and to conduct exercises to test such mechanisms. This includes a thorough examination of the potassium iodide stocking issue. Health effects studies have been followed up, and as can be

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seen from the attached paper from the U.S. Center for Disease Control regarding neonatal hypothyroidism in Pennsylvania, have not shown a real increase in health effects around nuclear plants. The NRC has investigated many accusations that there are adverse health effects in the vicinity of nuclear facilities and found them unsubstantiated by the medical evidence. I cannot respond to your notations on enclosures to your letter or Dr. MacLeod's charge that health effects data has been withheld or falsified. However, I can assure you that many of the recommendations made in his paper have in fact been implemented even before the preparation of his paper.

For your further information, I've enclosed a copy of an article by Dr. Bernard Cohen who is on the staff of the University of Pittsburgh, as is Dr. MacLeod. Dr. Cohen has summarized very completely the cancer risk from low-level radiation. I've also enclosed Dr. Fabrikant's recent article on the health effects of the TMI accident. In closing, should you like to more fully evaluate Dr. Gotchy's estimates of the health risks of the nuclear fuel cycle, the details of his assessment will be included as a chapter in the AAAS Symposium Series entitled "Health Risk Associated with Energy Technology," scheduled for publication later this year.

Sincerely,

Original Signed by
H. R. Denton

Harold R. Denton, Director
Office of Nuclear Reactor Regulation

Enclosures:
1. Summaries frm Congressional Service, Library of Congress and Health and Safety Executive for the United Kingdom
2. Paper on Neonatal Hypothyroidism in Southeastern Pennsylvania
3. Paper on the Cancer Risk frm Low-Level Radiation
4. Paper on the Health Effects of the Nuclear Accident at TMI
5. NUREG-0558

cc: Chairman Hendrie
Commissioner Gilinsky
Commissioner Bradford
Commissioner Ahearne
Senator Don Riegle
Senator Carl Levin
Congressman Don Albosta

ENCLOSURE 1a

COAL AND NUCLEAR POWER POLICIES: SEEKING PROTECTION FROM UNCERTAIN RISKS

A REVIEW OF HEALTH, SAFETY AND ENVIRONMENTAL FACTORS

Langdon T. Crane
Specialist in Science and Technology
Science Policy Research Division

August 1, 1980

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A SUMMARY OF HEALTH RISK ESTIMATES

Table 3 illustrates the safety and health data on the risks associated with coal and nuclear power plants as described in Part B of this report.* The numbers have been scaled wherever necessary to indicate the health risks that are expected to be associated with the operation of a 1000 megawatt power station operating for one year at a load factor of 0.75. For a coal combustion plant of that size as typically equipped today, the "most probable" estimates of the total death risks range from about 25 to 257 fatalities per year of operation of an existing plant, or from about 5 to 137 fatalities per year of operation of a new plant, most of them among the general public as a result of emissions of sulfur dioxide and particulates. The incidence of chronic and acute health problems among the general public is also expected to be high as a result of coal combustion at the generating plant. Apart from plant emissions, deaths can be expected among the general public from two associated activities. The processing of the coal--i.e., the cleaning, crushing, and washing of the coal, which is usually done in the vicinity of the mine--may cause a number of deaths through local air pollution; and there may be about two deaths resulting from highway accidents involving private autos and coal-hauling trains. Occupational health risks associated with the operation of a 1000 megawatt coal plant for a year may be substantially less than the risks to the general public. If the coal is mined underground, one miner will die from accidental causes and as many as 3.5 may die on the average

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* Data in this table are from the references cited in part B of the report. Sources used most extensively were (1) the OTA report entitled "The Direct Use of Coal," (2) NRC report NUREG-0332 revised, as reported in NRC hearings document [illegible], (3) GESMO (NUREG-0002, vol. 3), and (4) WASH-1400. (See reference list for complete entries.)

diseases associated with the [illegible] of coal; and as many as [illegible] on the average, contract pneumoconiosis per year of plant operation. The figures will be lower if the coal is mined on the surface: a miner may die only every four years, and a case of pneumoconiosis may be contracted only every two years of plant operation. Another occupational health hazard is the transportation of coal, where there may be a death as often as every two and one-half years of plant operation in moving the coal for one such generating plant.

The health risks associated with the operation of a 1,000 megawatt nuclear plant are lower, if the estimates are reliable. Apart from the possibility of nuclear accidents, estimates indicate that, among the general public, one person may die for every ten years of plant operation as a result of the gases released from mine tailings; and possibly one person might die for each year of plant operation as a result of gases released from mill tailings. Operation of the power plant itself has not been estimated to be as large a hazard as the mining and milling tailings piles: approximately one death for every 50 years of plant operation among the general public, according to latest estimates. The number of deaths through occupational hazards involving radioactivity is approximately equal to the number of deaths among the general public, though the sources of radiation exposure are different. The largest occupational risk from radioactivity is in the operation of the generating plant itself, where one worker may die for every 16 years of plant operation. A slightly lower risk is associated with mining of the uranium. Occupation accidents (not involving radiation) may cost about one life every five years of plant operation from mining, one life every five years of plant operation from fuel processing activities, and will cause about seven injuries from all activities related to the nuclear fuel cycle for each year of plant operation.

... greatest concern associated with nuclear plants is, of ... that of an accident in which a large amount of radiation is released. While a number of studies have agreed that the methodology that has been developed for assessing the risks of nuclear accidents is appropriate in principle, there is general agreement that the results calculated in the one comprehensive effort conducted to date to determine those risks are not reliable. The charge of unreliability does not imply that they are necessarily too high or too low in value, but rather that there is as yet no way, on the basis of detailed analysis, to determine the range of uncertainty in the figures. In other words, the results that were calculated may well lie within an appropriate range of values, but no one knows how wide the total range should be to depict accurately the maximum and minimum numbers of deaths, or illnesses, to be expected.

Table 3 lists an upper value for the "most probable" average annual death rate to be expected from accidents associated with a year's operation of a 1000 megawatt power plant as 2.4, in agreement with the estimate of the Union of Concerned Scientists, and cites the calculated value of 0.02 from WASH-1400 as the lower "most probable" value. This would produce a maximum "most probable" estimate of the total average annual mortality risk associated with a year's operation of a 1,000 MW nuclear plant (normal operations plus accidents) of about four deaths, and a minimum "most probable" estimate of the total average annual mortality risk of about two deaths per year of plant operation. ("Extreme" values are summarized in footnote I of the table).

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As noted throughout the discussion in this report, the risk figures relating to this entire subject area are uncertain. In some areas, as indicated by the shaded regions of table 3, the uncertainties are large enough

TABLE 3

ILLUSTRATIVE SUMMARY OF RISKS ASSOCIATED WITH EACH YEAR OF OPERATION OF A 1000 MW POWERPLANT AT LOAD FACTOR 0.75

	COAL GENERATION				NUCLEAR GENERATION						
	MINING	PROCESSING	TRANSPORT	CONVERSION TO ENERGY	MINING	MILLING	FUEL PROCESSING	TRANSPORT	CONVERSION TO ENERGY	WASTE DISPOSAL	[illegible]
OCCUPATION RISKS											
DEATHS											
Accidental	1 [A], 0.25 [B]	0.02-0.04 [D]	0.055-0.4 [D]	0.01-0.03 [D]	0.09-0.2	0.01	0.003-0.2 [D]	0.002	0.01 [D]		[illegible]
From Disease	0-3.5 [D]				0.038 [F]	0.03 [F]	0.012 [F]		0.06 [F]	[illegible]	[illegible]
INJURIES	110 [A], 14 [B]	2.6-3 [D]	0.33-23	0.9-1.5	1.6	←— 1.5 —→		0.055-0.15 [D]	1.5		
INCAPACITATING ILLNESSES	CWP { 3.5-5.5 [A,C]; 0.5 [B,C] }	?	?	?	?	?		?	?	*	
PUBLIC RISKS											
DEATHS											
Accidental			1.9-2.25					0.01			
From Disease		1-10 [D]		{ 22-240 [G,I]; 4-120 [H,I] }	0.085 [F]	0.025-1.1 [F]	0.004	0.00019	0.016-0.2 [F]	0.001 [F]	[illegible]
ILLNESSES	Cases of chronic respiratory disease--------41,000-120,000 [A]; Person-days of heart-lung symptoms-------424,000-1,200,000; Numbers of asthma attacks------------------85,000-250,000; Cases of children's respiratory diseases-----10,000-29,000										
SERIOUS GENETIC DAMAGE [I]	?	?		?	0.06	0.01-0.55	0.006	0.00008	0.018-0.04	0.0005	[illegible]

A--Underground.
B--Surface (Eastern).
C--Assuming 25 year career.
D--From Comar and Sagan article.
E--The estimate of 2.4 deaths is the estimate of the Union of Concerned Scientists, the estimate of 0.02 deaths is from WASH-1400.
F--These estimates reflect calculations of the effects in the next 1000 years of radon and carbon-14 environmental contamination, as reported in recently revised tables for NRC's NUREG-0332.
G--Existing Plants.
H--New Plants.

I— These figures have been presented in this report as "most probable" values. The [illegible] range of possible values is wider. Existing coal plants might produce from [illegible] deaths; new coal plants from zero to 480 deaths (see page 55ff.) Nuclear plants [illegible] been estimated, on the basis of 200 reactor-years of experience without a meltdown, to pose a risk of 59 deaths, which scales to an estimate of 27.6 deaths if the current 500 years of reactor experience without meltdown is employed (see page [illegible].) All [illegible] these estimates are at a 90-95 percent confidence level.

NOTE: Figures surrounded by shading must be regarded as being [illegible] uncertain on the basis of current information and are therefore subject to revision.

[illegible] estimates only provide an indication of some of the estimates, or perhaps the conjectures, that have been made. The volume of material on the subject of the risks and impacts associated with coal combustion and with nuclear energy is voluminous. While recent major studies by groups of scientific and technical experts, both in and out of the Government, are represented here with care, there has been no way to independently critique or evaluate alternative viewpoints by individuals--particularly by those most strongly opposed to nuclear power. Even so, there are broad ranges of uncertainty in the data for both coal and nuclear power that merit examination.

As stated in the text, the data on occupational health risks are based on health and accident records, occupational radiation dose records or radiation dose regulations plus careful scientific analysis to determine the effects of low level radiation. The uncertainty in this information is relatively small, and though there are points which could be argued, those who have attempted to assess the relative risks of coal and nuclear power plants have seemed to feel that other areas of uncertainty are more significant. It therefore seems reasonable to regard these statistics as fairly reliable. Similarly, the estimates of injuries and fatalities incurred in the transportation of coal and new nuclear fuel (the transportation of spent nuclear fuel is included in table 3 under "waste disposal") are based on actual records of performance and are therefore fairly reliable.

The health risks to the general public from the normal operation of nuclear plants, including mining and fuel fabrication, have attracted considerable public concern. As outlined in this report, the calculations leading to these risk predictions are extremely complicated and are certain to contain errors.

The question is whether these errors are likely to be significant in the overall assessment of the relative risks of coal and nuclear energy. The references cited in Part B direct attention to other questions as being of much greater significance to this, and at least the next 30, generations of mankind--though there are differences of opinion about whether, and how, projections should be made beyond that time scale. For instance, the latest calculations by the Nuclear Regulatory Commission of the mortality risks to the general public from the total nuclear fuel cycle provided in NUREG-0332, revised, include and correct the figures provided in GESMO and extend the analysis to include estimates of the effects of carbon-14 and radon emissions to this and future generations of mankind over the next 1000 years. They predict the mortality risk exclusive of accidents for each year of operation of a nuclear plant to be 1.3 deaths among the general public at maximum, the minimum being 0.2 deaths. Comparing this with the figure of about 2 deaths among the general public which are much more certain to occur, on the average, each year from the rail transportation of coal for a distance of 300 miles to a similar sized coal-fired plant, it is difficult to conclude from the magnitudes of risk currently predicted, even with acknowledged uncertainties in the calculations, that the health effects of the fueling and normal operation of nuclear power plants are likely to be a decisive factor in assessing the relative merits of coal and nuclear power.

Clearly, the safety and health uncertainties that are most significant to any assessment of the relative risks of coal and nuclear power are 1) the health effects of the solid and gaseous combustion products of coal (plus those that might be implied if the hypothetical Greenhouse Effect comes to be substantiated), and 2) the effects of nuclear accidents. In both cases, predictions of those health impacts are large and very uncertain, meaning

[illegible] range of values, the extent of which cannot be conclusively determined.

Consider first the case of coal emission mortality figures. Table 2, on page 58 of this report, presents figures on coal emissions effects from a National Academy of Sciences report, stating that they could be high by a factor of ten or low by a factor of two. Thus a remotely located plant (1000 MW at 0.75 load factor) might produce as few as 2.2 deaths per year, or as many as 44 deaths per year. (The remote plant was hypothetically located 230 miles upwind from New York City.) A plant located in the vicinity of an urban area would produce between 6.7 and 134 deaths annually. However, the quoted figures of 22 and 67 deaths annually were scaled to 1000 MW plant size from figures computed to be the "most probable" values by those who did the analysis, and thus the figure of 22 deaths is entered as a lower "most probable" value in the appropriate place in table 3 and was employed in the calculations used in this report. The upper "most probable" estimate provided in table 3 for deaths among the general public from a 1000 MW power plant was derived from a study performed by Brookhaven National Laboratory and calculated in the manner described on page 56 of this report. The Brookhaven study is highly statistical in its basic design, and calculates the probabilities of numbers of mortalities over a range extending from zero mortalities to four times the number of mortalities found to be most likely to occur. While that study found that, for an existing plant, there was about 10 percent probability of having zero mortality, and an equal probability of a mortality greater than 920, the "most probable" number predicted by the model was 240 deaths to be expected from emissions from a 1000 MW coal plant for each year of operation. This figure of 240 is approximately at the 50th percentile level: there is a 50 percent chance that the proper result should be less than 240 deaths

[illegible]

[illegible], according to [illegible] result, the figure, of [illegible] was cited as [illegible] upper limit of the range of "most probable" values for the average annual death rate to be expected from an existing plant. As noted on page 57 of this report, these results have been severely criticized. Presumably future studies will either validate or discredit this high figure, but for the present it would appear to reflect the most probable upper value, and 22 the most probably lower value, among a range of possible values that extends in the extreme from zero to 920 deaths per year as determined by two different and independent analyses. Any health and safety impacts of nitrogen oxide and carbon dioxide emissions that may exist have not been, and cannot be, estimated in present calculations. As noted in earlier sections, emissions of a coal plant meeting new source standards might be expected to cause from 4.4 to 120 deaths annually, with uncertainties ranging from perhaps zero to 480. For reference, the recent CONAES risk study calculated emission deaths of 40 and 200 per plant year, depending on the method of analysis use. However, as outlined in Part B, all recent studies have raised questions about the magnitude of health effects to be expected from coal emissions, and some reports have questioned the existence of those effects at current pollution levels.

The uncertainties in estimates of the risk of nuclear power reactor accidents are equally great. According to the National Academy of Sciences literature review entitled <u>Risks Associated with Nuclear Power</u>, our experience to date with reactor accidents (i.e., the total lack of accidents prior to the publication of the report) permits statistical inferences to be drawn about the possible maximum average numbers of cancer deaths per year to be expected from nuclear accidents.* The report provides estimates on the basis of two different assumptions.

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*It should be noted that the radiation released by the accident at Three Mile Island appears, on the basis of current information, to be in keeping with the predictions of WASH-1400 in terms of timing of occurrence and severity.

[illegible] predicted the relative probability [illegible] and correctly predicted the consequences of each size of release, then the absence of accidents in 200 reactor years would predict an average death rate per plant of less than about 1.1 per year, according to this Academy report. On the other hand, if it is assumed that the lack of a major accident to date can only imply a maximum likelihood of the worst possible accident, but that the effects of releases of given amounts of radioactivity have been calculated correctly in WASH-1400, then the average death rate that might be inferred from the absence of a meltdown in 200 reactor years might be as great as 23 per plant year, according to the report. Now that 500 reactor years have passed without a meltdown, this maximum estimate would currently be about 9.2 deaths per plant year. (See comments relating to the resonabilities of the "worst-accident" assumption on page 100.) This figure is a maximum upper value, somewhat comparable to the extreme upper estimates of coal emission health effects. Both must be accepted as indicating the extreme upper end of a possible range of values. Since this number was calculated on the basis of the operating history of the nuclear power industry, it will diminish with each passing year in which no core meltdown occurs. The numbers just stated are claimed to be at a 63% confidence level. A 95% confidence level would require that they be three times larger.

The findings of two other major studies of nuclear power risks deserve particular attention in this review. One is that of the Union of Concerned Scientists, which the NAS report describes as "the most comprehensive and specific" of the comments that have been made about WASH-1400 "by groups opposed to the expansion of nuclear-power production." The calculations of the UCS predicted an average of 2.4 cancer deaths per plant year as being probable. The other study is the "Ford-MITRE" study, which stated, "In the

[illegible] . . . the overall rate-of-loss would be about ten fatalities per year for a 1000 MW nuclear power plant." (p. 241) On the other hand, in an adjacent sentence, the Ford-MITRE study said that the WASH-1400 estimates " . . . could even be on the high side as well."

Thus it would seem that the maximum range of uncertainty in the predictions of the mortality risks of nuclear power extend is very broad: a total range of uncertainty in extreme estimates of nuclear risks are roughly equivalent to the range of uncertainty in extreme coal emission health risk estimates. These two ranges of uncertainty in extreme risk estimates are not overlapping, however, except that the upper end (the larger values) of the range of nuclear plant risks overlaps the lower end (the smaller values) of the range of coal plant risks.

Under these uncertain circumstances, which apply to both the coal and nuclear fuel cycles, a reasonable procedure would seem to be to limit consideration to those estimates that are regarded as probable, rather than to those which are the most extreme possible. The general view and approach of this report are well summarized in the overview discussion presented in the recent CONAES study on pages 74 and 75. It reads as follows:

> The routine risks of nuclear power include the induction of cancer and genetic effects by ionizing radiation released throughout the nuclear energy cycle. These risks are very small in comparison to the overall incidence of cancer and genetic effects in the general population, and they could be significantly smaller yet if the most important source of radiation in the nuclear energy cycle--uranium mill tailings--were generally better protected. There are also risks of severe accidents, whose probabilities have been estimated with a great deal of uncertainty, but whose severities could be comparable to those of large dam failures and liquefied natural gas storage system fires. There are also risks from the disposal of radioactive waste; these are less than those of the other parts of the nuclear energy cycle, but only if appropriate action is taken to find suitable long-term disposal sites and methods.

[illegible] nia, [illegible] and [illegible] [illegible], certainly [illegible] middle age, might be attributable, at least in part, to coal emissions, and that this fraction may be larger than might otherwise be immediately evident. Certainly the pre-existing conditions for pneumonia, heart disease, and so forth can take years to develop, so coal emissions might play a contributory role. Thus it does not seem possible to obtain agreement that coal emissions can be clearly eliminated as a contributing factor for deaths from those diseases in middle age and later. (Those who die from air pollution emergencies, of course would seem to be those who are infirm. On the other hand, coal emissions may have contributed to some of those infirmities.) For the present, this question seems to need much more study to understand the effects of both chronic and acute exposures to coal emissions.

Though the following calculations would not seem to deserve great credence on the basis of current knowledge about the health risks of either coal or nuclear plants, it seems appropriate to note for completeness that the Nuclear Regulatory Commission reported the following average life-shortening for those exposed to the emissions of a 1000 MW coal or nuclear power plant, including all phases of the nuclear fuel cycle. The average person's life-shortening due to a nuclear plant was predicted to be less than 0.5 seconds per person, while the average life shortening due to a coal plant was predicted to be from 160 to 270 seconds per person from emissions, though it must be pointed out that many more people are affected by the nuclear plant than the coal plant because of the differences in the two technologies. These data can be found in the NRC hearings on the Pebble Springs licensing action, Docket 50-514 and Docket 50-515, held on June 8, 1978 in Portland, Oregon. It must be emphasized that these predictions should be regarded as highly conjectural.

ENCLOSURE 1b

[illegible]

A V Cohen and D K Pritchard

[illegible] laboratories at Buxton, Cricklewood, and Sheffield, by specialists in other Divisions of the Executive, and through contracts placed with outside organisations. Accounts of some of this work are published as HSE Research Papers which are listed on the inside back cover of this publication.

Any enquiries regarding this publication should be addressed to the Health and Safety Executive at any Area Office or to the general information and enquiry point, Baynards House, 1 Chepstow Place, London W2 4TF (tel. 01-229 3456).

Great Britain. *Health and Safety Executive*

The comparative risks of energy production systems.

1 Electric power production
2 Electric power-plants – Environmental aspects
3 Electric power-plants – Reliability
4 Risk
I Title

[illegible] 333.7 [illegible]

[illegible]

[illegible] and this implies some judgement [illegible] rather than run together [illegible] so that as far as possible, like is compared [illegible] non-quantifiable effects (para [illegible]). Suspected [illegible] should not be ignored.

[illegible]isk estimates for 'unconventional' alternative systems which have not got beyond prototype stage, or for [ener]gy conservation systems, are too speculative for [com]parisons to be drawn (para 12). Most of this note [th]erefore compares estimates, in broad and generic [ra]ther than specific terms, of the risks of the three 'con[ve]ntional' alternative systems – coal, oil, and nuclear. It [d]raws on experience much of which is foreign but, with [th]e obvious caveat, we have no reason to doubt the [g]eneral conclusions.

90 Risks of entire systems can only be expressed as overall averages, but estimates of marginal effects are more appropriate for assessing the risk of a decision to add to a system (paras 6d, 7, 15). Care must be taken to distinguish average from marginal. Comparisons (paras 14–54) can then be made of the quantifiable risks, indicating the broad degree of precision, the range of expert view, and the remaining areas of ignorance. For some risks, the quantification is so imprecise as to call in question whether the quoted figures have any significance.

91 Non-nuclear risks are often less well understood than the corresponding nuclear risks (para 73). The existence, let alone magnitude, of some of the alleged non-nuclear risks is questionable, and in some cases maintained by only a minority. But greater understanding (para 74) is needed of:

(a) the significance of upper and lower limits to alleged chronic sulphur effects;

(b) long-term non-nuclear waste effects, for which there is no evidence at present;

(c) the potential major hazards associated with certain non-nuclear plant;

(d) the distinction between average risks of a system, and the risk associated with marginal change.

92 The quantifiable risks are discussed in paras 75–77. None of the three systems is free of hazard, whether in normal operation, or in potential for major incident. For coal-burning systems, the largest incident could cause hundreds of deaths. For the other two systems each taken as a whole, there is a small risk of involving up to tens of thousands of deaths. Because of the limitations of the assessments, it is better to express the overall conclusion (para 78) in qualitative terms

[illegible] would be valid even if, as may well be the case, the alleged sulphur effects were zero. It is based on studies which mostly refer to the Pressurised Water Reactor or the Boiling Water Reactor, though we have no reason to believe that the conclusion for other reactor systems would be markedly different. For a specific installation, nuclear or otherwise, this generic statement implies no exemption from normal strict scrutiny before specific safety clearance is given.

94 The conclusion is contrary to the beliefs of sections of the public. One reason is that only recently has the safety of non-nuclear installations come to be considered with the same approach employed to consider nuclear safety (paras 80–83). But there is also evidence that some sections of the public perceive nuclear risks as being significantly higher than the estimates of experts of which they may be sceptical (paras 84–87), and that different sections of the public evaluate the acceptability of such risks in different ways and by different criteria.

95 Only long and safe operational experience is likely to convince the majority of the public that the predicted safety is achievable (para 87).

Table A1 Fuel extraction

Estimated annual consequences to occupational safety and health given by the various studies for the extraction, processing and fabrication of fuel required for a 1000 MW(e) station working at 75% load

	Coal				*Oil*		*Nuclear*		
	Accidental deaths	Accidental injuries**	Pneumoconiosis deaths‡	Pneumoconiosis cases‡	Accidental deaths	Accidental injuries**	Accidental deaths	Accidental injuries**	Cancer (cases/deaths)
HSC Report	1.05	–	~7	–	0.23	–	0.075	–	–
Norwegian	2.13	125	–	–	0.17	4.7	0.05–0.2	1.0–10.0	
Swedish	1.6	394 (4–20) 219 (21–56) 73 (56 or more)	2.0	44	0.22	26	0.051	16.2	0.06–0.09††††
Inhaber (REV-1 & REV-3)	0.53–1.13	30–52.5 (93)	0–2.6	0.41–0.62	0.11–1.28	11.3–90 (55)	0.06–0.43	2.55–12 (50)	0.16–0.45
WASH 1224	0.98	40.5 (60)	–	0.6	0.11	10.5	0.095	5.1	
Comar & Sagan****	0.47–1.03	24.6–52	0–3.5	0.6–48	0.1–1.21	10.5–83	0.053–0.4	2.4–11.5	0.015–0.43
Fagnani & Maccia	1.05	1039	–	0–1.6	0.08	11.4	0.12	27	0.07
Hamilton ([16])	0.75	52	0.02–0.46***	0.58–1.15***	–		0.36	15.3	0.11
Hamilton ([12])	0.64	33 (50)	0–7	20.5–27	1.12	74	0.25	10.6	0.11
US NRC ([20])†	0.1–0.66	4–40							
Black & Niehaus	0.50–0.55	2300 days	0.07	–	0.29	1980 days	0.07††	143 days††	0.003–0.014
Ramsay†††	0.33–0.99	66–132	3.3	–	–	–	0.07–0.23	13–23	0.07–0.13
Range	0.33–2.13	24.6–1039	0–7*	0.41–48	0.1–1.28	4.7–90	0.05–0.43	1–27	0.015–0.45

* A blank in the table does not mean there is considered to be no risk, but either no attempt has been made to estimate the risk, or the estimates given in the reports cannot be broken down into the risks for each stage of the energy cycle.

** The average number of days lost per injury is given in brackets, if known. Swedish coal figures based on W. German data.

*** Referred to as occupational "disease".

**** Reference quotes studies with load factors mostly at or near 75%.

‡ Some US figures refer to 'miners' illnesses' or to 'black lung disease'. 'Cases' sometimes exclude fatal cases or list projections rather than current experience.

† Lower and upper limits are for open-cast and deep underground extraction. A 50% mix is assumed in calculating risks.

†† Black and Niehaus's nuclear accidental deaths and injuries include reprocessing. Cancer figures for mining only.

††† Includes occupational deaths and accidents at all stages of the fuel cycle. Coal extraction assumed to be 40–70% open cast.

†††† Includes subsequent genetic effects.

Table A2 Fuel transport

Annual deaths and injuries* due to fuel transport given by the various studies for a 1000 MW(e) station working at 75% load

	Coal				*Oil***		*Nuclear*			
	Deaths		Injuries***		Deaths	Injuries***	Deaths		Injuries***	
	Occupational	Public	Occupational	Public	Occupational	Occupational	Occupational	Public	Occupational	Public
HSC Report	0.15	–	–	–	–		–	–		
Revised UK estimate	0.03	0.20	–	–	–					
Inhaber	1.2–3.75	0.6–1.43	9.75–36	12	0.03–0.11	1.2–9.75	0.002–0.009	0.009	0.045–0.15	[illegible]
(REV-1 & REV-3)			(93)	(93)		(55)			(50)	(70)
Norwegian	0.19	0.3	4	–	0.11	2.2	0	0.01	0.05–0.14	0.08
Swedish	0.8	–	236	–	0.34	17	0.002		0.045	
WASH 1224	0.055	0.55	5.1	1.17	0.03	1.1	0.002	0.009	0.045	0.08
			(47)	(171)		(36)			(25)	(75)
Comar & Sagan****	0.055–0.4	0.55–1.3	0.33–23	–	0.03	1.1–9	0.002	0.009	0.045–0.14	
Fagnani & Maccia	0.07	–	13	–	0.12	2.1	0.007	–	1.6	
Hamilton ([16])	0.35–1.5		1.4–6.8		–	–	0.011	ca0.001	0.11	ca0.0[illegible]
Hamilton ([12])	1–3		10–30		0.1	9		–		
US/NRC ([20])††	–	1.9	–	21						
Black & Niehaus	0.26–0.29	0.43–1.04	533–660 days	458–555 days	0.051†††	353 days†††	0.0015	0.0023–0.0045	5.3 days	4.5 days
Range	0.055–3.75	0.3–1.9	0.33–236	1.17–21	0.03–0.34	1.1–17	0–0.011	0.001–0.01	0.045–1.6	0.001–0.[illegible]

* A wide variation due to national practices must be expected.

** None of the studies estimated risks to the public from transport of oil for power stations.

*** The average number of days lost per injury is given in brackets, if known.

**** Reference quotes studies with load factors mostly at or near 75%.

† A blank in the table does not mean there is considered to be no risk, but that no attempt has been made to estimate it.

†† Level-crossing accidents. US conditions.

††† Public oil deaths and accidents are quoted at approximately 1% of occupational levels.

	Accidental deaths	Accidental injuries**	Accidental deaths	Accidental injuries**	Accidental deaths	Accidental injuries**	Cancer (cases/deaths)
HSC Report	0.15	-		-	0.11	-	-
[illegible] (RFV-1 & RFV-3)	[illegible]	1.2-6.4 (95)	[illegible]	[illegible] (55)	0.01-0.013	1.37 (50)	0.081
Norwegian	0.01	4	0.01	3.6	0.01-0.2	0.7-2.8	-
Swedish	0.05	2	0.03	4	0.03	11.1	0.14-0.21**
WASH-1224	0.03	1.2 (142)	0.037	1.5 (85)	0.012	1.42 (37)	-
Comar & Sagan*	0.01-0.03	0.9-1.5	0.01-0.037	0.6-1.5	0.01	1.3	0.024
Fagnani & Moccia	0.017	2.9	0.017	4.3	0.013	4.9	0.09
Hamilton (16)	0.12	3.8	-	-	0.015	1.3	0.08
Hamilton (12)	0.01	1.2	0.01	1.2	0.01	1.3	-
Black & Niehaus***	0.012	160 days	0.0098	98 days	0.011	105 days	0.098-0.135
Range	0.01-0.15	0.9-6.4	0.01-0.038	0.6-4.3	0.01-0.2	0.7-11.1	0.024-0.21

* A blank in the table does not mean there is [illegible] to be no risk, but either no attempt has been made to estimate the risk, or the estimates given in the reports cannot be broken down into the risks for each stage of the energy cycle.

** The average number of days lost per injury is given in brackets, if known.

*** Nuclear effects exclude reprocessing. Cancer figures also include all subsequent genetic effects.

* Reference quotes studies with load factors mostly at or near 75%.

** Includes subsequent genetic effects.

The Record DATE February 28, 1980

FROM :

SUBJECT: Neonatal Hypothyroidism in Southeastern Pennsylvania

The Chronic Diseases Division of CDC learned of a potentially unusual scattering of cases of neonatal hypothyroidism in 3 counties in southeast Pennsylvania. Information from the Pennsylvania Department of Health (Dr. Evelyn Bodin) and dosimetry data from the Nuclear Regulatory Commission reveals the following: Children born with thyroid defects were discovered through the normal operation of a neonatal metabolic screening program that has been operating since July 1978. These defects resulted in diagnoses of hypothyroidism. Although baseline incidence data on hypothyroidism are not available for Pennsylvania, the number of cases detected statewide in 1979 is no more than expected, based on previous studies in the United States and Canada, according to Dr. Evelyn Bodin of the Pennsylvania Department of Health, who heads up the screening program.

The purpose of the neonatal screening program is to find newborns with metabolic defects such as phenylketonurea and hypothyroidism early enough after birth to prevent severe mental retardation. Several states, including New York, New Jersey and Maryland have similar programs. Hypothyroidism is detected in the program by looking for depressed levels of thyroid hormone and elevated levels of thyroid stimulating hormone in the infant's blood. Confirmation is done by thyroid scan. The thyroid scan can determine whether the hypothyroidism is due to the absence of a gland, difficulty with hormone synthesis or release, or displacement of the gland from its normal position. Sometimes, however, confirmatory studies are not done or not reported to the health department, resulting in the classification of the cause as "unknown on scan." According to Dr. Bodin, the fourteen cases of hypothyroidism are classified as follows:

Lancaster County (7 cases)

One was a case of severe multiple brain abnormalities. This child was born 3 months after the accident, therefore, all of these defects would have come about prior to the radiation release, by at least 13 weeks.

Two were cases of dysgenesis, i.e., the thyroids were displaced from their normal position. One of these was from a pair of twins in an Amish family; the twins were discordant with regard to thyroid disease, therefore, non-supportive of etiology secondary to radiation exposure.

One was a case of dyshormonogenesis, i.e., it is familial and inherited as an autosomal recessive. This case is in an Amish family with a probable high degree of consanguinity. It is likely not to be related to radiation.

Three were "unknown on scan" (One of these occurred in January 1979, before the accident.) These patients were begun on therapy without a scan.

Bucks County (4 cases)

3 were "unknown on scan". These cases were also begun on therapy without scan.
1 was a case of dysgenesis, i.e. displaced from its normal position.

Lehigh County (3 cases)

1 was "unknown on scan". This patient was begun on therapy before a scan.

2 cases were twins who had no thyroids

Except for those cases that were "unknown on scan", these types of anomalies are not expected to result from direct or indirect exposure of the fetus to radioiodine.

Lehigh and Bucks Counties are not adjacent to Dauphin County (where TMI is located) and Lancaster County is southeast of the site. The Washington Post article reports that local groups contend that "insufficient monitors were in place or not operating at the time of the accident" and that "wind currents might have carried radioactive particles over nearby monitors and deposited them in faraway areas." This kind of reasoning would be necessary to explain the pattern of the reported excess incident. However, it should be noted that estimates of the radioiodine releases are not subject to the same degree of uncertainty that is associated with the quantity of the noble gas activity release. The amount of radioiodine released has been estimated from the amounts retained on the effluent particulate and charcoal filters. By analyzing the distribution of radioiodine with depth of the filter, it was possible to estimate the efficiency of the filters and the quantity released. Both the NRC staff and Special Investigation Group (Rogovin Report) estimated that approximately 15 curies of radioiodine -131 were released, the maximum quantity estimated by the Rogovin group was 32 curies. Analysis of effluent air sample cartridges by the licensee gave estimates of 14.1 curies of iodine -131 and 2.6 curies of iodine -133. All estimates are for the period March 28 - April 30, 1979.. The total uncertainty is therefore within a factor of 2.

The maximum airborne iodine concentrations of 120-250 pCi/m^{3}* occurred mid-April in connection with replacement of the auxilliary building charcoal filters. The maximum predicted thyroid dose from inhalation was approximately 20 millirem** to a child.*** Extensive milk monitoring was performed by EPA, FDA, NRC, the

*The 10 CFR Part 20 concentration limit for continuous annual exposure is 100 pCi/m^{3}
**for the period March 28 - April 30, 1979
***NRC staff panel report to the Commission on Extraordinary Nuclear Occurrence (NUREG-0637), Appendix E, page 30

State, and the licensee. The maximum radioiodine concentration in cow's milk was 36 pCi/liter which would have resulted in a thyroid dose to an infant of less than 5 millirem. Higher radioiodine concentrations were observed in goat's milk (41 pCi/liter and 110 pCi/l). Even though this milk was not used for human consumption, the projected thyroid doses to infants would be 5 millirem and approximately 14 millirem, for the 41 and 110 pCi/liter concentrations. These values are under the 10 CFR Part 50, Appendix I design objective for normal operation of 15 millirem per year per reactor unit.

Although the uptake physiological parameters for the fetus are not well-defined, a conservative upper bound estimate is that the thyroid dose to a fetus might be as high as 10 times the maternal adult dose. This would give a maximum thyroid dose to a fetus of 140 millirem from inhalation plus 50 millirem from milk ingestion or approximately 200 millirem total fetal thyroid dose.

Estimates of the health effects of thyroid irradiation are derived from studies of persons irradiated for ringworm, Marshallese Islanders exposed to fresh fallout, and atomic bomb victims. The risk estimate (based on children and teenagers) derived from the Marshallese data is 175 thyroid cancers per million-person-rem. These are from substantial doses, the average thyroid dose being 200 rem. The risk is believed to be higher in younger children. When adjusted for the U.S. population, an average risk of 50-70 thyroid cancers per 10^6 person-rem would be more appropriate. When applied to the doses at Three Mile Island (3300 person-rem total body + 1280 thyroid-rem), approximately 0.27 potential thyroid cancers would be predicted using the population average risk and 0.8 potential cancers using the higher Marshallese risk value for children. Thyroid cancer can be effectively treated and the fatality rate is less than 10 per cent.

Radioactive iodine is routinely used for therapy of hyperthyroidism (over-active thyroid) at doses of the order of 1000 rem or more and hypothyroidism is commonly observed as a result. Impaired thyroid function (hypothyroidism) has been found to be prevalent in the exposed Marshallese at doses of about 50 rem (27-95 rem).

Based upon a conservative upper bound estimated total collective dose at TMI of 4580 person-rem (3300 total body, 1100 thyroid-rem from milk and 180 thyroid-rem from inhalation) the expected number of cases of hypothyroidism would be 0.6 (range 0.1-2.8) based upon NRC calculations using the Marshallese risk data.

Certain factors which need to be obtained in the case histories (as yet incomplete) include occupational exposure of parents, their ingestion of any iodine-related compounds, (seafood or water), or dietary habits (vegetarians eating cabbage take in goitrin).

Ingesting manganese, selenium, technesium, or any thiocyanates by the mother would also suppress the thyroid of mother and child. A history of thyroid disorders (as yet unobtained) in a given family would be important in ruling out radiation-related hypothyroidism.

Statistically, the significance of an excessive number of cases in all three counties is lacking as summarized in the following table (using Poisson distribution):

County	Observed*	Expected*	P value
Lehigh	3	1	P=0.0803
Bucks	4	1.8	0.1087
Lancaster	7	1.4	0.0006
	(3)	(1.4)	(0.1665)

The expected rate is approximately 1 case of hypothyroidism in 4000 five births (Journal of Pediatrics 94:700, 1979).

In Lancaster county only 3 cases can be categorized "observed" as 2 are chronologically not related to the TMI accident and one in an Amish family probably relates to consanguinity. In that case, the p value implies nonsignificance, even though it would be significant if all seven cases are considered.

Although these statistics have considered rates based on 12 months (March, 1979-March, 1980) they do not support a radiation etiology. The twins of Lehigh County may only be counted causally as one case if they are identical. One of the 13 cases' mothers was reported to have been on therapy for asthma which may have included potassium iodide as an expectorant. The geographical gerrymandering obviously begs that <u>all</u> southeast Pennsylvania counties be examined.

In summary, based on data from Dr. Evelyn Bodin of the Pennsylvania Department of Health, dosimetry data from Robert Goldsmith, Ph.D. (NRC) and our own clinical assessment of the genetics, the supporting evidence for radiation-induced hypothyroidism is lacking.

Gary F. Stein, M.D.
Cancer Branch
Chronic Diseases Division
Bureau of Epidemiology

Frank Greenberg, M.D.
Birth Defects Branch
Chronic Diseases Division
Bureau of Epidemiology

ENCLOSURE 3

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THE CANCER RISK FROM LOW-LEVEL RADIATION

BERNARD L. COHEN
University of Pittsburgh, Pittsburgh, PA 15260

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Abstract—The various lines of evidence that lead to current estimates of the cancer risk from low-level radiation are reviewed. It is first shown why it is very difficult to get direct experimental evidence, so that much reliance is placed on extrapolation of data from high level radiation. The evidence that a linear extrapolation is conservative, i.e. more likely to over-estimate than to under-estimate the risk at low levels, is extensively reviewed. The "new evidence" that has been claimed to indicate that the linear extrapolation under-estimates effects at low levels is examined. Complications in deriving risks based on the linearity assumption are considered, and final estimates from various sources are presented.

I. EFFECTS AT HIGH LEVELS AND THE LINEARITY HYPOTHESIS

THERE HAVE been many situations in which large numbers of people have been exposed to high levels of radiation, and through studies of them (NAS72; UN77) the health effects of high-level radiation are rather well known. Some of these data are summarized in Table 1. Among the survivors of the atomic bomb attacks on Japan, there were 24,000 people who received an average exposure of 130 rem, and about 120 extra cancers developed among them up to 1972. There were 15,000 British patients treated with X-rays for ankylosing spondylitis (arthritis of the spine) with doses averaging 370 rem, and they had about 115 extra cancers. Over 900 Germans were treated for that same disease and for bone tuberculosis with injections of ^{224}Ra giving an average dose to the bone of 4400 rem,* and 45 of them got bone cancer (vs 0.1 expected). About 1700 U.S. women employed during the 1920s in painting radium on clock and watch dial numerals to make them self-luminous used their tongues to put a fine tip on the brush, getting radium into their bodies; their average bone dose was 17,000 rem and 48 of them died of bone cancer (vs 0.4 expected). Among 4100 U.S. uranium miners exposed to excess levels of radon gas due to poor mine ventilation, the average exposure to bronchial surfaces was 4700 rem and up to 1972 there were 135 lung cancer deaths among them vs 16 expected. There have been several other miner groups which have experienced excess lung cancers, like a group of 800 Canadian fluorspar miners whose average bronchial exposure was 2800 rem, resulting in 51 lung cancer deaths vs 2.8 expected. There have been a number of situations in which there have been high exposures resulting in something like 10 extra cancers, such as women in a Nova Scotia tuberculosis sanitorium exposed to excessive X-rays in the course of fluoroscopic examinations, U.S. women

*For loose discussion as in this section, we use 1 rad = 10 rem (ICRP59) for α-particle radiation of the lung and bone (with radium).

Table 1 Sources of information on risk of cancer from radiation (NAS72)

Type of cancer	Cause of exposure or X-ray treatments	Exposure date	Years after exposure considered	Number of subjects	Average dose (rem)	Cases observed	Cases expected	Cases 10^6 rem yr
Leukemia	A-bombs, Japan	1945	5–25	23,979	130	81	19.7	1.0
	Spondylitis	1935–54	0–25	14,554	372	52	5.5	0.9
	Menorrhagia	1940–60	0–24	2000	136	6	1.3	1.2
Bone	Ra^{226} intake	1915–35	11–56	775	17,000	48	0.4	0.11
	Ra^{224} treatments	1944–64	4–25	925	4410	45	0.12	0.84
	Spondylitis	1935–54	6–27	14,654	372	4	0.63	0.10
Breast	A-bombs, Japan	1945	16–25	12,000	125	26	12.9	0.9
	Fluoroscopy	1940–49	10–30	243	121	(22)	(4)	8.4
	Mastitis		10–29	606	200	11	4.2	6.0
Lung	Uranium mines	1920–63	6–50	4146	4680	135	16	0.53
	Fluorspar mines	1935–63	11–33	800	2770	51	2.8	1.6
	Metal mines		16–37	1759	1720	45	16	0.67
	spondylitis	1935–54	6–27	14,554	400	96	54	1.2
	A-bombs, Japan	1945	16–25	19,472	133	71	57	0.60
Gastro-intest.	A-bombs, Japan	1945	25	23,979	130	378	363	0.52
	Spondylitis	1935–54	11	14,554	375	53	34	0.81
Leukemia age 0–9	A-bombs, Japan	1945	6–24	4507	112	19	2.9	1.6
	Thymus X-rays	1926–57	0–35	1451	65	6	1.0	3.0
	Tinia capitis	1940–49	0–22	2043	30	4	0.9	3.4

treated with X-rays for inflammation of the breasts following childbirth, women treated with X-rays for gynecological maladies, various types of pelvic X-ray treatments, children treated with X-rays for enlargement of the thymus gland, infants radiated with X-rays for ringworm of the scalp, patients in several countries fed a thorium compound to aid in X-ray contrast studies and Marshall Island natives exposed to fallout from a nuclear bomb test. As a result of numerous studies of these groups, there is a great deal of information available on induction of cancer by high levels of radiation. This is periodically reviewed and updated by prestigious study-evaluation groups (NAS72; UNSCEAR77).

If one seeks to find similar information on low level radiation, one is immediately confronted with statistical limitations. For example, suppose one found a group of 10,000 white males who had received an extra 10 rem of whole body radiation. The easiest evidence to find would be excess leukemias because that disease develops earliest and is among the most sensitive to radiation. As a first approximation we might use the results of high level radiation studies that leukemias are induced at a rate of about 1.0×10^{-6}/yr per rem of exposure. We would then expect $10{,}000 \times 10 \times 10^{-6} = 0.1$ extra leukemias per yr among this group. In the absence of radiation, one would expect 0.88 leukemias if we take statistics for the entire U.S. In the 25 yr over which radiation is effective in causing leukemias, we then expect 22 ± 4.7 cases from natural causes vs 2.5 from the 10 rem radiation exposures. Clearly, the statistics here are marginal at best. But the problem goes much deeper—the total U.S. population is hardly a suitable control group. Cancer is largely caused by environmental factors and hence is subject to wide variations in incidence rates. Even for entire states, the 0.88 cases given above as the expectation varies from 1.0 (MN, DC) to 0.77 (ME, NM). In our above examples, this could vary the number of expected cases from 19 to 25, making it still more difficult to ascertain that there are 2 or 3 extra. Moreover, a group of people with 10 rem

of extra radiation would typically have more environmental factors in common than merely living in the same state.

Any experimental study of effects of low-level radiation would therefore need large populations, like millions of subjects, and there would still be considerable difficulty in selecting a control group. One way to achieve large numbers of subjects would be to use variations in natural radiation; for example citizens of Colorado, Wyoming and New Mexico are exposed to about 5 rem more than the U.S. average over their lifetimes. However, the leukemia rates in those states are considerably *below* the U.S. average, 8.11 vs 8.81×10^{-5}/yr for white males and 5.13 vs 5.74 for white females. The same is true for all cancers; the high natural radiation states have annual rates of 140×10^{-5} for white males and 114×10^{-5} for white females, while the U.S. average is 174 and 130 respectively. The fact that states with high natural radiation have considerably *lower* cancer rates than average is generally dismissed as indicating only that radiation is very far from being the principal cause of cancer, and this point is logically correct. However, this author is highly skeptical over whether that attitude would be accepted if states with high natural radiation happened to have somewhat *higher* than average cancer rates.

Since there is little direct evidence on effects of low-level radiation, the simplest option is to use our abundant data on effects of high-level radiation to derive estimates of effects of low levels by assuming a linear dose-effect relationship, i.e. if some high level dose D causes a cancer risk R, we assume that a dose 0.1D will cause a risk 0.1R, that a dose 0.01D will cause a risk 0.01R, etc down to extremely low doses.

This "linearity hypothesis" was recommended by the National Academy of Sciences Committee on Biological Effects of Ionizing Radiation (BEIR) in 1972 (NAS72) with a statement that it is a "conservative" approach, more likely to over-estimate than to under-estimate the effects of low levels. This statement seems to represent the general thinking in the involved scientific community, although there is considerable variation in opinions of *how much* more likely the over-estimate is. There is a considerable body of opinion that the over-estimate is gross, say by a factor of 2–10, while there is also an important body of opinion that linearity does not give an over-estimate. We now turn to a review of the evidence behind these positions.

2. EVIDENCE THAT LINEARITY IS CONSERVATIVE

In this section we review the principal evidence bearing on whether the linearity assumption is conservative as a means of estimating effects of low-level radiation. This evidence comes from various sources, each of which is discussed in a separate section.

(A) *Repair processes*

There is a great deal of evidence that nature provides mechanisms for repair of radiation damage to biological molecules. There have been many experiments in which it was shown that single doses in the 1000 rem range cause fatal radiation sickness in mice and other animals whereas fractionating these doses over several days or more does not (Fo77). Perhaps the best demonstration of repair mechanisms with regard to cancer is the dose rate effect, examples of which are shown in Figs. 1 and 2.

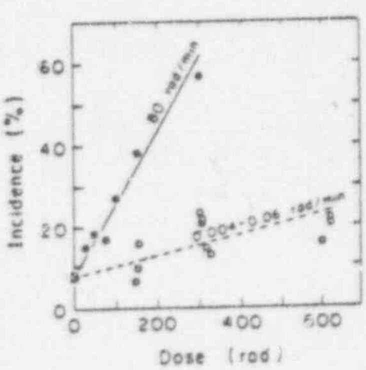

FIG. 1. Myeloid plus thymic leukemia in male RF mice exposed to X- or γ-rays (Up70). Plot shows per-cent incidence vs total dose for a high dose rate (80 rad/min) and a low dose rate (0.004–0.06 rad/min).

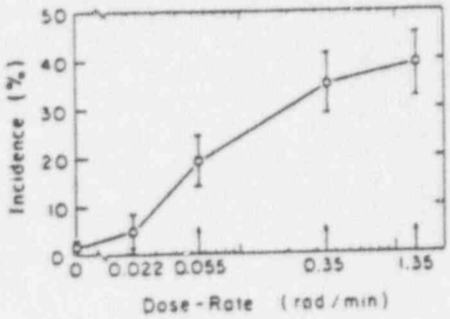

FIG. 2. Leukemia in CBA and C57B1 mice after a γ-ray dose of 1000 rad (Mo59). Plot shows percent incidence after 15 months vs dose rate.

We see there that a given dose of radiation is generally much less carcinogenic when spread out in time than when given rapidly; this implies that damage from earlier doses was repaired before the later doses were administered. The dose rate effect is well established in many animal studies with X-rays and γ-rays (Gr72; Sh66; Up70; Mo59) although there is some contrary evidence with α-particle radiation (Spe73; May78a) which will be explained later. It has been pointed out (Brow76) that effects from the high dose rates received by the Japanese A-bomb survivors were no larger than from low dose rate medical exposures, but this could have other explanations. Increased effects of high dose rates are well established in studies of genetic effects, a mutagenic process somewhat linked to cancer induction (Rus72).

In addition to this indirect evidence from dose rate effects, there is direct evidence for repair processes in that broken chromosomes have been observed to re-unite into a single strand (Le55; Wo61). There is also a vast amount of evidence for DNA repair in bacteria (Fo73; El77; UNSCEAR72; Mc66; To73).

In view of the well established existence of repair mechanisms, there is a general feeling that effects of low doses should be largely repaired, whereas repair of the much more extensive damage from high doses would be far less complete. This implies that the linearity hypothesis *over*-estimates effects of low-level radiation. On the other hand, it is argued that large doses may kill cells, which prevents them from becoming cancerous; this could cause linearity to under-estimate effects of small doses. However, there is good evidence that cell killing is not an important effect below about 100 rem (Mars78; El67), so if data in the 100 rem range is utilized, it would be difficult to use cell killing as a reason for linearity under-estimating effects of low-level radiation.

(B) *Mechanism for radiation induction of cancer*

One of the strongest reasons for believing that the linear hypothesis is conservative derives from our understanding of the processes by which radiation induces cancer (Ke72). Radiation affects matter largely by knocking electrons out of molecules and thereby disturbing molecular structure. In the process, the radiation gives up energy, transferring it to the material. The number of electrons knocked out of position is proportional to this energy deposited, and the latter is the basis for defining radiation dose. If the biological effects of radiation were simply due to single electrons being knocked out of position—this is called a "single hit" process—the cancer risk would be proportional to the total number of single hits, which is proportional to the energy deposited, regardless of the type of radiation. However, this is well known *not* to be the case (ICRP59); for a given energy deposited, α-particles and neutrons (known as high LET—linear energy transfer—radiation) are an order of magnitude more effective in doing biological damage than γ-rays or electrons (low LET). This is strong evidence that biological effects of radiation are not caused by single hits, but rather by multiple hits.

The basic difference between high and low LET radiation is that the former concentrates its damage within a much smaller volume of tissue. Since high LET is more effective, we may presume that effects are caused by multiple hits very close together, within some small sensitive volume.

Confirmatory evidence for a multi-hit process derives from the dose rate dependence discussed above. If cancer induction were a single hit process, it could not matter whether these hits were close together or far apart in time; each hit would have a certain probability of resulting in a cancer. However, as noted previously in connection with Figs 1 and 2, effects are much larger at high dose rate. With a multi-hit model, this is readily explainable by repair processes. If the two hits are well separated in time, damage from the first may be repaired before the second hit occurs.

Granted that radiation induced cancer is a multi-hit process (we assume a two-hit process) the multiple hits may be by the same particle of radiation or by separate particles. If they are by the same particle, effects are linearly proportional to dose, with the proportionality constant much larger for high LET than for low LET radiation because the former has a much better chance of making two hits close together.

On the other hand, if the two hits are by separate particles of radiation, effects are proportional to the square of the number of single hits* and therefore proportional to the square of the dose, regardless of whether the radiation is high LET or low LET. These considerations lead to dose-effect curves like those shown in Fig. 3: at very low doses the linear term must be predominant, and at very high doses the term proportional to dose-squared (quadratic terms) must predominate. The transition between the two should occur at a dose where it is not unreasonable to expect two hits by separate particles of radiation within the sensitive volume. This would occur somewhere near the dose where there is an average of one hit per sensitive volume. The latter dose, of course, depends on the sensitive volume: for example, if it is 1 μ in diameter as suggested by some experiments (Ke72; Se73; Ke75), the dose for an average of one hit within it is 8 rad for a 1-MeV γ-ray and 300 rad for a 5-MeV neutron whereas if the sensitive volume is 5 μ in diameter, the size of an entire cell nucleus, the required dose is 0.3 rad for a 1 MeV γ-ray and 12 rad for a 5-MeV neutron. We don't really know what the sensitive volume is, but these examples give the general impression that the transition from a linear to a quadratic dependence occurs at relatively low levels for β's and γ's, and at relatively high levels for α's and neutrons as shown in Fig. 3. This means that over the range of principal interest, the dose-effect curves should be linear for the latter and concave upward (quadratic) for the former, which leads to the conclusion that application of the linear hypothesis based on data at high doses will over-estimate effects of low doses for β- and γ-ray exposure.

*For example, if there were 100 targets, the chance of hitting a given pair in 10 shots is about $\frac{10}{100} \times \frac{10}{100} = 0.01$, whereas in 20 shots it is about $\frac{20}{100} \times \frac{20}{100} = 0.04$. Note that it increases as the square of the number of shots.

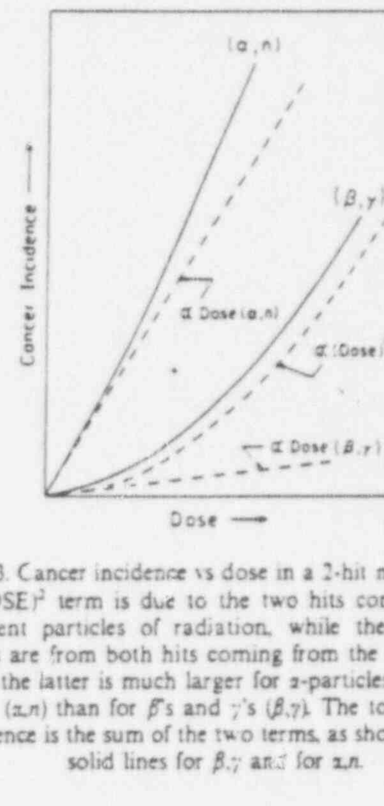

FIG. 3. Cancer incidence vs dose in a 2-hit model. The α(DOSE)^2 term is due to the two hits coming from different particles of radiation, while the α-DOSE terms are from both hits coming from the same particle; the latter is much larger for α-particles and neutrons (α,n) than for β's and γ's (β,γ). The total cancer incidence is the sum of the two terms, as shown by the solid lines for β,γ and for α,n.

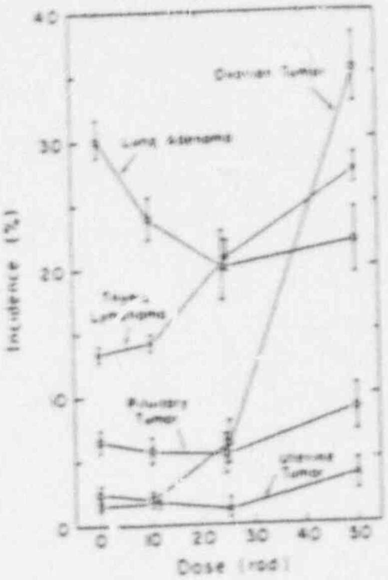

FIG. 4. Incidence of various neoplasms in γ-ray irradiated mice (Ul76) as a function of dose. Error bars are $\pm$ 1 S.D. In all cases, incidence is much increased at doses above 50 rad.

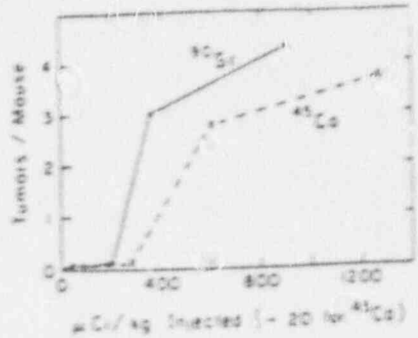

FIG. 5. Osteogenic sarcomas produced in CF1 female mice by intravenous injection of ^{90}Sr and ^{45}Ca at age 70 days (Fi68). Plot shows tumors per mouse vs radioactivity injected. Controls had 0.03 tumors per mouse. ^{90}Sr experiments used 810 mice and 150 controls; results for 1.3, 4.5 and 20 μCi/kg, not shown on plot, showed no excess over controls.

It may be noted that the above-outlined discussion assigns most α-particle radiation effects as due to multiple hits by the same α-particle at the same time. This implies that there would be no dose-rate effect for α-particles, in agreement with experimental evidence (Spe73). In fact there is some evidence that effects of α-particles are increased at lower dose rates (May78a).

(C) Data on cancer induction by radiation

One basis for judging the validity of the linearity hypothesis is to observe how well it behaves in explaining data down to the lowest doses at which effects are statistically meaningful. There is a rather large body of animal data extending down to the 10-rem region with reasonable statistical significance. These data for X, γ- and β-rays preponderantly indicate that linearity *over*-estimates effects at low levels (Up61; Fi68; Bu68; Mal69; May70; May72); examples are shown in Fig. 4 for external radiation and in Fig. 5 for exposure to irradiation by internally absorbed radionuclides. Note that these curves are concave upward. In some cases results are close to linear (St75), and there is one well known situation in which the observed dose-effect curve is concave downward (Sh69); the latter case involves mammary cancers in Sprague-Dawley rats, a special breed in which all females are virtually certain to die of that disease even in the absence of radiation exposure; it is widely recognized that this is an exceptional situation in many ways (Ke72).

The animal data for α-particle radiation usually show something close to a linear

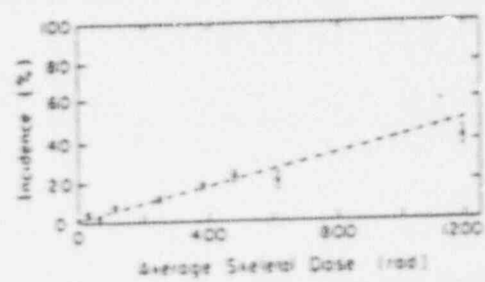

FIG. 6. Bone cancers induced in mice by injection of ^{226}Ra. Plot is percent incidence of bone sarcomas vs dose to bone in rad. Plot shown is work reported in (Fi69), adapted in (May 78b). Note that dose equivalent in rem is an order of magnitude larger than dose in rad shown on the plot. Dashed line is experimenter's straight line fit to data.

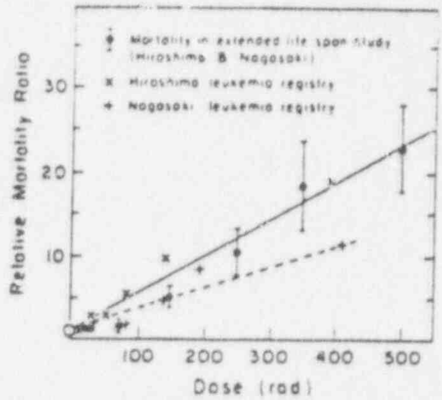

FIG. 7. Leukemia among Japanese A-bomb survivors (Be77). Solid circles are mortality data from leukemia among the "extended life span study" group chosen for careful analysis and follow-up, and solid line is a straight line between those data for high dose and zero dose (natural occurrence level). Other points are from the Hiroshima and Nagasaki leukemia registries analysed as described in text. Dashed line represents a straight line through data from Nagasaki leukemia registry.

dependence (May79a); an example (Fi69) is shown in Fig. 6. It should be noted that here, as in all other cases, there are no significant data below about 100 rem ($\sim$ 10 rad for α's).

Probably the best human data is that for leukemia among the Japanese A-bomb survivors (Be77), shown in Fig. 7. Unfortunately this has a controversial aspect. The mortality data for subjects in the group chosen for careful follow-up—the so-called "extended life-span study"—are shown by the solid circles with error bars, and they seem to indicate that linearity grossly over-estimates effects at low doses. However, there are leukemia registries in both Hiroshima and Nagasaki which keep track of the number of cases of leukemia among people living at various distances from the bomb explosion and compare them with the total population living at these distances (in 1950); the number of cases divided by the population is also plotted vs dose (as derived from the distance) in Fig. 7. There is no consideration as to age distribution, number of people who left the city, etc. but it is presumed that these factors do not vary systematically with dose. It is evident that these data are much better fit to a straight line than are the mortality data for the "extended life span" study. However, even the tumor registry data give no evidence that linearity *under*-estimates effects of low level radiation.

Data on bone cancer among the radium dial painters (Ro78) are plotted in Fig. 8 and we see there that the data points for low doses lie consistently below the prediction of the linearity hypothesis. While the statistical significance of this conclusion is not very great, there is certainly good evidence here that the linearity hypothesis is, if anything, conservative. Note that these data are for α-particle exposure.

(D) *Information from natural environmental exposure*

The clearest evidence that linearity *over*-estimates effects of low doses, if the basic assumptions of the study are accepted, comes from a comparison of radon-induced lung cancer between miners exposed to high doses and the non-cigarette smoking members of the

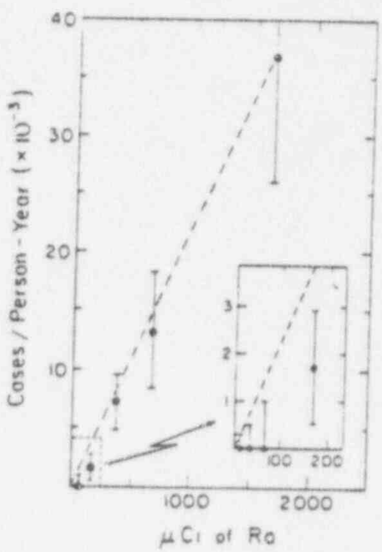

FIG. 8. Bone sarcomas among radium dial painters (Ro78). Main plot shows higher dose data used to obtain straight line fit, and inset compares this straight line with the low dose data.

general public exposed to natural radon in the environment at low doses (Co80). It turns out that 70% of the excess cancers among the miners were of one particular histological type, small cell-undifferentiated (SCU), and if linearity is applied to this disease based on the miner data, the number of SCU lung cancers due to normal environmental radon exposure among non-smokers is *over*-predicted by a factor of 8.

The significance of this conclusion depends on some basic assumptions that require justification. The most important assumption is that radon induced lung cancer has the same risk factor for smokers and non-smokers, i.e. that there is no synergism between smoking and radon exposure. Actually, there were indications in the early U.S. miner data that smoking accentuated the effects of radon, but the most recent data do not seem to support that viewpoint. One strong evidence against a smoking-radon synergism is that lung cancer incidence vs radon exposure is very similar between modern U.S. miners and a group of 19th century miners in the Erz mountains of central Europe who suffered their fate before cigarette smoking began (in early 20th century). There is independent evidence against a smoking-radon synergism from the studies of the Japanese A-bomb survivors: the *difference* in lung cancer rates between those with very low and very high exposure is the same for smokers and non-smokers, although the percentage increase is only 40% for smokers vs 200% for non-smokers. If there were a synergism, the percentage increase should be about the same for the two groups. It may also be noted that the male/female ratio of excess lung cancer from radiation was about unity, whereas that ratio in the general population was about 3, due to heavier smoking by males. If there were a strong synergism, these ratios should be the same.

Another basic assumption in the high-level vs low-level radon comparison was that the percentage of lung cancers that are SCU cell type does not decrease with decreasing dose. The evidence for this is that among the uranium miner victims, the fraction of the excess lung cancers that were SCU was 77% for the lowest dose group, 68% for the intermediate dose group, and 68% for the highest dose group (Ar74).

The above outlined evidence would seem to justify the conclusion that a linear dose-effect relationship normalized to the high dose data on miners over-estimates the effects of environmental radon exposure by a factor of 8.

The reason why this test is so sensitive is that average environmental radon exposures are quite high, well over 1 rem/yr to the bronchial epithelium. The lowest dose range for which there is significant evidence on the linearity hypothesis is leukemia caused by natural background γ-rays, levels of about 0.1 rem/yr.

Radiation induced leukemia is much better understood than other types of radiocarcinogenesis because it develops much sooner after exposure; thus we know the age dependence rather well. It has been rather easily diagnosed since the 1890s, which allows us to go back in time to the early years of this century when it was a much rarer disease than it is now. It is therefore possible to establish that a linear dose-effect relationship normalized to the high dose data on Japanese A-bomb survivors and radiation therapy patients requires that essentially all of the leukemia observed among 20–35-yr-old British females in the 1911–20 time period was due to natural environmental γ-ray exposure (Co80). This is evidence that the linear hypothesis does not under-estimate effects of radiation levels in the 2–3 rem range.

(E) *Latent period increases with decreasing dose*

An entirely separate reason for believing that the linear hypothesis is conservative derives from evidence that the latent period for radiocarcinogenesis, the delay between radiation exposure and development of cancer symptoms, increases as radiation dose decreases. There is evidence for this from many animal experiments (Up64; Hu67; Bu68; Do69; Hu69; Sh69; Ni70). An example is shown in Fig. 9 for injec-

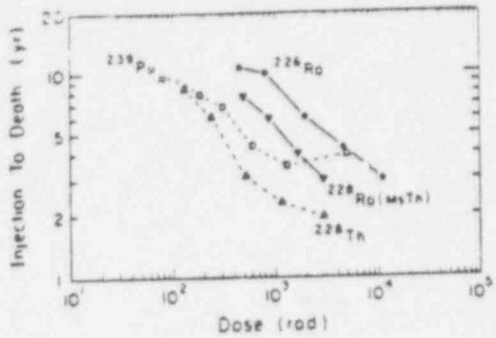

FIG. 9. Survival time for beagle dogs who developed bone cancer from injections of various α-emitting radioactive isotopes (Do69) vs dose to their bone at 1 yr before death. Note that ^{239}Pu and ^{228}Th are much more effective than ^{226}Ra because the former concentrate on the bone surfaces. These differences are taken into account in converting rad to rem.

tions of radioactivity into beagle dogs (Do69); each point represents the average time delay for a number of dogs, all of whom died of bone cancer. Dogs not injected (controls) had a post injection survival of 11.3 yr, so we may infer from Fig. 9 that doses very much below 100 rad to the bone would be totally ineffective.

There is evidence on this effect from human data for the group of German ankylosing spondylitis patients injected with ^{224}Ra (May78a), for skin cancer in Japanese radiological workers (Ki73), and for the U.S. radium dial painters (Ev74). Data for the last-named group are given in Fig. 10 which shows the time delay vs dose for each case: since there is no averaging, there are wide fluctuations, but when it is recognized that the data are cut off by time limitations on the study at an ordinate value of about 55 yr, it is reasonably clear that the trend of the data are as shown by the line, sloping upward to the left.

If the latent period increases with decreasing dose, at a rate even remotely approaching those indicated in Fig. 9 and 10, at low doses this latent period will far exceed the normal life span so there will be *no* cancers caused by low level radiation.

3. "NEW EVIDENCE" INDICATING LINEAR HYPOTHESIS *UNDER*-ESTIMATES EFFECTS

The news media have recently given heavy publicity to several reports from different sources purporting to indicate that the linear hypothesis grossly *under*-estimates health effects of low-level radiation. We here consider these reports, treating each in a separate section.

(A) *Mancuso–Stewart–Kneale (MSK) studies of Hanford workers*

Probably the best known report of the type under discussion is a study of the effects of occupational radiation exposure to workers at the Hanford Laboratory (near Richland, WA) by Mancuso *et al.* (Man77), which we refer to hereafter as MSK. It is based essentially on the 3500 male deaths from the work force of 25,000, searching for correlations between causes of death as obtained from death certificates and radiation exposures as recorded by film badges. MSK found that those who died of cancer had slightly higher radiation doses than those who died of other causes—2.1 vs 1.6 rad, and that those who received more radiation more frequently had cancer as their cause of death. Note that these statements do not necessarily imply that those who received more radiation had a larger probability of dying of cancer. In fact that is not the case, at least

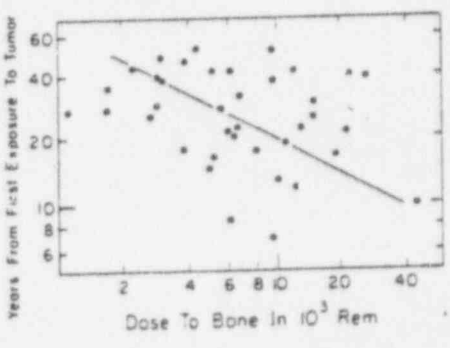

Fig. 10. Time between first radiation exposure and development of tumor for individual radium dial painters (Ev74). Line shows average trend in data considering that the ordinate is effectively cut off at about 55 yr by the length of the follow-up.

within the statistical accuracy of the available data (Gi78): the age-adjusted cancer mortality rates per yr per thousand white males aged 25–70 were 1.7 ± 0.4 for 0–2 rem exposure, 2.1 ± 0.8 for 2–5 rem, and 1.4 ± 0.6 for >5 rem, as compared to 2.1 for the total U.S. population (± denotes 95% confidence limits). There are some tricky aspects in considering only those who have died in that no consideration is given to the great majority of those exposed since they are still alive. Moreover, a higher proportion dying of cancer can mean either a higher probability of cancer death *or* a lower probability of dying from other causes.

MSK break their data down in various ways, and when this is done they obviously find some ages, some employment periods, some time interval between exposure and death, etc. which give larger results than average. This especially applies to types of cancer; for example, they find large excesses for cancer of the bone marrow (22 observed vs 13.4 expected), pancreas (49 obs. vs 37.3 exp.), and lung (192 obs. vs 144 exp.); they give no further consideration to types where results are in the opposite direction, as for lymphatic leukemia (3 obs. vs 9.4 exp.), other RES neoplasms (5 obs. vs 20.3 exp.), and genito-urinary cancers (15 obs. vs 30.9 exp.).

Since the difference in radiation dose between cancer and non-cancer deaths is so small and they explain the entire effect by these small differences, they naturally find very small "doubling doses". Some of these are listed in Table 2, in which we include also the results of their later revision (Kn78).

The MSK work has drawn criticism from a wide variety of sources (Gi77; Gi78; Mark78; Brod78; Sa78; Sa78a; Kl78; Re78a; Re78b; Pa78; An78; NR76; NR78; Rub78; Hu79; Ta79; Co78; Mo78; Ge78; Spi79; Gi79; Co80a). We attempt here to summarize it only briefly. There has been widespread criticism of the statistical methodology and handling of data; to cite one example, for multiple myeloma there were 8 cases among men with <1 rem exposure and 3 cases with about 30 rem, and this was treated, using averaging, as equivalent to 11 cases with 8 rem each. This procedure, plus some non-standard disease grouping—"bone marrow" cancer, which includes multiple myeloma, is not a standard classification—led to the estimate in Table 2 of 9.7 radiation induced deaths due to bone marrow cancer whereas the 3 myeloma victims were the only ones with appreciable exposure (An78).

There was no consideration given to the "healthy worker" effect (Gi78)—the fact that the Hanford workers had steady jobs means that they had less chronic disease than average which would result in their dying less frequently from some other causes and hence relatively more frequently from cancer. MSK used 1960 national statistics for comparisons, although most of the worker deaths occurred closer to 1970; since lung cancer was increasing rapidly over that period, this error alone explains their entire lung cancer effect (Hu79).

MSK paid no attention to the fact that dose correlates with many other factors such as years of service, job type and socioeconomic class, and these in turn correlate with exposures to other carcinogens and to general

Table 2. Results of study of Hanford workers by Mancuso et al. Table is from (Re78b)

Cancer type	Number of cases: Total	Number of cases: Due to rad	Doubling dose (rad): (Man77)	Doubling dose (rad): (Kn78)
Bone marrow	14	9.7	0.8	3.6
Pancreas	31	6.0	7.4	15.6
Lung	130	12.6	6.1	13.7
All RES	47	11.1	2.5	—
All cancer	442	25.8	12.2	33.7

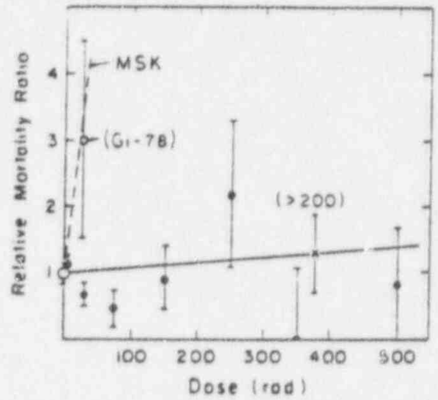

FIG. 11. Mortality from cancer of the pancreas among Japanese A-bomb survivors (black circles), among Hanford workers (Gi78, open square), and according to MSK (dashed line). Point labelled (>200) represents the average of all data above 200 rad. From (Co80b).

mortality from cancer; for example, technicians were exposed to much more radiation than office workers, and they were also exposed to far more chemical carcinogens. Several of the critics cited above pointed to lack of increased leukemia incidence as a strong point against the validity of the study. It was never made very clear what MSK meant by "doubling dose" as regards the role of natural background radiation, and in fact the derivation of doubling doses below total background exposure has a ring of unreality.

At least two independent analyses were made of the Hanford worker data used by MSK (Gi78; Hu79), and the conclusions of each were that the only results worthy of consideration were those for cancer of the pancreas and multiple myeloma. For the former there were 5 cases with exposures above 10 rad vs 1.4 expected, and for the latter there were 3 cases vs 0.4 expected (Hu79); for exposures above 15 rem there were 3 cases vs 1.0 expected for the former and 2 cases vs 0.4 expected for the latter (Gi78). These results are clearly not explainable as statistical fluctuations, although they could easily be due to a factor which correlates with radiation dose such as exposure to chemical carcinogens.

One way of deciding whether radiation is the causative agent is to check for evidence of these diseases among other groups exposed to radiation. Data on cancer of the pancreas among Japanese A-bomb survivors are shown in Fig. 11 along with the single data point from the Hanford workers [taken from (Gi78)], and the prediction from the MSK doubling dose (Co80a). It is clear that the MSK conclusion is grossly inconsistent with the A-bomb survivor data.

The Japanese A-bomb survivor data on multiple myeloma (Ni73) are much more sparse—4 cases vs 1.9 expected up to 1965— but doubling dose is of the order of 100 rad which is 30 times the MSK doubling dose for bone marrow cancers. The rate derived for the A-bomb survivors was 3×10^{-6} cases/man-rem. In studies of patients exposed in thorotrast treatments, the rate was only 0.25×10^{-6} cases/man-rem, and among the German patients treated for ankylosing spondylitis with ^{224}Ra, there were 54 bone cancers but no cases of multiple myeloma which corresponds to less than 0.04×10^{-6} cases/man-rem (May79b). Castleman searched the X-ray exposure history of multiple myeloma patients, and found no correlations (Ca79).

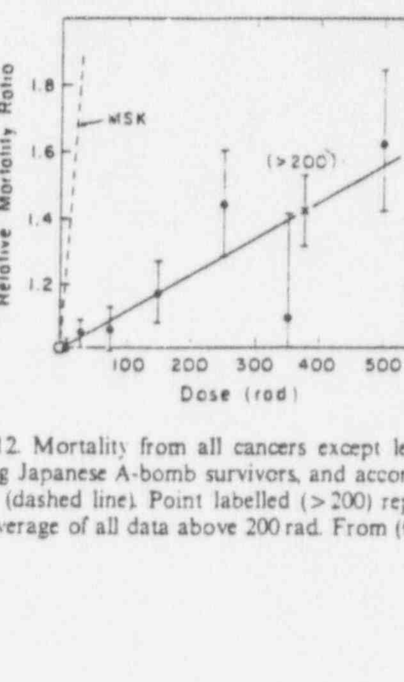

FIG. 12. Mortality from all cancers except leukemia among Japanese A-bomb survivors, and according to MSK (dashed line). Point labelled (>200) represents the average of all data above 200 rad. From (Co80a).

By very complicated and questionable procedures, MSK derived a doubling dose for all cancers as 12.2 rad (Man77), later revised to 33.7 rad (Kn78). The latter is shown in Fig. 12 along with the data from the Japanese A-bomb survivors for all cancers except leukemia (Be77). Clearly there is an enormous discrepancy here, by about a factor of 30 in doubling dose. It should be noted that MSK make no effort to compare their results with those for the Japanese A-bomb survivors or with any of the other groups with high radiation exposure.

The reaction to MSK of the prestigious national and international groups charged with evaluating health effects of radiation has been cool. The minutes of the Stockholm meeting of ICRP states "the Commission has concluded that the information available up to May 1978 does not call for changes in the risk factor given in ICRP Publication 26". The latter was published in January 1977 and MSK was published in November 1977. They made no mention of MSK.

The UKNRPB (Re78b) report on MSK concludes: "Despite the claims of the authors, a wide body of experts agree that there is no evidence in the Hanford data to support the suggestion that ICRP [26] values do seriously underestimate the risk."

The National Academy of Sciences BEIR Committee 1979 report has not yet appeared, but in a press conference it was stated that it found "no substance" in the MSK work.

(B) *Rotblat comments on A-bomb survivor data*

Rotblat has pointed out that the survivors of the A-bomb attacks on Japan are a select group in that they survived the injuries and trauma of the attack (Ro78a). He points out that for some types of cancer, evidence from medical patients treated with radiation indicates higher risks, and explains the difference as due to the fact that the A-bomb survivors are such a select group. He does not seem to consider the fact that the medical patients are also a select group in that they are already suffering from another serious disease. He concludes that if there had been no early deaths from injuries and trauma in the original bombing episodes, the cancer deaths from radiation would have been 5 times higher.

It is interesting to point out that the Rotblat effect should be very much larger for the high dose cases than for the low dose cases, since the former were close to ground zero while the latter were far away and thus much less likely to be directly injured by the blast, heat and other effects of the bomb (Co59). Thus, if Rotblat is correct, the data on the right side of Fig. 12 would be moved up by an order of magnitude while the low dose data would be little affected. This would give a curve very much concave upward. In any case, the effects of low doses would not be much changed.

The Rotblat thesis has not been accepted by the prestigious evaluation groups, and there has been little indication of significant acceptance by the scientific community.

(C) *Najarian studies of workers at Portsmouth Navy Yard*

Thomas Najarian, a physician practicing in Boston, got the impression from discussions with patients, that there might be an excess of leukemia among workers at the Portsmouth (NH) Naval shipyard where nuclear ships are serviced, and suspected that it might be due to their occupational radiation exposure. With the help of a team of reporters from the Boston Globe, he searched through 90,000 death certificates and found 1700 former Portsmouth workers. Of these, 22 died of leukemia as compared with only 5 expected, according to the February 1978 story in the Boston Globe; according to a more scientific account published in *Lancet* (Na78), there were 1450 workers identified, and among these there were 20 leukemias vs 10.8 expected. The latter number is subject to considerable variation depending on the control group chosen, as explained in section 1 above.

Age distribution is also a sensitive parameter (La78), as the leukemia rate increases rapidly

with increasing age—the average age of Portsmouth workers is clearly above the average age of all males which includes children. It was not explained how the "expected" number was derived. It is also well known that rates for various cancer types show strong occupational correlations; in a study in Washington State (Mi76), poultrymen were found to have over double the average leukemia rate, and such diverse groups as dairymen, bankers and bus drivers also seemed to suffer far above average leukemia rates.

Najarian attempted to separate out radiation workers by asking their close relatives whether they remembered them wearing film badges, a somewhat marginal methodology. He thereby identified 146 radiation worker deaths among which there were 6 leukemias vs 1.1 expected.

At this stage, data finally became available on doses measured with film badges, and it turned out that only 3 of the 6 radiation worker leukemia victims had any radiation exposure, and the average exposure for the group was 1.3 rem. This raises the question of the role of natural and medical X-ray radiation, which exposed the average worker to about 10 rem by the time of his death. How is it possible that 10 rem causes at most 1.1 leukemias, whereas an extra 1.3 rem to make the total 11.3 rem causes 6 leukemias? No imaginable dose-effect relationship could explain such a situation, especially in view of the variability of natural radiation with geography which is not correlated with leukemia rates.

It may be noted that there are many chemical carcinogens in a shipyard environment, including benzene and other organic solvents, welding debris and asbestos.

On 19 June 1979, Najarian, appearing before Sen. Edward Kennedy's subcommittee, withdrew most of his claims, and those not withdrawn were heavily criticized in other testimony. As reported in the Boston Globe which first promoted Najarian's work, a highly agitated Sen. Kennedy chided Najarian with "I don't think we ought to be alarming families unduly... we have seen you repudiate two areas of your study, and the National Cancer Institute has repudiated the third" (We79).

(D) *Bross re-analysis of Tri-State Study*

Bross and collaborators (Bros79) reported a re-analysis of the well known "Tri-State Study" carried out in NY, MD and MN in 1959–62 (Gr66). They emphasize that different people respond to radiation in different ways, and attempt to take this into account by considering 5 different categories of people—this multiplies the number of parameters available for adjustment by 5. They then consider the triple correlation between number of X-rays received, cancer and heart disease. They treat the problem with what they call a new statistical methodology, which they explain only cursorily. They finally conclude that the linear hypothesis under-estimates the effects of low-level radiation by an order of magnitude.

Immediately following the Bross article in *American Journal of Public Health*, there was a scathing critique of it by Boice and Land (Bo79) of National Cancer Institute. It is ironic that the *New York Times* published a long article on the Bross paper (NY79), but made no mention whatsoever of the Boice-Land critique.

Boice and Land questioned the Bross statistical methodology and method of choosing parameters (the latter seems to be highly arbitrary). They note that there are clearly too many parameters for the individual values of each to have statistical significance. They point out that there is a great deal of independent evidence that radiation does *not* cause heart disease; for example, among the Japanese A-bomb survivors, there is no more heart disease among those exposed to >200 rad than among those with less than 1 rad exposure.

They point out many problems in the data collection process: X-rays may have been given for a pre-leukemic disease—half of all X-rays were made within the 5 yr previous to development of leukemia; most information was obtained from interviews with relatives, a generally unreliable source, with a strong tend-

ency to look for causes; there may well have been a tendency for interviewers to probe harder for radiation information on those whom they knew to be leukemia victims than on controls; and the dosimetry was very crude. They also point out that the Bross analysis considers only 206 of the 399 cases in the Tri-State Study, and gives no explanation for not considering the others.

The National Academy of Sciences BEIR Committee Report considered the Bross paper and reported in a press conference that it found "no substance" in the work.

The 1979 paper by Bross and collaborators is the culmination of a series of previous papers re-analyzing the Tri-State Study (Gi68; Bros72; Bros77). The evolution of these, as well as a preliminary version of the 1979 paper, were heavily critiqued by Rothman (Ro78b) in which he emphasized that the whole approach was highly unscientific. Details of the Bross 1972 paper were critiqued by MacMahon Mac72) and by Mole (Mo74).

(E) *Lyon paper on excess childhood leukemia down-wind from Nevada Test Site*

Lyon *et al.* (Ly79) reported an analysis of mortality from childhood (age 0–14) leukemia in Utah, in which they divided the state into areas of high fallout and low fallout from the Nevada Test Site, and also considered time periods of high fallout (1951–58) and low fallout (before and after those dates). Where a person's pre-leukemia years were partially during low fallout and partially during high fallout time periods, the responsibility for the leukemia was divided proportionately between the two. Their results on childhood leukemia mortality rates are shown in Table 3(a).

There appears to be a large excess in the high fallout areas attributable to the high fallout time period which is not reflected in the data for the low fallout areas or for the total U.S. If the earlier and later time periods are assumed to represent the situation in the absence of fallout, this excess consists of 32 cases vs 13.1 expected.

On the other hand, it should be noted that the statistical uncertainty is rather high, enough so that even under the assumptions used there is a few percent chance that the entire effect is simply a statistical fluctuation. Moreover, the effect is not so much an excess over the U.S. average during the high fallout time period as it is a deficiency relative to the U.S. average before and after the high fallout time period.

It is interesting to include data for other childhood cancers as given in Table 3(b). Note that there was a sharp *drop* in the rate during the high fallout time period as compared with the before–after average. Land has pointed out (La79a) that this drop has about the same statistical significance as the increase for leukemia.

Table 3(a). Childhood leukemia mortality rates in high fallout and low fallout areas of Utah and in the U.S. Figures are rates per 10^5 population, and ± indicates 2 S.D.

Area	1944–50	1951–58	1959–75
High fallout	2.1 ± 1.56	4.39 ± 1.58	1.96 ± 1.23
Low fallout	3.84 ± 1.14	4.21 ± 0.70	3.28 ± 0.64
Total U.S.	3.2	3.5	3.1

Table 3(b). Childhood cancers other than leukemia (see caption for Table 3(a))

Area	1944–50	1951–58	1959–75
High fallout	6.36 ± 2.72	3.07 ± 1.37	3.05 ± 1.60
Low fallout	4.52 ± 1.25	4.33 ± 0.68	3.09 ± 0.62

The Lyon paper actually has little direct bearing on the question of effects of low level radiation since there are no data available on doses. However, the Utah situation has often been cited as evidence for increased danger from low level radiation, and the Lyon paper is the only one in the scientific literature on that subject. There has been widespread publicity about evidence for increased adult leukemia in Southern Utah (PBS79) due to fallout, but none of it seems to be of a quality worthy of scientific consideration.

(F) *Smoky Test*

In 1957, 3200 soldiers participated in a tactical warfare exercise in which they occupied an area in which a nuclear bomb had been detonated shortly before. Their radiation exposure as obtained from film badges averaged about 1 rem.

A group of these men was recently studied, and there were found to have been 8 leukemias among them. The number of cases expected is poorly known because this is highly sensitive to their age distribution which cannot be reconstructed because records were lost in a fire in St. Louis. If their average age was 22, only 1.8 cases would have been expected by now, but if their average age was 35, there would be 5 cases expected (Lap79).

If the facts as outlined were correct and there were 8 cases vs roughly 3 expected, one is faced with the idea that natural plus medical exposures of 10 rem (plus all other causes of leukemia) caused 3 cases while 1 rem additional caused 5 cases. No reasonable person could believe in such a dose-effect relationship, especially in view of the low leukemia rates in states with high natural background. If the extra leukemias were indeed caused by radiation, there must have been an error in dosimetry. It has been suggested that the soldiers involved may have inhaled or ingested radioactivity; this would not affect film badge readings, so their doses may have been much higher.

In any case it seems clear that the Smoky Test experience sheds no light on the dose-effect relationship for low-level radiation, although a linkage has frequently been implied in press reports.

(G) *Reported excess leukemia due to mill tailings in Grand Junction, CO*

The ABC-TV "20-20" program has more than once presented the viewpoint that low-level radiation is much more dangerous than it is generally believed to be, with heavy emphasis on a report that leukemia rates are double what is expected in Grand Junction, CO (Cu78) where uranium ore-processing mill tailings were used in construction. The "expected" rate is the Colorado state average, and the result is based on 41 cases vs 20.1 expected in Mesa County (which includes Grand Junction) between 1970 and 1976.

It is widely believed that most leukemias are due to environmental factors, since, for example, the U.S. mortality rate from that disease has increased by a factor of five over the last half century, and the rates in different states vary by as much as 30% (with negligible statistical uncertainty). It thus seems reasonable to conclude that there may be a leukemogenic agent in the Mesa County environment. This, of course, does not imply that it is radiation.

A case-control study was carried out (Cu78) in which it was found that there was no significant difference between the leukemia victims and the control groups as regards exposure to tailings. This would seem to indicate that exposure to tailings is not the responsible factor. Further evidence for this is that the principal expected radiation effect from mill tailings is lung cancer (due to radon emissions), and there was no evidence for an increased level of lung cancer in Mesa County (Cu78).

Even after all of these facts became known, the ABC-TV "20-20" program referred to them as "inconclusive" and repeated their assessment that mill tailings are causing large numbers of leukemias in Grand Junction.

(H) *Excess lung cancer near Rocky Flats, CO*

The ABC-TV "20–20" program also featured evidence for increased cancer rates in Jefferson County, CO in which the Rocky Flats plutonium processing plant is situated. However, these charges do not seem to be verified by the statistics (La79). The total cancer mortality rate in Jefferson County is just equal to the Colorado State average which is somewhat below the U.S. average. Since the principal expected effect of plutonium in the environment is lung cancer, statistics on that disease are also of interest here: before the Rocky Flats plant was built, the lung cancer rate in Jefferson County was slightly greater than the U.S. average, but in recent years it has been significantly below the U.S. average. No information supporting the charges of increased cancer near Rocky Flats has appeared in the scientific literature.

(I) *Summary on "new evidence"*

None of the "new evidence" purporting to indicate that the linear hypothesis underestimates effects of low-level radiation seems to stand up under scientific scrutiny. None of it has been accepted by any of the prestigious evaluation committees such as BEIR, ICRP, etc. The publicity given to them by the news media thus seems to be completely unwarranted.

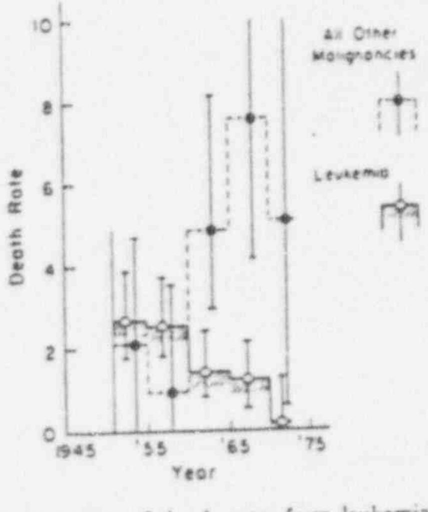

FIG. 13. Variation of death rates from leukemia and from all other cancers with time for Japanese A-bomb victims. Exposure was in 1945, and data begin in 1950. Ordinate is mortality rate/10^6 rad, and error bars indicate 90% confidence limits. From (UNSCEAR77).

4. ESTIMATION OF EFFECTS OF LOW-LEVEL RADIATION

We have reviewed a great deal of evidence indicating that the linear hypothesis gives a conservative estimate of the effects of low-level radiation. This leaves us with the problem of estimating risks per unit radiation dose for use with the linear hypothesis. As indicated previously, this is done by analysing effects of high-level radiation situations. From these analyses, one derives the number of fatalities per yr per rem of exposure. However, in the process of converting these numbers to a lifetime risk, there are several complications:

(1) *Latent period*

The mortality rates from leukemia and from all other cancers among the Japanese A-bomb survivors are shown vs time in Fig. 13. We see that for the solid tumors the rate was relatively low until 1960, 15 yr after the exposure, and then suddenly jumped to a much higher level. This implies that there is a long latent period during which cancers develop without presenting symptoms. This must be taken into account in any analysis. In many of the high radiation incidents, as with miners exposed to radon or radium dial painters exposed to internally deposited radioactivity, the exposure takes place over a very long time period, which greatly complicates the analysis.

(2) *Duration of risk*

Once the latent period is past and the risk approaches its full value, one must estimate how long this risk will persist. There is reasonable evidence for leukemia in Fig. 13 that the risk falls off with time and becomes much less after about 25 yr. For other cancers, however, there is little direct evidence on this question. There is a general impression that it lasts about

Table 4. Cases of all cancers but leukemia occurring between 1960 and 1970 among Japanese A-bomb survivors of various ages at time of exposure. Data are from (NAS72)

Age in 1945	Approximate number of subjects	Average dose (rem)	Cases observed	Cases expected	Number/ 10^6-rem-yr
0–9	5000	111	6	2.1	0.75
10–19	5500	157	25	16.9	0.72
20–34	5500	134	85	63.9	3.1
35–49	5800	122	286	251	5.4
50+	2500	106	221	210	5.3

30 yr, and this is often used in calculations. In most cases, results would not be very much different if the risk persists throughout the remainder of life.

(3) *Age dependence*

There is evidence in Table 1 that young children develop leukemia at about double the adult rate for a given exposure. For other cancers, the situations seems to be reversed as indicated by data for the Japanese A-bomb survivors in Table 4 where we see that those exposed as children experienced a lower rate by nearly an order of magnitude. On the other hand, it must be recognized that those exposed as children have not yet reached the age range where cancer is an important risk, whereas those exposed as adults are well into that age range. Because of this, the ratio of observed to expected numbers of cancers is actually higher among those exposed as children. It is an open question as to whether this high ratio or the low absolute incidence will persist when those exposed as children reach the age of high normal cancer risk.

In treating the problems of latent periods, duration of risk, and age dependence, one can adopt models (NAS72) or use piece-meal estimates (UNSCEAR77). In either case, it would be unrealistic to expect any high degree of accuracy. Moreover, data from different high radiation dose situations are often inconsistent, as may be seen from Table 1.

Nevertheless, BEIR, ICRP and UNSCEAR have all given estimates of age-averaged risks. These are listed in Table 5. We see that there is a reasonable degree of consistency among the three estimates. ICRP gives less detail than the other two, so more types of cancer are included in the "other" category.

It may be noted that the "totals", which represent the effect of radiation to the whole body, are not equal to the sum of the risks to the various organs. Part of the reason for this is that the totals represent a male-female average, whereas the breast cancer entry applies to females only. When this is corrected for, there is still a considerable discrepancy for the ICRP and UNSCEAR estimates, but they offer no explanation for it. Actually they seem to derive the total independently from summing the risks to each organ, and the uncertainties are large enough to cover the discrepancies. In any case, Table 5 gives the best information available for estimating effects of low level radiation.

An average radiation-induced cancer shortens the victim's life by about 20 yr, so if we adopt the BEIR estimate, 1 rem reduces life expectancy by $180 \times 10^{-6} \times 20$ yr = 1.3 days.

Table 5. Estimates of cancer risk per 10^6 rem by the different evaluation groups (NAS72, ICRP77; UNSCEAR77). Risks are averaged over ages, and the totals are sex-averaged

Type of cancer	BEIR	ICRP	UNSCEAR
Leukemia	25	20	15–25
Lung	39	20	25–50
Breast (female)	90	25	60
Bone	6	5	2–5
G-I tract	30	—	25
Thyroid	—	5	5–15
Other	30	50	~25
Total	180	100	120

Table 6. Deaths from various causes among survivors of A-bomb attacks on Japan vs radiation exposure. Listings are total deaths 1950–74 [upper line] and ratio of these to the number expected in the absence of radiation [lower line]. The final column is the observed/expected ratio for the three highest dose groups divided by the observed/expected ratio for the zero exposure group. Data are from (Be77)

Disease	Radiation dose received (rad): 0	1–9	10–49	50–99	100–199	200–299	300–399	400+	200+/0
Leukemia	31 0.50	23 062	20 0.76	7 0.96	16 2.8	15 5.9	12 10.3	20 12.6	17.5
Other cancers	1586 0.97	881 0.97	704 1.02	202 1.03	159 1.14	80 1.39	28 1.05	58 1.58	1.42
All non-cancer	6367 1.01	3652 1.01	2684 0.99	747 0.97	513 0.97	202 0.95	91 0.92	149 1.11	0.98
Cerebrovascular	1891 1.01	1080 1.01	800 0.99	228 0.99	159 1.03	57 0.92	27 0.94	35 0.89	0.92
Circulatory system	1264 1.01	704 0.98	534 0.98	179 1.17	98 0.96	39 0.97	23 1.23	24 0.93	1.01
Blood and blood-forming organs	40 0.77	23 0.81	23 1.05	7 1.12	9 2.04	6 3.19	3 3.59	6 5.44	5.16
Digestive system	700 1.02	383 0.97	293 1.00	79 0.95	58 1.01	27 1.16	5 0.47	21 1.40	1.06
Other natural causes	2059 1.045	1158 1.021	798 0.94	204 0.85	140 0.88	57 0.89	24 0.81	48 1.20	0.92
Accidents, poisons, violence	546 1.03	324 1.03	195 0.90	63 1.04	46 0.97	12 0.57	6 0.64	18 1.37	0.83
Suicide	183 1.09	122 1.18	50 0.71	22 1.09	15 0.91	1 0.13	0 0	2 0.44	0.17

One mrem then reduces life expectancy by 2 min. By way of comparison, smoking a single cigarette reduces life expectancy by 10 min, and an overweight person reduces his life expectancy by 15 min for each extra 100 calories ingested (Co79a).

With present technology, low level radioactivity releases if all U.S. electric power were nuclear are estimated (APS78; Po76; NRC76a; UNSCEAR77) to cause an average population exposure of about 0.2 mrem/yr, or 40,000 man-rem/yr in the U.S. This might then be expected to cause $180 \times 10^{-6} \times 40{,}000 = 7$ additional cancers per yr among the public. This corresponds to a loss of life expectancy for the average American of about 30 min, which represents a risk equal to that of smoking one cigarette every 20 yr, or of an overweight person gaining an additional 0.01 oz.

There has been speculation as to whether radiation causes diseases other than cancer in those exposed. The best evidence on this is from the Japanese A-bomb survivors, which is listed in Table 6 and compared there with the evidence on leukemia and other cancers. We see that, with the relatively minor exception of diseases of the blood and blood-forming organs which are closely related to leukemia, there is no indication that any somatic effect other than cancer is related to radiation.

REFERENCES

An78 Anderson T. W., 1978, *Health Phys.* **35**, 743.

Ar74 Archer V. E., Saccomanno G. and Jones J. H., 1974, *Cancer* **34**, 2056.

APS78 APS (Am. Phys. Soc.), Study Group on Nuclear Fuel Cycles, 1978, *Rev. Mod. Phys.* **50**, (1), Part II, January.

Be77 Beebe G. W., Kato H. and Land C. E., Radiation Effects Research Found. Rep. RERF TR1-77.

Bo79 Boice J. D. and Land C. E., 1979, *Am. J. Public Health* **69**, 137.

Brod78 Brodsky A., 1978, Testimony for U.S. House of Representatives Subcommittee on Health and the Environment, 8 February.

Bros72 Bross I. D. J. and Natarajan N., 1972, *New Eng. J. Med.* **287**, 107.

Bros77 Bross I. D. J. and Natarajan N. 1977, *J. Am. Med. Assoc.* **237**, 2399.

Br76 Brown J. M., 1976, *Health Phys.* **31**, 231.

Bros79 Bross I. D. J., Ball M. and Falen S., 1979, *Am. J. Public Health* **69**, 130.

Bu68 Burns F. J., Albert R. E. and Heimbach R. D. 1968, *Rad. Res.* **36**, 225.

Ca79 Castleman B., 1979, Private communication.

Co78 Cohen B. L., 1978, *Health Phys.* **35**, 582.

Co79a Cohen B. L., 1979a, *Bull. Atomic Scientists* 53, February.

Co79b Cohen B. L. and Lee I. S., 1979b, *Health Phys.* **36**, 707.

Co80a Cohen A. F. and Cohen B. L., 1980, *Health Phys.* **38**, 53.

Co80b Cohen B. L., "The Low-level Radiation Link to Cancer of the Pancreas", *Health Phys.* **38**, 712.

Cu78 Cunningham M. C., Ferguson S. W. and Foreman T., 1978, "Excess Cancer Incidence in Mesa County, Colorado", Colorado Dept of Health Report, November.

Do69 Dougherty T. F. and Mays C. W., 1969, in: *Radiation Induced Cancer*, p. 361 (Vienna: IAEA).

El67 Elkind M. M. and Whitmore G. F., 1967, *The Radiobiology of Cultured Mammalian Cells*, p. 219 (New York: Gordon & Breach).

El77 Elkind M. M. and Redpath J. L., in: *Cancer* (Edited by Bicker S. S.), Chap. 3, p. 51 (New York: Plenum Press).

Ev 74 Evans R. D., 1974, *Health Phys.* **27**, 497.

Fi68 Finkel M. P. and Biskis B. O., 1968, *Prog. Exp. Tumor Res.* **10**, 72.

Fi69 Finkel M. P., Biskis B. O. and Jenkins P. B., in: *Radiation Induced Cancer* (Edited by Ericson A.), p. 369 (Vienna: IAEA).

Fo73 Fox B. W. and Lajtha L. G., 1973, *Br. Med. Bull.* **29**, 16.

Fo77 Fowler J. F. and Denekamp J., in: *Cancer* (Edited by Becker S. S.), Chap. 5, p. 139 (New York: Plenum Press).

Ge78 Gertz S. M., 1978, *Health Phys.* **35**, 723.

Gib68 Gibson R. W., Bross I. D. J., Graham S., Lilienfeld A., Schuman L. M., Levin M. L. and Dowd J. E. 1968, *New Eng. J. Med.* **279**, 906.

Gil77 Gilbert E. S., 1977, "Methods of Analyzing Mortality of Workers Exposed to Low-levels of Ionizing Radiation", Battelle Pacific Northwest Laboratory Rep. BNWL-SA-634, May.

Gil78 Gilbert E. S., 1978, Testimony for U.S. House of Representatives Subcommittee on Health and the Environment; also available as Document PNL-SA-6341 Rev.

Gil79 Gilbert E. and Marks S., 1979, *Health Phys.* **37**, 791.

Gr66 Graham S., Levin M. L., Lilienfeld A. M., Schuman L. M., Gibson R., Dowd J. E. and Hempelmann L., 1966, "Preconception, Intrauterine, and Postnatal Irradiation as Related to Leukemia", Natl Cancer Inst. Monograph 19, p. 347.

Gr72 Grahn D., Fry R. J. M. and Lea R. A., 1972, in: *Life Sciences and Space Research*, Vol. X (Edited by Strickland A. C.) (Berlin: Akademie-Verlag).

Hul67 Hulse E. V., 1967, *Br. J. Cancer* **21**, 531.

Hug69 Hug O., Gossner W., Muller W. A., Luz A. and Hindringer B., 1969, in: *Radiation Induced Cancer*, p. 393 (Vienna: IAEA).

Hut79 Hutchinson G. B., MacMahon B., Jablon S. and Land C. E., 1979, *Health Phys.* **37**, 207.

ICRP59 International Commission on Radiological Protection, 1959, "Report of Committee II on Permissible Dose for Internal Radiation", *ICRP Publication 2*, (New York: Pergamon Press).

Ke72 Kellerer A. M. and Rossi H. H., 1972, *Current Topics in Rad. Res.* **8**, 85.

Ke75 Kellerer A. M. and Rossi H. H., 1975, in *Cancer* (Edited by Becker F. F.), Vol. 1, p. 405 (New York: Plenum Press).

Ki73 Kitabatake T., Watanabe T. and Koga S. 1973, *Strahlentherapie* **146**, 599.

Kl78 Kleitman D. J., 1978, "Critique of Mancuso-Stewart-Kneale Report", Submission to U.S. Nucl. Reg. Comm., 2 March.

Kn78 Kneale G. Stewart A. and Mancuso T. F., 1978, *IAEA Symp. on the Late Biological Effects of Ionizing Radiation*, Vienna, March (Vienna: IAEA).

Lan79 Land C. E., 1979, *New Eng. J. Med.* **300**, 8, 431.

Lap79 Lapp R. E. *The Radiation Controversy* (Greenwich, CT: Reddy Communications).

Le55 Lea D. E., 1955, *Actions of Radiation on Living Cells* (London: Cambridge Univ. Press).

Ly79 Lyon J. L., Klauber M. R., Gardner J. W. and Udall K. S., 1979, *New Eng. J. Med.* **300**, 397.

Mac72 MacMahon B., 1972, *New Eng. J. Med.* **287**, 144.

Mal69 Maldague P., 1969, in: *Radiation Induced Cancer*, p. 439 (Vienna: IAEA).

Man77 Mancuso T. F., Stewart A. and Kneale G., 1977, *Health Phys.* **33**, 369 (referred to as MSK).

Mark78 Marks S., Gilbert E. S. and Breitenstein B. D., "Cancer Mortality in Hanford Workers", IAEA Document IAEA-SM-224.

Mars78 Marshall J., 1978, Argonne National Laboratory, Private communication.

May70 Mays C. W., Dougherty T. F., Taylor G. N., Stover B. J., Jee W. S. S., Christensen W. R., Dougherty J. H., Stephens W. and Nabors C., 1970, *Hearings on Environ. Effects of Producing Electric Power*, Joint Com. on Atomic Energy, U.S. Congress, Vol. II, Part 2, p. 2192.

May72 Mays C. W. and Lloyd R. D., in *Biochemical Implications of Radiostrontium Exposure* (Edited by Goldman M. and Bustad L. K.), USAEC Rep. CONF-710201.

May78a Mays C. W., Speiss H. and Gerspach A., 1978. *Health Phys.* **35**, 83.
May78b Mays C. W., 1978. "Discussion of Plutonium Toxicity", *Proc. Symp. Natl Energy Issues* (Edited by Sachs R. G.), Argonne National Laboratory, September.
May79a Mays C. W., 1979. *Argonne National Laboratory Symp. on National Energy Issues—Plutonium as a Test Case* (Edited by Sachs R. G.), p. 127 (Ballinger Press).
May79b Mays C. W., 1979. Private communication.
Mc66 McGrath R. A. and Williams R. W., 1966. *Nature* **212**, 534.
Mi76 Milham S., 1976. "Occupational Mortality in Washington State 1950–71", Report to Dept HEW-NIOSH, Cincinnati, April.
Mo59 Mole R. H., 1959. *Br. J. Radiol.* **32**, 497.
Mo74 Mole R. H., 1974. *Br. J. Cancer* **30**, 199.
Mo78 Mole R., 1978. *Lancet* 1978-i, 582.
NAS72 National Academy of Sciences, 1972. *The Effects on Populations of Exposure to Low Levels of Ionizing Radiation* (Washington, DC: NAS).
Na78 Najarian T. and Colton T., 1978. *Lancet* 1978-i, 1018.
Ni70 Nilsson A., 1970. *Acta Radiol. Ther. Phys. Biol.* **9**, 155.
Ni73 Nishiyama H., Anderson R. E., Ishimaru T., Ishida K., Ii Y. and Okabe N. 1973, *Cancer* **32**, 1301.
NRC76a U.S. Nucl. Reg. Comm., 1976a. Staff Committee Report of November 1976.
NRC76b U.S. Nucl. Reg. Comm., 1976b. NUREG-0002, August.
NRC78 U.S. Nucl. Reg. Comm., 1978. Staff Committee Report of May 1978.
NY79 *New York Times*, 22 February, 1979. "Leukemia is Linked to Small Radiation".
Pa78 Hon. Mr. Justice Parker, *The Windscale Inquiry*, 26 January (London: HMSO).
PBS79 Public Broadcast System, 1979. PBS program, "Paul Jacobs and the Nuclear Gang", March 1979.
Po76 Pochin E. E., *Estimated Population Exposure from Nuclear Power Production and other Radiation Sources* (Paris: OECD).
Re78a Reissland J. A. and Dolphin G. W., 1978a. Radiation Protection Bull. 23, UKNRPB, Harwell.
Re78b Reissland J. A. 1978b. "An Assessment of the Mancuso Study", *UKNRPB Publication* NRPB-R79, September.
Row78 Rowland R. E., Stehney A. F. and Lucas H. F., 1978. *Rad. Res.* **76**, 368.
Rotb78 Rotblat J., 1978. *Bull. Atomic Scientists*, September.
Roth78 Rothman K. J., 1978. "Review of Dr. Irwin Bross' Presentation on Radiation Exposure and Cancer Risk", U.S. Nuclear Reg. Comm. 7 April.
Rub78 Rubenstein D., 1978. Report to U.S. Nuclear Regulatory Commission.
Rus72 Russell W. L., 1972. "Peaceful Uses of Atomic Energy", *IAEA Publication* STI PUB 1300, Vol. 13, p. 487 (Vienna: IAEA).
Sag78 Sagan L. A., 1978. "Low Level Radiation Effects: The Mancuso Study", EPRI Report; *Atom* 262, August.
San78 Sanders B. S., 1978. *Health Phys.* **34**, 521.
Sc73 Schmid E., Rimpe G. and Bauchinger M., 1973. *Rad. Res.* **57**, 228.
Sh66 Shellabarger C. J., Bond V. P., Aponte G. E. and Cronkite E. P., 1966. *Cancer Res.* **26**, 509.
Sh69 Shellabarger C. J., Bond V. P., Cronkite E. P. and Aponte G. E., 1969. in: *Radiation Induced Cancer*, p. 161 (Vienna: IAEA).
Spe73 Speiss H. and Mays C. W., 1973. in: *Radionuclide Carcinogenesis* (Edited by Sanders C. L. *et al.*, USAEC Rep. CONF-720505, p. 437.
Spi79 Spiers F. W., 1979. *Health Phys.* **37**, 784.
St75 Storer J. B., 1975. in: *Cancer* (Edited by Becker F. F.), Vol. 1, Chapt. 16, p. 453 (New York: Plenum Press).
Ta79 Tait G. W. C., 1979. *Health Phys.* **37**, 251.
To73 Town C. D., Smith K. C. and Kaplan H. S., 1973. *Rad. Res.* **52**, 99.
Ul76 Ullrich R. L., Jernigan M. C., Cosgrove, C. E., Sutterfield L. C., Bowles N. D. and Storer J. B., 1976. *Rad. Res.* **68**, 115.
UNSCEAR72 United Nations Scientific Committee on Effects of Atomic Radiation, 1972. *Ionizing Radiation: Levels and Effects* (New York: U.N.).
UNSCEAR77 United Nations Scientific Committee on Effects of Atomic Radiation, 1977. *Sources and Effects of Ionizing Radiation* (New York: U.N.).
Up61 Upton A. C., 1961. *Cancer Res.* **21**, 717.
Up64 Upton A. C., 1961. *Natl Cancer Instit. Monog.* **14**, 221.
Up70 Upton A. C. *et al.*, 1970. *Rad. Res.* **41**, 467.
We79 Wernuel S. 1979. "Doctors Shift on Shipyard: Kennedy Chides Portsmouth Researcher", *Boston Globe*, 20 June.
Wo61 Wolff, S., 1961. in: *Radiation Protection and Recovery* (Edited by Hollaender A.), p. 157 (New York: Macmillan).

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GUEST EDITORIAL

HEALTH EFFECTS OF THE NUCLEAR ACCIDENT AT THREE MILE ISLAND*

JACOB I. FABRIKANT, M.D., Ph.D.†
Donner Laboratory, University of California, Berkeley, Berkeley, CA 94720

and

Department of Radiology, School of Medicine, University of California, San Francisco, CA 94102

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INTRODUCTION

MY ASSIGNMENT this morning is to try to provide some understanding of the real and potential health effects of the nuclear reactor accident at Three Mile Island. This task is not an easy one, since it involves two very complex areas of scientific enquiry—the biological effects of low-level radiation, and the behavioral response of populations and individuals under stress. I think the best thing for me to do is to discuss our current knowledge of the health effects of low-level radiation—what we know and what we do not know—and the potential risks to health of such radiation in exposed human populations. To place this into perspective, I shall describe very briefly what the major sources of ionizing radiations are, and how we are exposed to these natural background and man-made radiations. I shall also try to discuss the scientific basis of the delayed or late biological effects of ionizing radiations, primarily carcinogenesis, teratogenesis and mutagenesis. To do this, I shall cite some numbers to provide a limited understanding of quantitative risk estimation of the potential health effects—radiation-induced cancer, developmental abnormalities in the newborn, and genetically-related ill-health—and what such risk estimation may have to do with the affairs of mice, men and nuclear energy. To make this current and relevant to today's discussion, I shall place all this in the framework of the events of the nuclear accident at Three Mile Island.

However, at that point my task is not completed until I discuss with you some understanding of the most important health effect of the accident at Three Mile Island, that of the mental stress and behavioral responses of the individuals and the special populations living in the area. To accomplish all this in the limited time available, I have chosen to draw heavily from my personal scientific experiences as Director of the Pub-

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†Professor of Radiology, School of Medicine, University of California, San Francisco.

Dr. Fabrikant was Director, Public Health and Safety Task Force, President's Commission on the Accident at Three Mile Island.

lic Health and Safety Task Force of the President's Commission on the Accident at Three Mile Island, and as a Member of the Committee on the Biological Effects of Ionizing Radiations of the National Academy of Sciences–National Research Council.

WHAT ARE THE SOURCES OF IONIZING RADIATIONS?

The major sources of ionizing radiations to which the general population is exposed in the U.S. are natural background and medical applications of radiation (BEIR80). Natural background radiation consists primarily of galactic cosmic radiation from outer space, from terrestial radiation in the rocks and soils, and our own internal radioactivity. In all, the average whole-body dose rate received by each American annually is about 100 mrem/yr. For a given person, the dose rate from natural background varies with altitude and geographic location, as well as with living habits. Medical applications of radiation contribute similar doses each year to the various tissues of the body. Workers in nuclear and other industrial activities in which radioactive materials or X-ray equipment are used are occupationally exposed to levels of radiation that may exceed background severalfold, and the number of such workers is increasing.

WHAT DO WE KNOW ABOUT THE HEALTH EFFECTS OF LOW-LEVEL RADIATION?

Low-level ionizing radiation can affect the cells and tissues of the body in three important ways (Fa79a; Fa80a). First, if the macromolecular lesion occurs in one or a few cells, such as those of the hematopoietic tissues, the irradiated cell can occasionally transform into a cancer cell, and after a period of time there is an increased risk of cancer developing in the exposed individual. This biological effect is called carcinogenesis, and the health effect, cancer.

Second, if the embryo or fetus are exposed during gestation, injury can occur to the proliferating and differentiating cells and tissues, leading to abnormal growth. This biological effect is called teratogenesis, and the health effect, developmental abnormality of the newborn.

Third, if the macromolecular lesion occurs in the reproductive cell of the testis or of the ovary, the hereditary genome of the germ cell can be altered, and the injury can be expressed in the descendants of the exposed individual. This biological effect is called mutagenesis, and the health effect, genetically-related ill-health.

There are a number of other biological and related health effects of ionizing radiation, such as cararact of the lens of the eye, or impairment of fertility, but these three important delayed or late effects—carcinogenesis, teratogenesis and mutagenesis—stand out as those of greatest concern. This is because a considerable amount of scientific information is known from epidemiological studies of exposed human populations and from laboratory animal experiments. Furthermore, we believe that any exposure to radiation, even at very low levels of dose, may carry some increase in the risk of such deleterious effects. And as the dose of radiation increases above very low levels, the risk of these health effects increases in exposed human populations. It is these latter observations that have been central to the public concern about the potential health effects of low-level radiation, and to the need of establishing standards for the protection of the health of exposed populations.

WHAT DO WE KNOW ABOUT RADIATION CARCINOGENESIS?

Cancers arising in a variety of organs and tissues of the body are the principal late somatic effects of radiation exposure at low-dose levels (BEIR80). Organs and tissues appear to differ greatly in their susceptibility to cancer induction by radiation. Induction of leukemia by radiation stands out because of the natural rarity of the disease, the relative ease of its induction by radiation, and its short latent period. When the total risk of radiation-induced cancer is considered, however, it is now clear that th risk of induced solid tumors (such as breast, thyroid

and lung cancers) exceeds that of leukemia. This may not be the case for the fetus and embryo, however.

There is great uncertainty in regard to the shape of the dose-response relationships for cancer-induction by radiation, especially at low doses. Estimates of any excess cancer risk from radiation at low doses depend more on what is assumed about the mathematical form of the dose-response relationship than on the epidemiological and radiobiological data themselves. There is now emerging among radiation scientists some general agreement that estimating the cancer risk from low doses of low-LET radiation, such as X- and γ-rays, can be approached by using dose-response models that are felt to be consistent with the vast amount of epidemiological and radiobiological data. However, it is this uncertainty, probably more than any other, that is central to the controversy which has emerged over the potential health effects of low-level radiation exposure.

There is now considerable evidence from human studies that age, both at exposure to radiation and at appearance of cancer, and sex, are major determinants of radiation-induced cancer risk (BEIR80). Furthermore, there is increasing recognition of human genotypes that confer increased cancer risk after exposure to carcinogenic agents, including ionizing radiations.

However, we do not know the role of constitutional susceptibility to cancer-induction by environmental mutagens. Nor do we know the extent to which the cells and tissues of the body can and do repair sublethal radiation damage. We are aware that reduction in dose rate may decrease the observed radiation effect per unit dose, and that this dose rate effect affects the risk of cancer induction. This observation is well recognized in mammalian radiobiology, but the information available on man is insufficient to adjust estimation of risk for it.

There are a number of ways of deriving quantitative estimates of excess cancer risk from radiation (BEIR72; BEIR77; BEIR79; Fa79a; Fa80a; ICRP66; ICRP77, UN72; UN77). Among the most appropriate for epidemiological studies of exposed human populations is the relative risk model. The relative risk is a measure of the change in incidence of a disease caused by an etiologic agent in a population. It is the ratio of the risk in those persons exposed to the risk in those not exposed, or it is the ratio of the incidence of a disease, say, cancer, in the exposed population to the incidence in a suitable unirradiated control population.

In any task to estimate the carcinogenic risk of low-dose, low-LET (i.e. X- and γ-rays) whole-body radiation, it must be recognized that the scientific basis for making such estimates, in spite of all that is known, remains inadequate. Accordingly, there is justifiable reason to place emphasis on the assumptions, procedures, and uncertainties involved in the estimation process, and not on specific numerical estimates. This is necessary, since it must be recognized that policy decisions and the exercise of regulatory authority require a position on the probable risks to health from low-dose radiation exposure. Since the epidemiological surveys on exposures to whole-body radiation at dose levels below 10 rad lack reliable data bases and dose-effect information to derive quantitative estimation of cancer risk with any certainty, it may be considered appropriate to limit such risk estimation to whole-body doses of 10 rad or higher. Thus, on the basis of the available epidemiological studies and extensive radiobiological data, for the lifetime risk of cancer mortality induced by low-LET radiation from a single whole-body exposure to 10 rad, the estimate of increase in cancer risk is about 0.5–1.4% of the naturally-occurring cancer mortality (BEIR80). For example, if the naturally-occurring lifetime cancer risk is about 160,000 cases per million persons, in the general population, the rate is 16%. An increase in the cancer rate due to radiation of 10 rad of whole-body exposure equal to 0.5% of the natural rate will result in an increase of 160,000 cases × 0.5%, or 800 cases, i.e. 160,800 total cancer cases will occur. This now represents a cancer rate of 16.08% after radiation. For continuous lifetime exposure to 1 rad/yr, the estimate of increase in cancer risk is about 3–8%.

It is not known whether dose rates of X- or γ-rays of about 100 mrad/yr, the range of natural background radiation, are detrimental to human health. Any somatic effects, if they do occur, at these dose rates would be masked by environmental or other competing factors—physical, chemical, or biological factors—that produce the same types of health effects as does ionizing radiation. It is unlikely that carcinogenic effects of doses of low-LET radiation administered at a dose rate of about 100 mrad/yr will be demonstrable in the forseeable future, indeed, if ever. The problem is, at the present time, too complex for our methods of epidemiology, radiobiology, and mathematics and statistics to decipher. However, for higher dose rates, e.g. a few rads per yr over a long period, a descernible carcinogenic effect could become manifest in exposed human populations; and this appears relevant to problems of occupational exposure and the nuclear power industry.

WHAT DO WE KNOW ABOUT RADIATION TERATOGENESIS?

There is ample evidence from laboratory experiments, and to a limited extent in man, that the developmental effects of radiation in the embryo and fetus are strongly related to the gestational stage at which the radiation exposure occurs (BEIR80; Mi76). Most information on such teratogenic effects is derived from laboratory animal studies, mainly from the laboratory mouse, but the human data are sufficient to indicate important qualitative correspondence for developmentally equivalent stages of embryogenesis in mouse and man. In laboratory animals, some developmental abnormalities have been observed at dose levels just below 10 rad. The most extensive study available in the human experience is that of the atomic bomb data for Hiroshima, which show that the frequency of small head size was significantly increased by acute air doses in the range of 10–19 rad kerma (the average fetal dose would be the equivalent of about 10 rad of γ-radiation) received during the most sensitive period of gestation (Mi76). At Hiroshima, about 20% of the radiation dose was from highly damaging neutron radiation. At Nagasaki, on the other hand, where almost the entire radiation was due to γ-rays, there was no significant increase in the frequency of small head size at air doses below 150 rad; the average fetal dose would have been about half of this value.

Because a given gross malformation or functional impairment probably results from damage to more than a single sensitive target, e.g. more than a single cell or a clone of cells with a common progenitor, we can predict that a threshold radiation dose exists below which that effect will not be observed. There is evidence of such dose thresholds for radiation-induced teratogenesis, but the dose levels vary widely depending on the developmental abnormality (BEIR80). Observed dose rate effects may also be the result of multitarget or multicellular causation of these developmental abnormalities, i.e. cells can repair the damage either by intracellular mechanisms or cellular proliferation, provided the dose rate is low enough. Furthermore, protraction of the radiation dose over a long period can reduce the teratogenic effectiveness of any radiation dose by decreasing to below the threshold level the portion of the dose received during a particular radiosensitive period of gestation.

WHAT DO WE KNOW ABOUT OTHER SOMATIC EFFECTS OF RADIATION?

For somatic effects other than cancer and developmental abnormalities (e.g. cataracts, aging and infertility), the available epidemiological and laboratory experimental data do not suggest any increased risk of low-dose low-LET radiation exposure (i.e. X- and γ-rays) in human populations (BEIR72; BEIR77; BEIR79; Fa79a; Fa80a; ICRP66; ICRP77; UN72; UN77).

WHAT DO WE KNOW ABOUT RADIATION MUTAGENESIS?

Radiation-induced transmitted genetic effects have not been demonstrated in man, and it appears likely that adequate information on radiation-mutagenesis in man will not soon be forthcoming (BEIR80). Thus, estimation of the genetic risk of radiation

must be based on laboratory animal data, and in recent years almost exclusively on laboratory mouse experiments. This necessarily entails the uncertainty of extrapolation from the laboratory mouse to man. However, there is information on the nature of the basic genetic lesions, which are believed to be similar in all organisms; and several physical and biological variables of radiation mutagenesis have been experimentally examined in considerable detail. For these reasons, some of the uncertainties arising in the evaluation of somatic risks—carcinogenesis and teratogenesis—are absent in the estimation of genetic risk.

The current estimate of the incidence of serious human disorders of genetic origin is about 10.7%, or about 107,000 cases per million liveborn offspring (BEIR80). Estimation of the genetic effects of radiation must take into account those which are expressed in the first generation, and those expressed in future generations at the time genetic equilibrium is reached and the effect is disseminated throughout the population. In the first generation, it is estimated that 1 rad of low-LET radiation exposure to the parents throughout the general population will result in an increase of about 5–75 additional serious genetic disorders per million liveborn offspring. Such an exposure of 1 rad received in each generation is estimated to result, at genetic equilibrium, in an increase of about 60–1100 serious genetic disorders per million liveborn offspring (BEIR80). These wide ranges of risk estimates emphasize the limitations of our current understanding of the genetic effects of radiation on human populations. However, even within this range of uncertainty, the genetic risk of radiation is nevertheless very small in relation to the naturally-occurring 107,000 cases of serious human disorders of genetic origin, perhaps an increase due to radiation equal to much less than 0.1% of the natural rate.

HOW CAN WE APPLY THIS INFORMATION TO THE THREE MILE ISLAND EXPERIENCE?

The heightened concern over the health effects of low-level radiation has been closely linked to the political developments of nuclear proliferation and to the parallel commercial development of nuclear energy. There is no doubt that the events of the nuclear accident at Three Mile Island have added enormously to a public awareness of the potential health effects of low-level radiation. What happened at Three Mile Island? What were the radiation levels? And what are the health implications, the radiation health effects, to be expected in the population living in and around the area of Three Mile Island?

Under normal conditions, and in the absence of any additional nuclear radiation, the 2,163,000 persons living within a 50-mile radius surrounding Three Mile Island would each receive about 116 mrem/yr, or an annual collective dose (i.e. the average yearly dose summed up for the entire population) of about 440,000 person-rem; about 240,000 person-rem would come from natural background radiation. In contrast, the collective dose to that population resulting from the radioactive releases during the Three Mile Island nuclear accident was approx. 0.5% of the normal annual exposure rate, or about 1% of natural background radiation (Au79; Fa79b; Fa79c).

The collective dose to the population is a measure of the potential health impact resulting from the total radiation dose received by the entire population; for the Three Mile Island experience, the population living within the 50-mile radius of the nuclear reactor site, approx. 2,163,000 persons, were included in the collective dose estimate calculations. Since this value is obtained by summing the estimated radiation doses, measured in rem, received by each person living within the affected area, the collective dose unit is the person-rem. The collective dose to all persons within a 50-mile radius of Three Mile Island during the first 10 days and outdoors based on the reliable thermoluminescent dosimetry available was estimated to be 2800 person-rem. Since most people spent most of their time indoors and partially shielded by buildings, and assuming that the radiation dose indoors was about three-quarters of that outdoors, a more accurate collective dose to this exposed population is

estimated to be about 2000 person-rem. The average dose to any individual in the population living within 50 miles of the nuclear reactor plant, therefore, is estimated to be about 1 mrem (Au79). The average dose to an individual living within 10 miles of the plant is estimated to be about 6.5 mrem. Almost all recorded excess exposure above background levels occurred within a 10-mile radius. There was no recordable radiation at levels above natural background at a distance greater than 10 miles from the nuclear plant at any time during the accident. Thus, an average dose of 6.5 mrem to individuals living within 10 miles of the nuclear plant is about 5% of the exposure from natural background radiatiion annually in Harrisburg, PA, and equivalent to that difference of living 2 weeks in Denver, CO. The average dose of about 1 mrem to individuals being within 50 miles of the nuclear plant is less than 1% of the exposure from natural background radiation annually in Harrisburg, and equivalent to the difference of living about 4½ days in Denver (Fa79b; Fa79c).

What does this mean in regard to the estimation of the potential delayed or late health effects of low-level radiation exposure and the population exposed at Three Mile Island There are three radiation health effects to consider—radiation-induced cancer, genetically-related ill-health and developmental abnormalities of the newborn.

It is estimated that the number of excess fatal cancers, if any, that might occur over the remaining lifetime of the 2 million persons living within 50 miles of the Three Mile Island nuclear plant and exposed to an average whole body dose of about 1 mrem is much less than 1, if any at all; a similar number could be estimated for excess non-fatal cancers (Ab79). These numbers are estimated to be only a very small fraction of the potential lifetime risk of radiation-induced cancer which may arise in this population from natural background radiation exposure.

The estimated number of cancer cases from all causes normally occurring in this population of about 2 million people over its remaining lifetime is 541,000 (i.e. 325,000 fatal cancers and 216,000 non-fatal cancers). The estimated excess number of fatal and non-fatal cancers associated with the increase in radiation exposure due to the nuclear accident is extremely low, probably cannot be measured, and could be zero, and it would not be possible to detect or to distinguish this excess either in the population or in the individual. The number of excess cancers, if any did occur, and probably none will, would be so small that it would not be possible to detect such an increase statistically in over half a million cancers that would occur in the population even if the Three Mile Island accident had not happened (Ab79). Furthermore, cancers caused by radiation are no different from any other cancers resulting from other causes; therefore, a particular cancer cannot be distinguished as having been caused by radiation.

Based on this information, we can conclude, therefore, that since the total amount of radioactivity released during the nuclear reactor accident at Three Mile Island was so small, and the total population exposed so limited, that there may be no additional detectable cancers resulting from the radiation (Ab79). If there are any additional cancer cases, however, the number would be so small that it will not be possible to demonstrate this excess or to distinguish these cases among the 541,000 persons (of the 2 million population) living within a 50-mile radius of Three Mile Island, who for other reasons will normally develop cancer during the course of their lifetimes.

There is persuasive scientific evidence which suggests that if an average human population were exposed to 1 rem (or 1000 mrem) of irradiation during their reproductive life span when they can produce children, about 5–75 cases of additional genetically-related diseases (such as mental retardation or diabetes) might be expected in 1 million children born to the irradiated parents (BEIR80). Genetically-related ill-health is extremely common in humans under normal conditions; about 10.7% of all live births are affected. Therefore, the increase due to 1000 mrem of radiation would represent a very small number of cases of

genetically-related ill-health in addition to the 107,000 cases (an increase of only about 1/1000th of 1%) of genetic disorders expected to develop in that newborn population.

During the accident at Three Mile Island, the collective dose to the reproductive cells of the testes and the ovaries of the 2 million persons living within 50 miles of the nuclear power plant was estimated to be about 2000 person-rem, with an average individual dose of about 1 mrem (Au79). In this population, assuming a 30-yr generation time, we would normally expect about 3000 cases of genetically-related ill-health among the approx. 28,000 live children born each year. These cases would occur in the absence of any additional radiation exposure and would be unrelated to the radiation from the nuclear power plant accident. From an additional radiation dose of 1 mrem above natural background radiation resulting from the nuclear accident, we would expect about 0.0001 to about 0.002 (i.e. about 1/10,000–2/1000th) additional radiation-induced cases of genetically-related ill-health. This additional 2/1000th case is an average number and is miniscule, representing less than 1 in 10,000,000 live births. Furthermore, this may result ultimately in a total of no more than about 1 additional case of genetically-related ill-health in a million liveborn children during all generations in the future. This number of additional cases is so small that it can never be detected or distinguished, if it does occur, among the cases of genetically-related ill-health in each generation during all future human existence. We can conclude, therefore, it is probable that there will be no detectable cases of genetically-related ill-health resulting from the radiation exposure to the general population following the accident at Three Mile Island (Ab79).

In the approx. 2,160,000 people who live within the 50-mile radius of Three Mile Island, it was estimated, based on vital statistics data, about 28,000 children were born in 1979. In this newborn population, about 300 children would normally be expected to be born with developmental abnormalities in the absence of any added radiation exposure as a result of the accident at Three Mile Island. The estimated average individual radiation dose (perhaps only 1/2 of 1 mrem) to the fetus of pregnant women exposed during the nuclear reactor accident was below any threshold dose level known to cause detectable cases of developmental abnormality in the human embryo or fetus, or in laboratory animal experiments. In addition, this estimated dose may still be too high, since many pregnant women left the area within the 5-mile vicinity of the nuclear plant. We can conclude, therefore, that no case of developmental abnormality can be expected to occur in a newborn child as a result of radiation exposure of a pregnant woman from the accident at Three Mile Island (Ab79).

WHAT WAS THE MAJOR HEALTH EFFECT OF THE THREE MILE ISLAND ACCIDENT?

Although no radiation health effects occurred during the nuclear accident, and probably no delayed or late radiation health effects are to be expected, what emerged from this experience was that the major health effect of the accident appears to have been on the mental health of the people living in the region of Three Mile Island and of the workers at the nuclear reactor plant (Do79). There was immediate, short-lived mental distress produced by the accident among certain groups of the general population living within 20 miles of Three Mile Island. The highest levels of distress were found among adults living within 5 miles of Three Mile Island, or with preschool children; and among teenagers living within 5 miles of Three Mile Island, with preschool siblings, or whose families left the area. Workers at the Three Mile Island nuclear plant experienced more distress than workers at the Peach Bottom nuclear plant in Pennsylvania which was studied for comparison purposes. This distress was higher among the nonsupervisory employees and continued in the months following the accident.

But, surprisingly, the main threat was not the fear of radiation exposure nor the dangers of radiation to health—not how one was threatened, but who was threatened. We have found, in all the behavioral studies, that the major measures of objective threat stemming

from the accident were whether a person was living within or living outside the 5-mile radius of Three Mile Island; and having or not having preschool age children in one's family. For the workers, an added measure of objective threat was whether they worked at the Three Mile Island nuclear plant, rather than at the Peach Bottom plant, at the time of the accident. For teenagers, an added measure of objective threat was whether their families left the area or not following the accident, because this was a factor outside the control of the teenagers themselves.

Demoralization is a term used to describe the psychological symptoms and reactions a person is likely to develop when he finds that he cannot meet the demands placed on him by his environment, and cannot extricate himself from his predicament. Such sources of intractable predicaments include, for example, situations of extreme environmental stress, such as combat or natural disasters, and physical illnesses, especially those that are chronic. Demoralization is something like an elevated temperature of the body; it tells us that there is something wrong, but it does not in itself tell us what is wrong.

Demoralization was sharply elevated immediately after the nuclear accident, but dissipated rapidly among most groups. A substantial minority, about 10% of the heads of households showed severe demoralization right after the accident that was directly attributable to the accident itself. The most demoralized persons were heads of households and teenagers living within 5 miles of Three Mile Island, and mothers and teenage siblings of preschool children. Teenagers who left the area temporarily were more distressed than those who did not. Levels of demoralization among workers at the Three Mile Island nuclear plant were high in comparison to the Peach Bottom nuclear plant workers, and in males in the general population, several months after the accident.

Although the perceived threat to physical health from the nuclear accident was higher in the general population immediately after the accident than later on, most people were considerably reassured by July. Workers at both the Three Mile Island and Peach Bottom plants also expressed a fairly low level of concern about the threat of their work situation to their physical health. However, workers at the Three Mile Island plant were more uncertain about health effects than workers at Peach Bottom plant. Household heads living within 5 miles of Three Mile Island were more uncertain than those living outside the area. And mothers of preschool children in the Three Mile Island area felt more uncertain than mothers of preschool children in Wilkes-Barre, the city studied for comparison.

Feelings in the population within 20 miles of Three Mile Island about continuing to live in the area were mixed and uncertain. Relatively unfavorable attitudes, though still generally uncertain rather than negative, were expressed by people living within 5 miles of Three Mile Island, and by mothers of preschool children. The only group with somewhat negative attitudes was those at risk on two counts; the mothers of preschool children who lived within 5 miles of Three Mile Island.

Attitudes toward nuclear power and reactivation of the Three Mile Island nuclear power plants No. 1 and No. 2 in the general population living within 20 miles of the plant showed uncertainty, with a leaning toward negative feelings. Mothers of preschool children expressed the most negative attitudes.

Among people living in the 20-mile area around Three Mile Island distrust of federal and state authorities and of the utilities was high immediately after the accident. Although it was somewhat lower in May, as early as can be estimated, it continued to be higher than the average in the nation throughout the period of the study. Workers at both the Three Mile Island and the Peach Bottom nuclear power plants, like the general population, expressed considerable distrust of federal and state authorities. They diverged from the general population, however, in expressing generally trusting attitudes toward the utilities. Workers at both the Three Mile Island and the Peach Bottom nuclear plants expressed fairly low levels of concern about the future of their occupation. They also were similar in perceiving people in their

communities as holding less than positive attitudes toward them. Since there was no evidence of a difference between the workers at the Three Mile Island and Peach Bottom nuclear plants on these matters, neither of these findings contributes to understanding the basis for the elevated level of demoralization among the Three Mile Island nuclear workers that continued to be evident in August 1979 and through September 1979 when the study ended.

WHAT CAN WE CONCLUDE ON THE HEALTH EFFECTS OF THE ACCIDENT AT THREE MILE ISLAND?

Based on the best available dosimetric and demographic information, it is estimated that between 28 March and 15 April 1979, the collective dose resulting from the radioactivity released to the population living within a 50-mile radius of the Three Mile Island nuclear plant was approx. 2000 person-rems. The estimated annual collective dose to this population from natural background radiation is about 240,000 person-rems. Thus, the increment of radiation dose to persons living within a 50-mile radius due to the accident was somewhat less than 1% of the annual natural background level. The average dose to a person living within 5 miles of the nuclear plant was calculated to be about 10% of annual background radiation and probably was less. The maximum estimated radiation dose received by any one individual in the general population (excluding the nuclear plant workers) during the accident was 70 mrem. On the basis of present scientific knowledge, the radiation doses received by the general population as a result of exposure to the radioactivity released during the accident were so small that there will be no detectable additional cases of cancer, developmental abnormalities, or genetic ill-health as a consequence of the nuclear reactor accident at Three Mile Island (Ab79).

During the period from 28 March to 30 June three Three Mile Island nuclear workers received radiation doses of about 3–4 rem; these levels exceeded the Nuclear Regulatory Commission's maximum permissible quarterly dose of 3 rem (Au79). The process of cleanup and recovery presents a special situation with regard to potential health effects, since these activities present additional sources of possible radiation exposure to the nuclear workers and to the general population living in the area.

The major health effect of the accident at Three Mile Island was that of a pronounced demoralizing effect on the general population in the Three Mile Island area, including teenagers and mothers of preschool children, and the nuclear plant workers (Do79). However, this effect proved transient in all groups studied except the nuclear workers, who continue to show relatively high levels of demoralization months after the accident. Moreover, the groups in the general population and the workers, in their different ways, have continuing problems of trust that stem directly from the Three Mile Island accident. For both the nuclear workers and general population, the mental health and behavioral effects are understandable in terms of the objective realities of the threats they faced during the nuclear accident at Three Mile Island.

But what have we learned about nuclear reactor safety and health from the experience of Three Mile Island? The present scientific evidence and the interpretation of the available human data from epidemiological surveys can draw very few firm conclusions on which to base scientific public health policy for protection standards for low-level radiation in the nuclear industry. However, even in the normal operation of nuclear reactor plants for the generation of electricity, based on the radiation risk estimates we have been able to ascertain with reasonable reliability, any lack of precision does not minimize the need to limit radiation exposure in all societal activities involving ionizing radiations to levels at which the risk to health are acceptable. Nor does it minimize the conclusion that such risks to health are extremely small when compared with those available from alternative options, and those normally accepted by society as the hazards of everyday life.

But nuclear reactor accidents are not normal societal activities. Radiation is different.

It is gratuitous and self-serving to conclude that more people die in coal-mining and oil-drilling accidents than in the nuclear energy activities. And it is not enough to conclude that no one died at Three Mile Island. The matters are complex and the solutions are elusive. When compared with the benefits that society has established as goals derived from the necessary activities of energy production, it is now both apparent and imperative that society must establish and maintain appropriate standards and seek appropriate procedures which continue to assure that its needs and services are met with the lowest possible risks, both to the individual and to society.

Acknowledgements—I am indebted to my scientific colleagues who shared in the work of the President's Commission on the Accident at Three Mile Island and of the National Academy of Sciences-National Research Council Committee on the Biological Effects of Ionizing Radiations. It is from their labors that I have drawn freely for the preparation of this presentation.

REFERENCES

Ab79 Abrahamson S., Bair W. J., Bender M. A., Bloom A. D., Bond V. P., Casarett G. W. and Fabrikant J. I., 1979, "Technical Staff Analysis Report on Report of the Radiation Health Effects Task Group," in: *Report of The Public Health and Safety Task Force Report to The President's Commission on the Accident at Three Mile Island* (Edited by J. I. Fabrikant), 98 pp. (Washington, DC: Government Printing Office).

Au79 Auxier J. A., Berger C. D., Eisenhauser C. M., Gesell T. F., Jones A. R. and Masterson M. E., 1979, "Report of the Task Group of Health Physics and Dosimetry," in: *Report of the Public Health and Safety Task Force to The President's Commission on the Accident at Three Mile Island* (Edited by J. I. Fabrikant.), 196 pp. (Washington, DC: Government Printing Office).

BEIR72 Advisory Committee on the Biological Effects of Ionizing Radiations, 1972, National Academy of Sciences–National Research Council, "The Effects on Populations of Exposure to Low Levels of Ionizing Radiation," Washington, DC.

BEIR77 Advisory Committee on the Biological Effects of Ionizing Radiations, 1977 National Academy of Sciences–National Research Council, "Considerations of Health Benefit-Cost Analysis for Activities Involving Ionizing Radiation Exposure and Alternatives", Washington DC.

BEIR80 Advisory Committee on the Biological Effects of Ionizing Radiations, 1980, National Academy of Sciences-National Research Council, "The Effects on Populations of Exposure to Low Levels of Ionizing Radiation", Washington, DC.

Do79 Dohrenwend B. P., Dohrenwend B. S., Kasl S. V. and Warheit G. J., 1979, "Technical Staff Analysis Report on Behavioral Effects," in: *Report of the Public Health and Safety Task Force to The President's Commission on the Accident at Three Mile Island* (Edited by J. I. Fabrikant), 81 pp. (Washington, DC: Government Printing Office,).

Fa79a Fabrikant J. I., 1979, "Perspectives of Decision-making and Estimation of Risk in Populations Exposed to Low Levels of Ionizing Radiation", in *Symp. Epidemiology Studies of Low-Level Radiation Exposure, AAAS Annual Meeting*, Houston, TX, January, Lawrence Berkeley Laboratory Rep. LBL-8667, pp. 1–40.

Fa79b Fabrikant J. I. (Ed.), 1979, *The Public Health and Safety Task Force Report to the President's Commission on the Accident at Three Mile Island*, 7 pp. (Washington, DC: Government Printing Office).

Fa79c Fabrikant J. I., 1979, *Summary of the Public Health and Safety Task Force Report to the President's Commission on the Accident at Three Mile Island* (Edited by J. I. Fabrikant), 32 pp. (Washington, DC:, Government Printing Office,).

Fa80a Fabrkant J. I., 1980, "The BEIR-III Report and the Health Effects of Low-level Radiation", in: *Symp. Nuclear Reactor Safety: A Current Perspective, AAAS Ann. Meeting*, San Francisco, To be published.

Fa80b Fabrikant J. I., 1980, "The BEIR-III Report and its Implications for Radiation Protection and Public Health Policy," in: *Proc. Int. Cong. IRPA Israel*, Lawrence Berkeley Laboratory LBL Rep. LBL-10494, pp. 1–20.

ICRP66 International Commission on Radiological Protection, 1966, "The Evaluation of Risks from Radiation," A report prepared for Committee I of the ICRP, *ICRP Publication* 8 (Oxford: Pergamon Press).

ICRP77 International Commission on Radiological Protection, 1977, "Recommendations of

the International Commission on Radiological Protection" (Adopted 17 January 1977), *ICRP Publication* 26 (Oxford: Pergamon Press).

Mi76 Miller R. W. and Mulvihill J. J., 1976, "Small Head Size After Atomic Radiation", *Teratology* **14**, 355–358.

UN72 United Nations Scientific Committee on the Effects of Atomic Radiation, 1972, "Ionizing Radiation: Levels and Effects" (New York: UN).

UN77 United Nations Scientific Committee on the Effects of Atomic Radiation, 1977 "Sources and Effects of Ionizing Radiation" (New York: UN).

5711 Summerset Drive
Midland, Michigan 48640
February 6, 1981

John Ahearne, Chairman
Nuclear Regulatory Commission
Washington, D. C.   20000

Dear John Ahearne:

Recently I attended the annual meeting of the American Association for the Advancement of Science in Toronto.

One of the seminars that I attended, called "Health Risks Associated with Energy Technologies," included Dr. Reginald L. Gotchy of the Nuclear Regulatory Commission. His topic was "Risk from Nuclear Power."

I was so incensed by the complete whitewash of the health risks of nuclear power that I am moved to write to you about it. One fission product of greatest concern is plutonium. Incredibly, Dr. Gotchy did not even mention the word.

Comparing radiation doses from Three Mile Island with what people get in Denver every day is also grossly misleading. Monitors are not going off scale in Denver as they did at Three Mile Island. No one is considering passing out vials of potassium iodide to block iodine-131 uptake in the thyroid as they did at Three Mile Island. Dr. Gotchy mentioned none of these facts--nor the fact that the Kemeny Commission recommended people around every plant be given potassium iodide to take in case of accidental releases.

In contrast to Dr. Gotchy's misleading kind of information on a subject of utmost importance to the people of this country, I am sending you documentation that I have received from Dr. Gordon MacLeod and friends in Pennsylvania. Dr. MacLeod was director of public health of Pennsylvania when the Three Mile Island accident occurred, and was appointed only three weeks prior to the accident by Governor Thornburg for that office because of his exceptional qualifications for the position.

Dr. MacLeod's attempts to do a responsible job of gathering and making public health data following that accident were repressed and he was forced to resign. He has pursued the problem of the serious deficiencies in public health care in relation to nuclear power. The address he gave before the Physicians for Social Responsibility at Columbia University on November 22, 1980 (enclosed), clearly describes those deficiencies and also analyzes the defects and cover-ups of the official position that the Dept. of Public Health of Pennsylvania has taken on the health data re-

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lated to Three Mile Island. He also points out how negligent the NRC has been in following up health effects data immediately following the accident which could have been an important source of data for better public health care following accidents.

The NRC is doing a grave disservice to the people of this country by sending out whitewash artists like Dr. Gotchy to discuss health risks of nuclear power. How can you believe you can get away with that type of presentation before a knowledgable audience such as you have at AAAS meetings? The fact that the public at large is routinely given this type of information by NRC spokespersons sickens me. This is a major reason why the public distrusts the NRC and the nuclear industry--they increasingly are discovering from accidents and severe harm to people to what an extent members of the nuclear establishment are misrepresenting and have been misrepresenting to people the health risks of nuclear power for years.

Those of us who study the technical literature realize to what an extent the NRC is failing to act upon scientific medical information to protect the public as the NRC is charged to do.

Dr. MacLeod makes some definite and sensible suggestions for improving public health care in the area of nuclear power plants. I hope you will act on it.

While I am sending copies of this letter to all other commissioners of the NRC, I am not including all the enclosures. I hope that you will make those available to them.

Yours sincerely,

Mary Sinclair

Mary Sinclair

MS/sh
Encls.

Cc: Joseph Hendrie
Peter Bradford
Victor Gilinsky
Senator Don Riegle
Senator Carl Levin
Congressman Don Albosta

to Barbara Stamiris
5795 N. River
Freeland, Mich
48623

Draft

TMI AND THE POLITICS OF PUBLIC HEALTH*

BY
GORDON K. MACLEOD, M.D., F.A.C.P.**

A NEAR NUCLEAR CATASTROPHE OCCURRED JUST OVER A YEAR AND A HALF AGO AT THREE MILE ISLAND. IT WAS AN ACCIDENT THAT JUST COULDN'T HAPPEN-- AFTER ALL, NUCLEAR POWER PLANTS WERE BUILT SO SAFELY THEY COULD NOT POSSIBLY AFFECT THE PUBLIC'S HEALTH.

YOUR BEING HERE REFLECTS A CONCERN ON YOUR PART FOR THE HEALTH IMPACT OF THAT ACCIDENT, ESPECIALLY AS IT COULD RELATE TO THE NUCLEAR POWER PLANT AT INDIAN POINT.

AND, I COMMEND YOU FOR THAT CONCERN.

SHORTLY BEFORE THE ACCIDENT AT THREE MILE ISLAND, I WAS PERSUADED BY THE NEW GOVERNOR OF PENNSYLVANIA TO TAKE A TWO-YEAR LEAVE OF ABSENCE FROM THE UNIVERSITY OF PITTSBURGH TO BECOME PENNSYLVANIA'S SECRETARY OF HEALTH. I ACCEPTED THE APPOINTMENT IN THE SPIRIT THAT PUBLIC SERVICE IS BOTH A PRIVILEGE AND AN OBLIGATION. THE PENNSYLVANIA HEALTH DEPARTMENT WAS RATED BY ONE COLLEAGUE AS 50TH OUT OF 50 AND NEEDED TO BE RESTRUCTURED. AFTER ALL, IT HAD NO PLACE TO GO, BUT UP.

JUST TWELVE DAYS AFTER BEING SWORN IN AS SECRETARY OF HEALTH, I HAD TO FACE THE TMI ACCIDENT, THE LIKES OF WHICH HAD NEVER BEEN THRUST UPON A PUBLIC HEALTH OFFICER ANYWHERE IN THE WORLD.

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*PREPARED FOR PRESENTATION FOR THE NEW YORK CITY AND OLD WESTBURY CHAPTERS OF PHYSICIANS FOR SOCIAL RESPONSIBILITY ON NOVEMBER 22, 1980 AT COLUMBIA UNIVERSITY INTERNATIONAL AFFAIRS AUDITORIUM, 420 WEST 118TH STREET, NEW YORK CITY.

**PROFESSOR AND CHAIRMAN OF HEALTH SERVICES ADMINISTRATION, GRADUATE SCHOOL OF PUBLIC HEALTH AND ASSOCIATE CLINICAL PROFESSOR OF MEDICINE, SCHOOL OF MEDICINE, UNIVERSITY OF PITTSBURGH, PITTSBURGH, PA 15261.

More than any other single event, TMI pointed up very abruptly--almost explosively--the deficiencies in at least one of the Nation's Health Departments.

Bureaucratic and political decisions had carved up the Pennsylvania Department of Health over the past 10 to 15 years. One effect of the politics of public health can be seen on the first slide which shows the decreasing percentage of total state dollars allocated to the health department.

(Slide #1 - Percentage of State Dollars to Health)

When I was called about the accident early in the morning of March 28, 1979, what did I find?

There was not even a book on radiation medicine in the Department. Worse yet, the medical library had been completely disbanded two years previously for budgetary reasons.

There was no Bureau of Radiation Health in the Health Department. That was in the Department of Environmental Resources.

No Office of Mental Health. That was in the Department of Welfare.

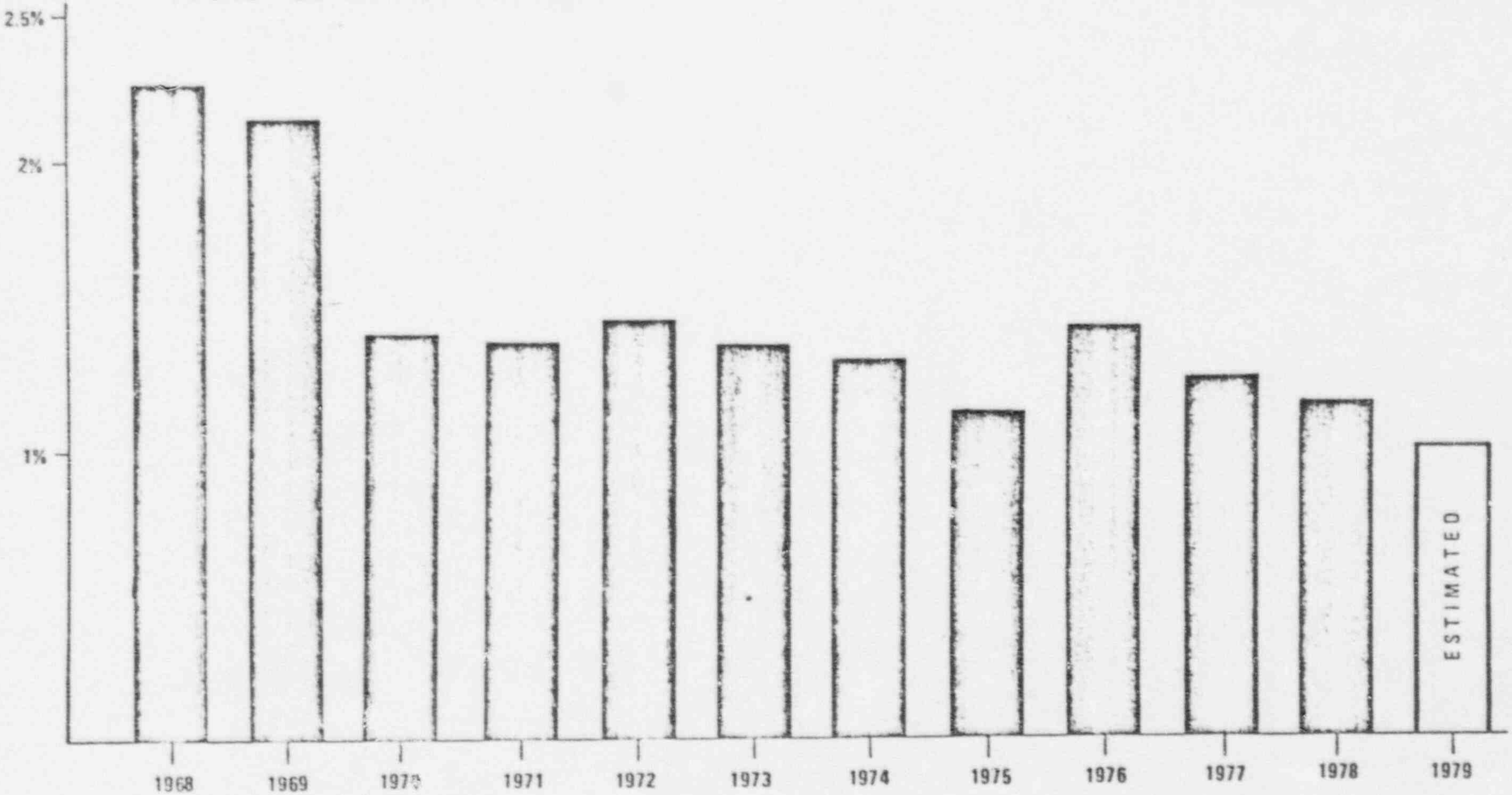
No Occupational Health. It was also in the Department of Environmental Resources--with no physicians on its staff.

Nor did the Governor have the capacity to bring together Pennsylvania's scattered health resources. Despite the intense mental stress during the TMI crisis, no one from the office of mental health ever sat in on a briefing session with the Governor.

In short, there was little or no capacity within the Department of Health--nor elsewhere in the state--to deal with the extraordinarily serious health problems facing us.

(Slide #1)

PERCENTAGE OF TOTAL STATE DOLLARS ALLOCATED TO THE HEALTH DEPARTMENT*



*From 1968 to 1978 the state budget increased from 2.016 to 5.886 billion dollars.

SOURCE: Bureau of Fiscal Management, Pennsylvania Department of Health

THE MANAGEMENT OF THE ACCIDENT WAS LEFT--AND CONTINUES TO BE LEFT--ALL TOO MUCH TO ENGINEERS AND PHYSICISTS--ANOTHER POLITICAL DECISION. THERE WAS LITTLE OR NO PHYSICIAN INPUT BY STATE AND FEDERAL GOVERNMENT INTO THE MANY DECISIONS MADE PRIOR TO THE ACCIDENT. THERE WAS LITTLE OR NO PHYSICIAN INPUT INTO DECISIONS MADE IN THE DAYS IMMEDIATELY FOLLOWING THE ACCIDENT. AND I AM SORRY TO SAY, THERE REMAINS LITTLE OR NO PHYSICIAN INPUT INTO DECISIONS MADE EVEN TODAY RELATIVE TO THE FRENETIC ATTEMPTS TO CLEAN UP RADIOACTIVE DEBRIS FROM THE ACCIDENT.

IN FACT, RADIATION HEALTH PROTECTION WAS, IS, AND PROBABLY WILL BE DOWNPLAYED UNTIL WE HAVE A NUCLEAR ACCIDENT WITH VISIBLE SIGNS OF RADIATION DAMAGE OR UNTIL CITIZENS SERVED BY STATE AND LOCAL HEALTH DEPARTMENTS BECOME SUFFICIENTLY CONCERNED TO DO SOMETHING ABOUT RADIATION PROTECTION.

LET'S BRIEFLY REVIEW THE EXTENT TO WHICH PUBLIC HEALTH IS BEING IGNORED IN THIS NUCLEAR AGE.

FIRST LET'S GO BACK IN HISTORY--TO THE 1950S. SOME OF YOU WILL RECALL THE NEAR ECSTASY WITH WHICH AMERICANS WELCOMED THE NATION'S COMMITMENT TO NUCLEAR ENERGY. MUCH OF THE ECSTASY WAS SPAWNED BY THE PROMISE THAT WE HAD EMBARKED ON A NEW MISSION--"ATOMS FOR PEACE"--IT WAS CALLED. AND THE PRODUCT OF THAT MISSION WOULD BE CLEAN, SAFE AND CHEAP ENERGY FOR ALL. AND WE BELIEVED THAT PROMISE. AND UNTIL RECENTLY, WE KNEW THAT NUCLEAR ENERGY WAS SAFE. OR I SHOULD SAY, WE <u>THOUGHT</u> IT WAS SAFE. THIS TOTAL ASSURANCE OF SAFETY STILL PREVAILS IN MANY QUARTERS TODAY. BUT THAT ASSURANCE OF SAFETY WAS SHATTERED BY THREE MILE ISLAND WITH POTENTIALLY SERIOUS CONSEQUENCES IN THE DAYS AND MONTHS FOLLOWING MARCH 28, 1979.

IN FACE OF THE RELEASE OF LOW LEVELS OF RADIOACTIVITY, IT SEEMED THAT NO OFFICIALS OUTSIDE OF PROFESSIONAL HEALTH CIRCLES COULD APPRECIATE THE POTENTIAL FOR HEALTH HAZARDS FROM THE ACCIDENT. THEY NEEDED TO SEE PEOPLE BEING CARTED OFF VOMITING FROM RADIATION SICKNESS. OR, PUT ANOTHER WAY--THERE WAS NO BLAST, SO THERE WAS NO HEALTH HAZARD. THAT'S THE ATTITUDE THAT SEEMED TO REIGN AMONG NUCLEAR ENGINEERS AND RADIATION PHYSICISTS.

AND THAT IS THE ATTITUDE THAT I CONFRONTED AFTER BEING SWORN IN AS SECRETARY OF HEALTH.

FOR YEARS, WE HAD BEEN SO THOROUGHLY IMBUED WITH THE IDEA OF SAFE NUCLEAR POWER THAT WE HADN'T EVEN ALLOWED OURSELVES TO THINK ABOUT A NUCLEAR ACCIDENT--LET ALONE PREPARE FOR ONE.

EVEN THOUGH WE HAVE HAD NUCLEAR REACTORS IN PENNSYLVANIA FOR YEARS, THERE WAS NO REGULARLY EMPLOYED PHYSICIAN EXPERT IN RADIATION MEDICINE IN THE HEALTH DEPARTMENT, NOR ANYWHERE ELSE IN PENNSYLVANIA STATE GOVERNMENT. WE WERE NOT PREPARED TO GRAPPLE WITH THE HEALTH CONSEQUENCES OF NUCLEAR RADIATION EXPOSURE, BECAUSE THE STATE HEALTH DEPARTMENT HAD DONE NO PRIOR PLANNING FOR SUCH AN EVENT.

SHORTLY AFTER THE ONSET OF THE ACCIDENT, I PROPOSED THE ESTABLISHMENT OF A DIVISION OF RADIATION HEALTH WITHIN THE DEPARTMENT. REGRETTABLY--THE GOVERNOR'S OFFICE REJECTED THIS PROPOSAL ON THE BASIS OF CONSIDERATIONS HAVING NOTHING WHATEVER TO DO WITH HEALTH STATUS--YET ANOTHER POLITICAL DECISION. DENIAL OF MY PROPOSAL TO STAFF A DIVISION OF RADIATION HEALTH HAS STRIPPED PUBLIC HEALTH IN PENNSYLVANIA OF ITS MANDATE TO PROTECT THE HEALTH OF ITS PEOPLE AND TO PREVENT DISEASE--PARTICULARLY IN CASE OF A NUCLEAR ACCIDENT.

WHAT WE HOPED TO DO WAS TO ASSIST PHYSICIANS AND HOSPITALS STATEWIDE IN ADDRESSING A VAST ARRAY OF TECHNICAL ISSUES--MORAL DILEMMAS IF YOU WILL--THAT HAVE BEEN THRUST UPON THE MEDICAL PROFESSION BY A TECHNOLOGY THAT HAS OUTSTRIPPED PREVIOUS GUIDELINES AND CONCEPTS GOVERNING OUR PROFESSIONAL BEHAVIOR.

LET US BRIEFLY CONSIDER THE FUNCTION OF STATE AND LOCAL HEALTH DEPARTMENTS IN PLANNING AND DIRECTING RESPONSES TO RADIOLOGIC EMERGENCIES.

THE PRIMARY ROLE OF STATE AND LOCAL HEALTH DEPARTMENTS IS THE PROTECTION OF THE PUBLIC'S HEALTH.

IN CASE OF RADIATION EXPOSURE HEALTH DEPARTMENTS MUST GIVE PARAMOUNT ATTENTION TO ITS EFFECTS ON HUMANS, AND THEY MUST ALSO WORK COOPERATIVELY WITH THOSE AGENCIES THAT COLLECT DATA AND MEASURE CONTAMINATION OF AIR, WATER, SOIL, FOOD--AFFECTING OUR HOMES, OUR CHILDREN, OUR CROPS, OUR ANIMALS, ET CETERA.

IN EMERGENCY PLANNING FOR A RADIATION EMERGENCY, THE RESPONSIBILITY OF HEALTH DEPARTMENTS IS TO ENSURE THAT THERE ARE SUFFICIENT PROFESSIONAL AND ORGANIZATIONAL RESOURCES AT THE STATE OR LOCAL LEVEL TO MEET WHATEVER HEALTH EMERGENCIES MAY OCCUR.

SUCH PLANNING INVOLVES AN INVENTORY OF BOTH PUBLIC AND PRIVATE RESOURCES AND THE INITIATION OF APPROPRIATE STEPS TO ENSURE THEIR AVAILABILITY IN AN EMERGENCY.

HEALTH PROFESSIONAL RESOURCES ARE ESSENTIAL AND MUST BE READILY AVAILABLE FOR A RADIOLOGICAL EMERGENCY PLAN TO WORK.

IN PLANNING FOR A RADIATION EMERGENCY, THE FIRST QUESTION TO ASK IS WHAT ARE THE IMMEDIATE AND LONG-TERM EFFECTS ON THE PUBLIC'S HEALTH. THIS REQUIRES PREPLANNING USING BASELINE DATA AVAILABLE TO MOST HEALTH DEPARTMENTS. HERE WE CAN CALL UPON MORBIDITY DATA AND VITAL STATISTICS: PRIMARILY LIVE BIRTHS, INFANT DEATH RATES, AND HYPOTHYROIDISM RATES.

IN ADDITION, PREPLANNING REQUIRES KNOWLEDGE OF WHAT HEALTH DATA IS TO BE COLLECTED, OF THE DEMOGRAPHIC CHARACTERISTICS OF THE POPULATION AT RISK, AS WELL AS THE AVAILABILITY OF HOSPITALS, PHYSICIANS, OTHER MEDICAL AND LOGISTICAL RESOURCES NEEDED TO HANDLE A RADIOLOGIC EMERGENCY.

SUCH BASELINE REFERENCE DATA SHOULD BE COLLECTED AROUND EACH NUCLEAR FACILITY EVEN BEFORE IT IS INSTALLED--AND IN THE CASE OF INDIAN POINT, CERTAINLY BEFORE IT RESUMES OPERATING.

IN ESSENCE, THEN, PREPLANNING FOR A RADIATION EMERGENCY PROVIDES A DATA BASE FOR DECISION MAKING BEFORE, DURING, AND AFTER THE EMERGENCY.

AT THIS POINT, LET ME STATE MY POSITION CLEARLY. ALTHOUGH I AM UNALTERABLY OPPOSED TO NUCLEAR WARFARE, I DO NOT HAVE A BIAS AGAINST NUCLEAR ENERGY. WHILE MANY OF YOU MAY NOT SHARE MY POSITION TOWARD NUCLEAR POWER, I AM SURE WE WOULD ALL AGREE TO BE PREPARED IN CASE A RADIATION EMERGENCY WERE TO OCCUR. I PERSONALLY BELIEVE THAT NUCLEAR POWER CAN BE MADE RELATIVELY SAFE IF WE DON'T IGNORE THE PUBLIC HEALTH LESSONS OF THE PAST.

IN OTHER WORDS, I BELIEVE THAT HEALTH PROFESSIONALS HAVE A RESPONSIBILITY--AND SOCIETY THE RIGHT--TO KNOW HOW RADIATION AND THE PRODUCTION OF NUCLEAR ENERGY AFFECTS THE HUMAN BODY AND ITS BEHAVIOR INSOFAR AS WE KNOW IT.

BUT, WHAT DO WE KNOW?

WE KNOW THAT DIAGNOSITC RADIATION HAS BEEN A BOON TO MANKIND--BUT IT CAN RESULT IN FETAL ABNORMALITIES.

WE KNOW THAT THERAPEUTIC RADIATION HAS PROLONGED LIFE IN MANY INSTANCES--BUT IT CAN RESULT IN RADIATION SICKNESS, INCREASED BLEEDING, AND INFECTION.

AND, TO DATE, WE KNOW THAT NUCLEAR POWER PLANTS HAVE BEEN RELATIVELY SAFE--BUT THEY CAN HAVE ACCIDENTS WHICH RESULT IN PHYSICAL AND PSYCHOLOGICAL DAMAGE OVER A WIDE GEOGRAPHIC AREA.

WHAT'S MORE, WE KNOW FROM THE UNITED NATIONS SCIENTIFIC COMMITTEE ON THE EFFECTS OF ATOMIC RADIATION THAT THE MOST IMPORTANT EFFECT OF "LOW DOSES OF RADIATION IS THE OCCASIONAL INDUCTION OF MALIGNANT DISEASES."

EVEN WITH ALL WE KNOW, THERE IS MUCH WE DON'T KNOW. WE DON'T KNOW MUCH ABOUT AGE-RELATED RESPONSES TO LOW DOSE RADIATION EXPOSURE, WE DON'T KNOW MUCH ABOUT THE RESPONSE TO ONE-TIME EXPOSURE VERSUS CONTINUOUS EXPOSURE, AND, MOST IMPORTANTLY, WE DON'T KNOW VERY MUCH AT ALL ABOUT THE PATHOLOGICAL RESPONSE TO THE INTERACTION OF LOW DOSE RADIATION WITH OTHER EXPOSURES.

WITHOUT ANY PROFESSIONALLY COMPETENT RADIATION MEDICINE PERSONNEL IN PENNSYLVANIA'S DEPARTMENT OF HEALTH, WE WERE--AND STILL ARE--ILL-EQUIPPED TO RESPOND TO THE EFFECTS OF EITHER LOW OR HIGH DOSE RADIATION EXPOSURE FROM A NUCLEAR REACTOR ACCIDENT.

IN ANY STATE OR LOCALE AT RISK OF EXPOSURE TO A NUCLEAR REACTOR ACCIDENT, A RADIOLOGICAL HEALTH UNIT NOW MUST BE DEEMED TO BE AN ESSENTIAL PUBLIC HEALTH ACTIVITY.

ANY RADIOLOGICAL EMERGENCY RESPONSE PLAN MUST NOT OVERLOOK POPULATION DENSITY FOR AT LEAST 20 MILES AND MAYBE UP TO 50 MILES AROUND EXISTING OR PROPOSED NUCLEAR REACTOR SITES. IN LIGHT OF PENNSYLVANIA'S LACK OF PREPAREDNESS FOR A NUCLEAR ACCIDENT EVEN AFTER TMI, THE PUBLIC HEALTH AND SAFETY OF MILLIONS OF NEW YORKERS WOULD BE AT RISK IF AN ACCIDENT WERE TO OCCUR AT INDIAN POINT.

AS A FIRST STEP TOWARD DEVELOPING AN EMERGENCY RESPONSE PLAN, EVERY STATE AND LOCAL HEALTH OFFICER IN THE VICINITY OF A NUCLEAR REACTOR SHOULD LEARN THE CLINICAL EFFECTS OF ACUTE IONIZING RADIATION DOSES.

(SLIDE #2 - SUMMARY OF CLINICAL EFFECTS)

THIS PARTICULAR CHART SHOWS RADIATION EFFECTS AT VARIOUS LEVELS OF EXPOSURE, BUT DOES NOT INCLUDE ACUTE RADIATION THYROIDITIS OR FETAL EFFECTS.

SUMMARY OF CLINICAL EFFECTS OF ACUTE IONIZING RADIATION DOSES

	Dose (rem)					
	0-100	100-200	200-600	600-1000	1000-5000	Over 5000
Vomiting	None	5-50%	50-100%	100%	100%	100%
Onset of vomiting	--	3 hr.	2 hr.	1 hr.	30 min.	30 min.
Principal organ system affected	None	----Hematopoietic tissue------------			Gastrointestional tract	Central Nervous System
Signs	None	Moderate leukopenia	--Severe leukopenia;-- purpura; hemorrhage; infection; epilation		Diarrhea; fever; electrolyte disturbance	Convulsions; tremors; ataxia; lethargy
Critical post-exposure period	--	--	-------4-6 weeks------		5-14 days	1-48 hr.
Prognosis	Excellent	Excellent	Good	Guarded	Hopeless	Hopeless
Convalescence	None	Weeks	Months	Long	--	--
Deaths	None	None	0-80%	80-100%	90-100%	90-100%
Time til death	--	--	-------2 months-------		2 weeks	2 days
Cause of death	--	--	--Hemorrhage; infection-		Shock	Respiratory failure; cerebral edema

From: Eisenbud: Environmental Radioactivity, 1973.

NOR DOES IT SHOW LONG TERM EFFECTS ON THE THYROID GLAND, THE GENETIC APPARATUS, OR THE LIFE SPAN.

NOR DOES IT SHOW SUCH DEFECTS AS REDUCED BODY SIZE, MICROCEPHALY, AND MENTAL RETARDATION.

NOR DOES IT SHOW THE LONG TERM CARCINOGENIC EFFECT LEADING TO SOLID TUMORS AND LEUKEMIA.

DURING THE ACCIDENT, THE MAXIMUM ESTIMATED RADIATION DOSE OFF SITE WAS CALCULATED TO BE LESS THAN 100 MILLIREM. BECAUSE OF THIS VERY LOW LEVEL OF EXPOSURE, I STILL BELIEVE WE MAY NOT BE ABLE TO MEASURE RADIATION EFFECTS ON THE EXPOSED POPULATION EVEN THOUGH IN APRIL 1979 THE SECRETARY OF THE THEN DEPARTMENT OF HEALTH, EDUCATION AND WELFARE ANNOUNCED THERE WOULD BE BETWEEN ONE AND TEN FATAL CANCERS AND THE SAME NUMBER OF NON-FATAL CANCERS IN THE EXPOSED POPULATION TO TMI.

IN FACE OF REPEATED HUMAN ERROR AT THE REACTOR SITE AND ELSEWHERE, EVEN WITH MY LIMITED KNOWLEDGE OF RADIATION EFFECTS, I WAS LOATHE TO ACCEPT ENGINEERING ESTIMATES OF THE SAFETY OF TMI.

ON DAY TWO OF THE ACCIDENT, I RECOMMENDED AND ON DAY THREE URGED THE GOVERNOR IN THE STRONGEST POSSIBLE TERMS TO CALL FOR THE DEPARTURE OF PREGNANT WOMEN AND YOUNG CHILDREN FROM AN AREA WITHIN FIVE MILES OF THE TMI PLANT. BUT--AND I HOPE YOU GRASP THE SIGNIFICANCE OF THIS--THE STATE'S RADIATION PHYSICISTS AND NUCLEAR ENGINEERS DID NOT AGREE WITH MY RECOMMENDATION. LIKE SO MANY OTHER TECHNICIANS RESPONSIBLE FOR MONITORING THE ADVERSE EFFECTS OF TECHNOLOGY, THEY THRUST THEMSELVES INTO THE POSITION OF MAKING MEDICAL AND PUBLIC HEALTH JUDGMENTS. ON DAY TWO, NON-MEDICAL JUDGMENT WAS ACCEPTED IN THIS MATTER, WHICH INDEED SHOULD HAVE BEEN DECIDED ON NO OTHER BASIS BUT THE PUBLIC'S HEALTH. FINALLY, IT TOOK THE ENDORSEMENT OF THE NUCLEAR REGULATORY COMMISSION'S CHAIRMAN, JOSEPH HENDRIE, A NUCLEAR ENGINEER, TO CONVINCE THE GOVERNOR TO ISSUE HIS DIRECTIVE FOR THE DEPARTURE OF PREGNANT WOMEN AND YOUNG CHILDREN ONE DAY LATER.

ISN'T THAT INTERESTING. A PHYSICIAN AND PUBLIC HEALTH PROFESSIONAL WARNS OF POTENTIAL HEALTH IMPACTS OF RADIATION AND THE WARNING GOES UNHEEDED. NOT UNTIL A NUCLEAR ENGINEER SUPPORTS THE WARNING ARE THEY ACCEPTED. CERTAINLY AN ALICE IN WONDERLAND APPROACH TO SOUND PUBLIC HEALTH DECISIONS.

THE DOMINANCE OF ENGINEERING AND PHYSICS OVER HEALTH DID NOT FLAG AFTER THE ACCIDENT. SIX MONTHS AFTER THE ACCIDENT, THE GOVERNOR CALLED TOGETHER SEVERAL STATE OFFICIALS TO PLAN FOR THE CLEAN-UP PROCEDURE AT TMI. NOBODY FROM THE DEPARTMENT OF HEALTH WAS PRESENT. BECAUSE NO ONE FROM THE DEPARTMENT OF HEALTH WAS INVITED.

MY RECOMMENDATION FOR PREGNANT WOMEN AND YOUNG CHILDREN TO LEAVE THE AREA WAS BASED UPON SEVERAL CONSIDERATIONS. TO BEGIN WITH, WE WERE DEALING WITH TOO MANY UNKNOWNS--NOT THE LEAST OF WHICH STEMMED FROM CONFLICTING REPORTS OF LEVELS OF RADIATION EMANATING FROM THE PLANT. FURTHER, WE WERE COMMITTED TO EXERCISING EXTREME CAUTION IN THE INTEREST OF THE PUBLIC'S HEALTH.

MOST PEOPLE KNEW ENOUGH TO BE CONCERNED ABOUT CONGENITAL MALFORMATIONS AND CANCER THAT COULD RESULT FROM RADIATION. BUT WHAT THE PUBLIC DID NOT KNOW--AND DOESN'T REALLY KNOW YET--IS THAT RADIOISOTOPES OF IODINE ARE AMONG THE MOST ABUDNANT BY-PRODUCTS OF NUCLEAR FISSION. NOR DID PREGNANT WOMEN KNOW THAT HIGH LEVELS OF RADIOACTIVE IODINE CAN HAVE SUCH A DEVASTATING EFFECT ON THE FETAL THYROID GLAND WHICH, IF DESTROYED CAN CAUSE CRETINISM WITH SEVERE MENTAL RETARDATION IN INFANTS IN THE FIRST FEW MONTHS OF LIFE.

THERE WAS ANOTHER THREAT PRESENT AT TMI--PERHAPS A MORE SIGNIFICANT THREAT THAN POSSIBLE THYROID DAMAGE, WHICH IS TREATABLE. AS HEALTH OFFICIALS, WE WERE FULLY AWARE OF THE RISING LEVEL OF CONCERN--IN SOME CASES OUTRIGHT PANIC--AMONG THE GENERAL PUBLIC AS CONFLICTING REPORTS OF RADIATION FALLOUT MOUNTED IN THE NEWS MEDIA. WE KNEW FULL WELL THAT FEAR OF RADIATION--HOWEVER UNREASONABLE THAT FEAR MAY HAVE BEEN--COULD CAUSE HEALTH IMPACTS AS DAMAGING AS ACTUAL RADIATION ITSELF. SUCH FEAR CAN PRODUCE REAL PSYCHOLOGICAL, IF NOT, PHYSIOLOGICAL, CHANGE.

MORE THAN A YEAR AFTER THE ACCIDENT, A HERSHEY MEDICAL CENTER STUDY REPORTED A SURPRISING PERSISTENCE OF ANXIETY AMONG A LARGE PART OF THE POPULATION NEAR THREE MILE ISLAND. THE HEALTH EFFECTS OF THIS DISTRESS INCLUDED INCREASES OF 113 PERCENT IN THE NUMBER OF PERSONS USING SLEEPING PILLS AND 88 PERCENT IN THOSE USING TRANQUILLIZERS. ALSO 14 PERCENT USED MORE ALCOHOL AND 32 PERCENT SMOKED MORE CIGARETTES.

ELOQUENT TESTIMONY, INDEED, TO THE STRESS THAT GREW OUT OF THE ATMOSPHERE SURROUNDING TMI.

I HAVE GONE INTO SOME DETAIL ON THE REASONS FOR REMOVING YOUNG CHILDREN AND PREGNANT WOMEN FROM THE TMI AREA BECAUSE I THINK IT, BETTER THAN ANY OTHER EXAMPLE--POINTS UP A DANGEROUS ATTITUDE TOWARD PUBLIC HEALTH--AN ATTITUDE THAT SURFACED ALL TOO OFTEN DURING THE ACCIDENT AT TMI. AND THAT ATTITUDE--WHICH STILL PERSISTS--SAYS THAT ENGINEERING EXPEDIENCY TAKES PRECEDENCE OVER PUBLIC HEALTH.

I FOUND IT INTERESTING THAT IN TESTIMONY BEFORE THE PRESIDENT'S COMMISSION ON TMI, ONE OF THE STATE'S RADIATION PHYSICISTS EXPRESSED STRONG OPPOSITION TO THE IDEA THAT RADIATION HEALTH ACTIVITIES SHOULD FALL UNDER THE AEGIS OF THE PENNSYLVANIA DEPARTMENT OF HEALTH. AND TO DATE HIS POSITION HAS PREVAILED AS I SHALL EXPLAIN LATER.

HE TOLD THE COMMISSION THAT BECAUSE A DOCTOR WOULD BE IN CHARGE, HE, AS A RADIATION PHYSICIST IN CHARGE OF RADIATION PROTECTION WITHIN THE DEPARTMENT OF HEALTH, WOULD HAVE TO BE NICE TO DOCTORS WHO OPERATE X-RAY EQUIPMENT. APPARENTLY HE NEVER REFLECTED UPON THE FAR GREATER LIKELIHOOD OF RADIATION PHYSICISTS AND NUCLEAR ENGINEERS BEING NICE TO THOSE WORKING AT NUCLEAR POWER PLANTS.

I CITE THIS EXAMPLE SIMPLY BECAUSE I THINK IT EXEMPLIFIES ANOTHER POLITICAL PROBLEM--AN EXAMPLE OF BUREAUCRATIC JEALOUSY WITHOUT REGARD FOR HEALTH CARE.

DESPITE THE CONSEQUENCES OF RADIATION BOTH TO THE HUMAN BODY AND THE SPIRIT, SUCH DEFICIENCIES ARE NOT LIMITED TO STATE GOVERNMENT.

EARLY IN THE ACCIDENT WE URGED THE FEDERAL GOVERNMENT'S NUCLEAR REGULATORY COMMISSION TO PROVIDE THE ON-SITE SERVICES OF A PHYSICIAN EXPERT IN THE FIELD OF RADIATION HEALTH.

I PERSISTED IN MY REQUEST TO NRC'S HAROLD DENTON, ONLY TO BE INFORMED FOR SEVERAL DAYS THAT NRC JUST COULD NOT FIND SUCH A PERSON.

I WAS TOLD, AND I THINK THIS IS SIGNIFICANT, THAT NRC HAD NO PHYSICIANS ON ITS STAFF, MUCH LESS A PHYSICIAN SCHOOLED IN THE FIELD OF RADIATION MEDICINE.

NO PHYSICIANS DIRECTLY EMPLOYED BY NRC--AGAIN A SAD COMMENTARY ON THE PRIORITY GIVEN TO PUBLIC HEALTH MATTERS INVOLVING NUCLEAR REGULATION.

OUR JOB--AND I DON'T HAVE TO TELL YOU THIS--WAS TO PREVENT THE HARMFUL EFFECTS OF ANY <u>POSSIBLE</u> RADIATION, NOT SIMPLY ALLOW FALLOUT TO OCCUR AND THEN HAVE TO DEPEND ON MEDICAL THERAPY TO CORRECT THE CONSEQUENCES OF EXPOSURE.

ANOTHER EXAMPLE OF THE LACK OF PUBLIC HEALTH EMPHASIS IN THE AFTERMATH OF TMI IS HOW LITTLE ATTENTION HAS BEEN PAID TO THE FEASIBILITY OF STOCK-PILING POTASSIUM IODINE AS A PROTECTIVE AGENT AGAINST RADIOACTIVE IODINES.

ALTHOUGH I HAD PREPARED LENGTHY TESTIMONY ON THIS MATTER FOR THE PRESIDENT'S COMMISSION, IT WAS ALMOST ENTIRELY PREOCCUPIED WITH THE NUCLEAR ENGINEERING AND EVACUATION LOGISTICS--IN FACT I WASN'T ASKED A SINGLE QUESTION ABOUT POTASSIUM IODIDE AS AN EFFECTIVE PREVENTIVE MEDICINE AGAINST RADIOACTIVE IODINE.

WHEN I INQUIRED INTO THE REASON FOR THIS GLARING OMISSION, THE COMMISSION CHAIRMAN, DR. JOHN KEMENY, WROTE ME THAT THE COMMISSION JUST DIDN'T HAVE TIME TO DISCUSS POTASSIUM IODIDE.

APPARENTLY, TOO MANY IMPORTANT NON-HEALTH ISSUES TOOK UP ITS TIME.

BUT LET ME TELL YOU THE POTASSIUM IODIDE STORY.

WE KNOW THAT A LARGE RELEASE OF RADIOACTIVE IODINE INTO THE ATMOSPHERE FROM A NUCLEAR POWER REACTOR WOULD RESULT IN THE PUBLIC'S INHALING OR INGESTING AMOUNTS WHICH COULD PRODUCE ACUTE, CONTINUING, OR LATE THYROID EFFECTS.

THESE EFFECTS RANGE FROM MILD THYROIDITIS TO HYPOTHRYOIDISM TO BENIGN THYROID NEOPLASMS, NODULES, AND CANCER.

FETAL HYPOTHYROIDISM ASSOCIATED WITH CRETINISM IS OF PARTICULAR CONCERN DUE TO THE INVERSE RELATIONSHIP BETWEEN IODINE UPTAKE AND AGE.

APART FROM EVACUATION AND SHELTER TO PROTECT AGAINST RADIOACTIVE IODINE EMISSIONS, PHARMACOLOGICAL AGENTS THAT BLOCK ACCUMULATION OF RADIO IODINE BY THE THYROID GLAND PRESENT THE MOST COMPLETE PROTECTION AGAINST THE HAZARDS OF INHALING OR INGESTING I-131.

POTASSIUM IODIDE (KI) WAS FOUND TO BE EMINENTLY SUITABLE FOR THYROID BLOCKING PURPOSES.

FOR TWO OR MORE YEARS PRIOR TO TMI, THE DEPARTMENT OF ENVIRONMENTAL RESOURCES IN PENNSYLVANIA HAD BEEN FRUSTRATED IN OBTAINING STOCKPILES OF POTASSIUM IODIDE FROM THE FEDERAL GOVERNMENT.

I THINK IT INTERESTING TO SPECULATE ON WHETHER THE DEPARTMENT OF HEALTH WOULD HAVE MET WITH EARLIER SUCCESS IF THE RESPONSIBILITY FOR THE MATTER HAD NOT BEEN LODGED THERE RATHER THAN IN THE DEPARTMENT OF ENVIRONMENTAL RESOURCES.

IMMEDIATELY AFTER THE ACCIDENT, THE STATE'S DEPARTMENT OF ENVIRONMENTAL RESOURCES AGAIN REQUESTED POTASSIUM IODIDE FROM THE FEDERAL DEPARTMENT OF HEALTH EDUCATION AND WELFARE. IT TOOK MORE THAN 60 HOURS AFTER THAT JUST FOR THE THEN SECRETARY OF DHEW TO GIVE THE ORDER TO INITIATE STEPS TO SHIP POTASSIUM IODIDE TO HARRISBURG.

FIVE DAYS AFTER THE ACCIDENT BEGAN THE FIRST SHIPMENT OF 11,000 LITTLE BROWN VIALS ARRIVED:

--6,000 OF THOSE 11,000 VIALS WERE UNLABELED;

--EACH DROPPED YIELDED ONLY ONE HALF THE CORRECT DOSAGE;

--THE DROPPERS DID NOT FIT THE VIALS; AND

--MANY OF THE VIALS CONTAINED HAIRLIKE FILAMENTOUS MATERIAL AND OTHER PARTICULATE MATTER.

SEVEN DAYS AFTER THE ACCIDENT BEGAN, WE RECEIVED INSTRUCTIONS FROM SECRETARY CALIFANO TO ADMINISTER POTASSIUM IODIDE TO ALL WORKERS AT THE SITE AND TO DISTRIBUTE IT TO ALL RESIDENTS WITHIN A TEN-MILE RADIUS.

THIS, AGAIN, WAS A RECOMMENDATION BASED UPON A TOTAL LACK OF UNDERSTANDING OF THE REAL PROBLEM.

BY THIS TIME WE HAD RECEIVED ASSURANCES FROM HAROLD DENTON THAT THE NUCLEAR ENGINEERING ASPECTS OF THE ACCIDENT WERE UNDER CONTROL AND THE REACTOR WAS PROGRESSING TOWARD A COLD SHUT DOWN.

THE VERY NEXT DAY, THE POLITICS OF PUBLIC HEALTH MUST HAVE PROMPTED SECRETARY CALIFANO TO APPEAR BEFORE SENATOR KENNEDY TO FAULT THE STATE FOR NOT ADMINISTERING THE DRUG.

AN IMPORTANT FACTOR IN OBTAINING SATISFACTORY BLOCKING OF RADIOACTIVE IODINE UPTAKE IS THE SPEED WITH WHICH KI IS ADMINISTERED FOLLOWING EXPOSURE TO RADIOIODINE.

WITHIN 30 MINUTES AFTER ORAL ADMINISTRATION, KI BLOCKS THE UPTAKE OF 99% OF I-131 FOR 24 HOURS.

STANDARD UPTAKE CURVES DEMONSTRATE THAT THE BULK OF THE RADIOACTIVE IODINE FROM A SINGLE EXPOSURE WILL HAVE ENTERED THE THYROID WITHIN 10 TO 12 HOURS; LITTLE BENEFIT MAY BE EXPECTED BY BLOCKING BEYOND THAT TIME. SIGNIFICANT BENEFIT (A BLOCK OF 50%) IS ATTAINABLE DURING THE FIRST 3 TO 4 HOURS.

OTHER FACTORS MILITATED AGAINST THE ADMINISTRATION AND DISTRIBUTION OF POTASSIUM IODIDE.

1) THE KNOWN INCIDENCE OF SIDE EFFECTS SUCH AS IODISM--A SEVERE SKIN RASH--PLUS THYROID DISEASES; AND AN OCCASIONAL CARDIAC DEATH IN THE ELDERLY HAS BEEN REPORTED--PRESUMABLY FROM EXCESS POTASSIUM.
2) THE LIKELIHOOD OF PRECIPITATING UNNECESSARY PANIC AMONG THE POPULACE AFTER 6 DAYS OF INTENSE STRESS AND STRAIN.

THUS, WE AVOIDED A FIASCO SIMILAR TO THE SWINE FLU MASS IMMUNIZATION WHERE THE CENTER FOR DISEASE CONTROL ATTEMPTED TO PREVENT AN EPIDEMIC THAT NEVER EXISTED.

AND WE WERE READY TO RESPOND INSTANTLY TO REAL AND IMMEDIATE PUBLIC HEALTH PROBLEMS.

BUT HAD WE EXPERIENCED THE MASSIVE FALLOUT THAT MANY PEOPLE FEARED WOULD RESULT FROM THE ACCIDENT DURING THE FIRST FEW DAYS, WE WOULD HAVE BEEN WITHOUT THE <u>ONLY</u> PROVEN EFFECTIVE PREVENTIVE MEDICINE AGAINST THE ACCUMULATION OF RADIOACTIVE IODINE IN THE THYROID GLAND, EVEN AS WE ARE TODAY.

LET US CONSIDER A MORAL ISSUE AT STAKE MANY MONTHS FOLLOWING THE NUCLEAR ACCIDENT--THE RIGHT TO KNOW THE TRUTH. FOUR MONTHS AFTER I HAD RESIGNED AS SECRETARY, I WAS CALLED ABOUT AN UNUSUAL CLUSTER OF THYROID DEFICIENCY CASES IN PENNSYLVANIA.

AFTER SEVERAL DAYS OF REFUSAL BY THE HEALTH DEPARTMENT TO ALERT THE PUBLIC TO THIS PREVENTABLE ILLNESS IN NEWBORNS, I ASKED A REPORT TO LOOK INTO THE MATTER.

IN MID-1978, THE STATE HEALTH DEPARTMENT FORTUITIOUSLY BEGAN SCREENING NEWBORNS FOR THYROID DEFICIENCY. SEVENTEEN CASES OF DEPRESSED THYROID FUNCTION WERE REPORTED AND TREATED IN THE NINE MONTHS PRIOR TO THE ACCIDENT. SURPRISINGLY, THE NUMBER OF CASES JUMPED TO 27 DURING THE NINE MONTHS FOLLOWING THE ACCIDENT. THE INCREASE WAS CONCENTRATED DOWNWIND OF THE REACTORS AT TMI AND PEACHBOTTOM. OF INTEREST, THE NUMBER OF CASES DOWNWIND HAS REMAINED ELEVATED DURING 1980.

(SLIDES #3, 4 AND 5 - INCIDENCE OF HYPOTHYROIDISM BEFORE AND AFTER TMI)

SINCE THE TMI ACCIDENT, MAJOR CONCENTRATION OF THYROID DEFICIENCY CASES HAVE OCCURRED IN LANCASTER COUNTY--IMMEDIATELY DOWNWIND OF THE COUNTIES CONTAINING TMI AND PEACHBOTTOM REACTORS. THESE CASES ARE APPROXIMATELY 8 TO 12 TIMES WHAT WOULD BE EXPECTED IN PENNSYLVANIA. EVEN THOUGH THE NUMBERS ARE SMALL, THEY WARRANT FURTHER EPIDEMIOLOGICAL INVESTIGATION WHETHER FROM INBREEDING, FROM ENVIRONMENTAL CAUSES SUCH AS CHEMICAL CONTAMINATION OF WATER AND FOOD, OR FROM INDUSTRIAL OR MEDICAL RADIATION SOURCES. IT'S PREMATURE TO BLAME THEM ON RADIOACTIVE IODINE BUT IT CANNOT YET BE RULED OUT.

(SLIDE #6 - RATIO OF HYPOTHYROID CASES TO NEWBORNS)

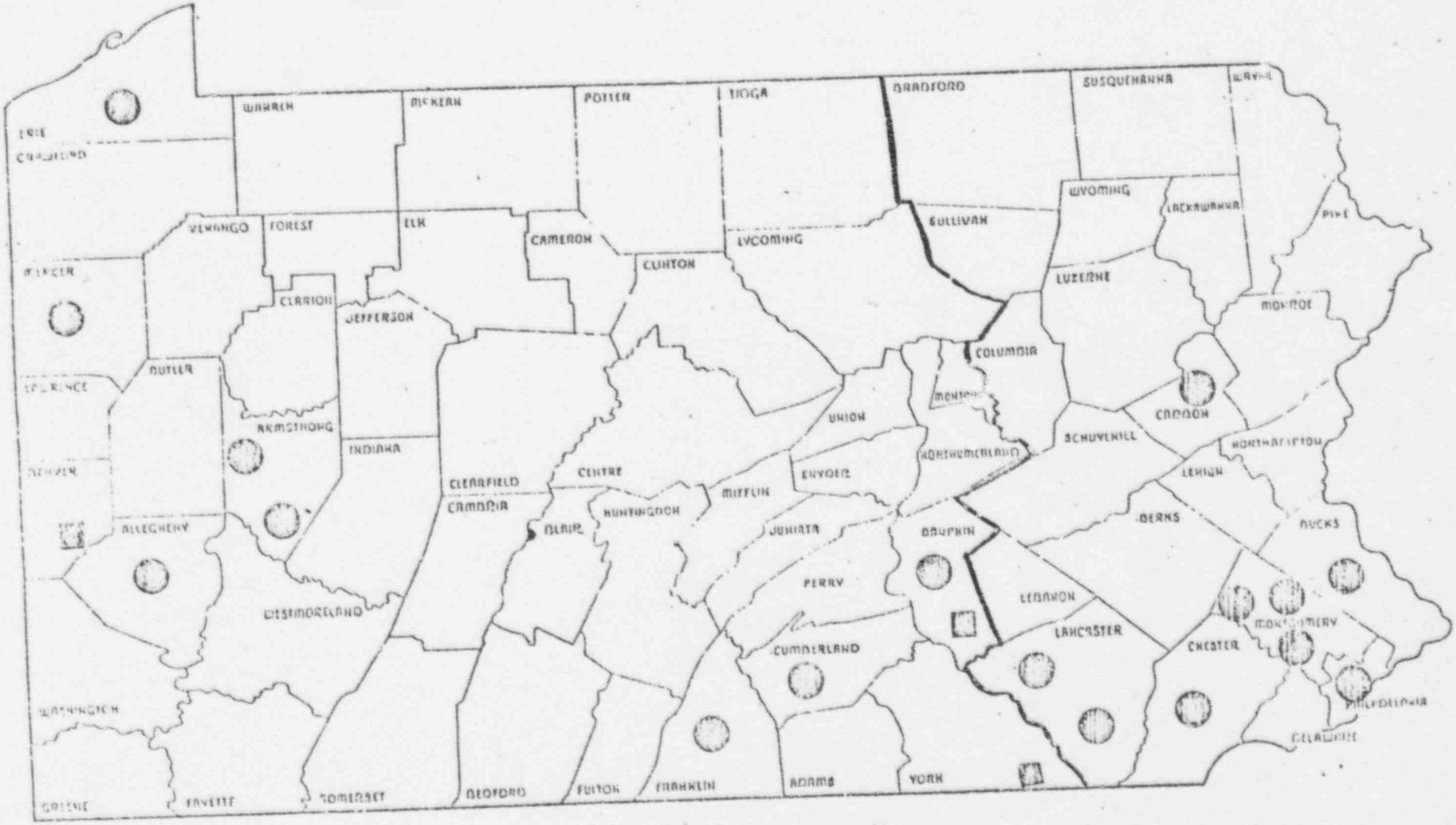
ONCE AGAIN, THE POLITICS OF PUBLIC HEALTH PREVAILED. THE HEALTH DEPARTMENT HAS REFUSED TO EXAMINE THE RELATIONSHIP OF THE TMI ACCIDENT TO THIS DRAMATIC INCREASE IN HYPOTHYROIDISM.

(SLIDE #7 - MARCH 28, 1980 PENNSYLVANIA CAPITAL UPDATE)

(Slide #3)

INCIDENCE OF NEONATAL HYPOTHYROIDISM

JUNE 20, 1978 - MARCH 28, 1979



NEONATAL HYPOTHYROIDISM CASE

NUCLEAR POWER PLANT

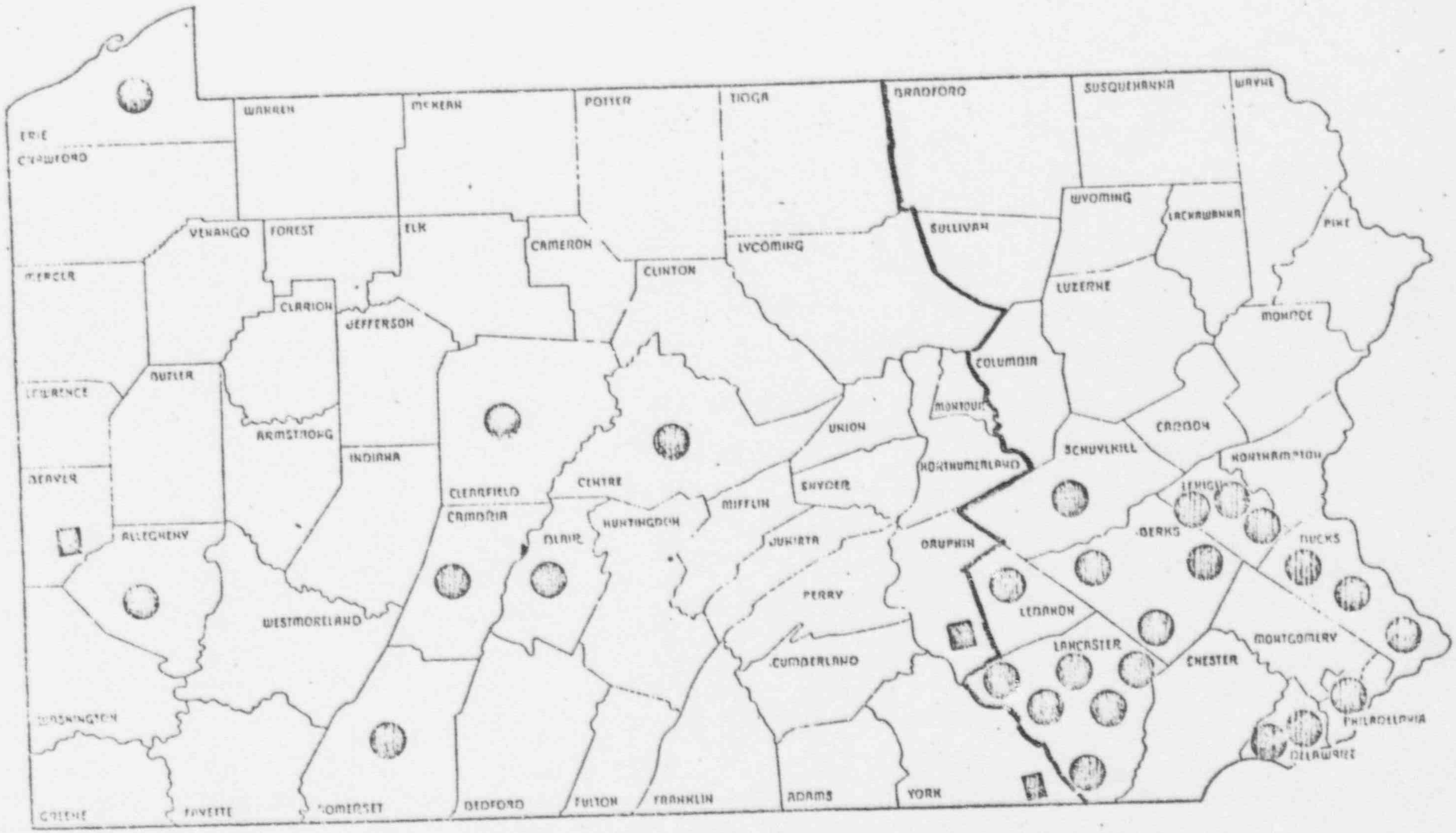
PENNSYLVANIA

CASES REPORTED BY DEPARTMENT OF HEALTH

(Slide #4)

INCIDENCE OF NEONATAL HYPOTHYROIDISM

MARCH 28, 1979 - DECEMBER 31, 1979



Neonatal Hypothyroidism Case

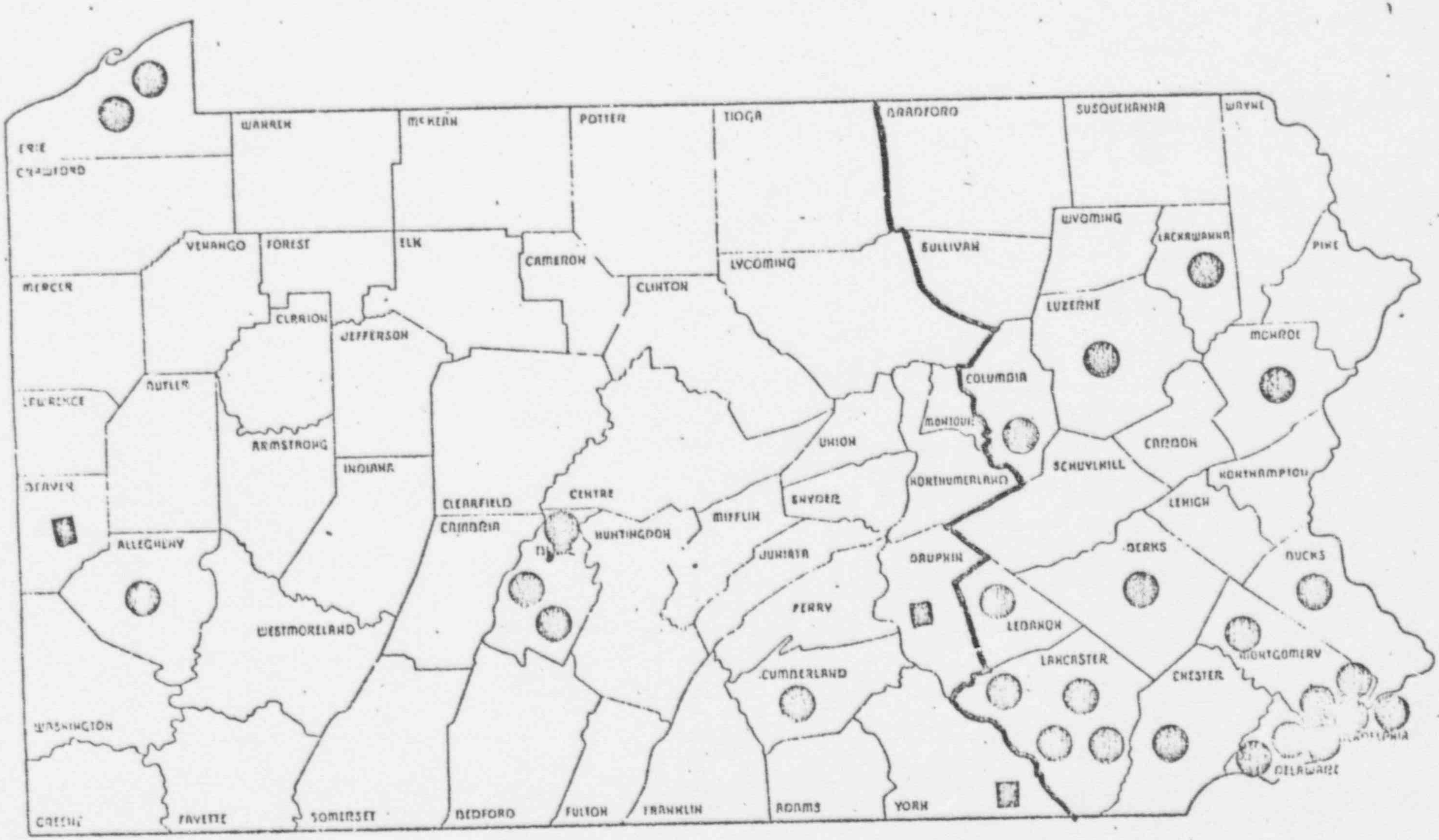
Nuclear Power Plant

PENNSYLVANIA
CASES REPORTED BY
DEPARTMENT OF HEALTH

(Slide #5)

INCIDENCE OF NEONATAL HYPOTHYROIDISM

JANUARY 1, 1980 - AUGUST 31, 1980



Neonatal Hypothyroidism Case

Nuclear Power Plant

PENNSYLVANIA

Cases Reported by
Department of Health

RATIO OF NEONATAL HYPOTHYROIDISM TO NEWBORNS IN PENNSYLVANIA

	WESTERN PA	EASTERN PA
JUNE 20, 1978 TO MARCH 28, 1979	1 : 6,805	1 : 6,554
MARCH 28, 1979 TO DECEMBER 31, 1979	1 : 7,955	1 : 3,021
JANUARY 1, 1980 TO AUGUST 31, 1980	1 : 7,231	1 : 2,746

ALL NEWBORN HYPOTHYROID CASES REPORTED BY PENNSYLVANIA DEPARTMENT OF HEALTH SINCE INITIATION OF NEONATAL HYPOTHYROID SCREENING PROGRAM, JUNE 20, 1978 UNTIL AUGUST 31, 1980.

BR213

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--PENNSYLVANIA CAPITOL UPDATE--

(HARRISBURG) -- A COMMITTEE TO INVESTIGATE HYPOTHYROIDISM IN PENNSYLVANIA MET FOR THE FIRST TIME TODAY... BUT THE RADIATION EFFECTS OF THE THREE MILE ISLAND ACCIDENT WERE NOT ON ITS AGENDA.

DOCTOR DONALD REID -- HEAD OF THE 11-MEMBER PANEL -- SAID THE GROUP WILL NOT DISCUSS EITHER THE PRO OR CON SIDE OF WHAT MAY OR MAY NOT HAVE OCCURRED SINCE THE THREE MILE ISLAND ACCIDENT.

HE SAID THE MEDICAL EXPERTS WILL CONDUCT AN UNBIASED OBJECTIVE STUDY OF WHY 34 PENNSYLVANIA INFANTS SUFFERED FROM HYPOTHYROIDISM IN 1979.

THE DISORDER IS A BIRTH DEFECT THAT, IF LEFT UNTREATED, CAUSES MENTAL RETARDATION. IT CAN BE CAUSED BY A VARIETY OF HEREDITARY AND ENVIRONMENTAL FACTORS... INCLUDING RADIATION.

THE COMMITTEE OF MEDICAL EXPERTS FROM PHILADELPHIA, PITTSBURGH, HERSHEY AND ATLANTA WAS FORMED AFTER 1979 FIGURES REVEALED SIX CASES OF HYPOTHROIDISM IN LANCASTER COUNTY.

ONE OTHER CASE HAS BEEN REPORTED THIS YEAR IN THE COUNTY... WHICH IS LOCATED NEAR THE CRIPPLED NUCLEAR PLANT.

REID SAID THE NUMBER OF CASES IS NOT UNUSUAL... BUT THE CLUSTERING IS.

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IT WAS OUR GOOD FORTUNE THAT THERE WAS NO IMMEDIATE LOSS OF LIFE, BUT LACK OF ADEQUATE COMMUNICATION WITH THE PUBLIC DURING AND AFTER THE ACCIDENT AT TMI LED TO A LOSS OF CONFIDENCE IN OUR PUBLIC OFFICIALS. PUBLIC HEALTH IS NOW IN JEOPARDY OF LOSING ITS CREDIBILITY AS HEALTH DATA BECOME AVAILABLE AND ARE NOT RELEASED OR ARE CARELESSLY COMPILED.

SINCE MY RESIGNATION AS SECRETARY OF HEALTH, SEVERAL CONCERNED HEALTH DEPARTMENT EMPLOYEES HAVE CALLED ME REPEATEDLY TO COMPLAIN THAT ABNORMAL HEALTH DATA WERE NOT BEING MADE AVAILABLE TO THE PUBLIC.

MORE THAN A YEAR AFTER THE ACCIDENT AT TMI, I RELEASED LONG OVERDUE INFANT MORTALITY STATISTICS WHICH I WAS TOLD WERE NOT GOING TO BE RELEASED BY THE HEALTH DEPARTMENT. MY PUBLIC ANNOUNCEMENT PROMPTED THE STATE TO RELEASE INFANT DEATH RATES WITHIN 72 HOURS. THESE DATA SHOULD HAVE BEEN MADE PUBLIC MONTHS BEFORE.

REGRETTABLY SOME WERE CONVINCED BY THE HEALTH DEPARTMENT THAT THESE DATA SHOWED CONCLUSIVELY THAT THE NUCLEAR ACCIDENT AT TMI HAD CAUSED NO DAMAGE TO UNBORN CHILDREN RESULTING IN BIRTH DEFECTS OR DEATH DURING INFANCY. WHILE THIS IS ENTIRELY POSSIBLE, IT IS PREMATURE TO CONCLUDE THIS FROM THE PENNSYLVANIA HEALTH DEPARTMENT DATA. FOR IN ITS EAGERNESS TO REPORT NO INCREASE IN INFANT DEATHS, THE HEALTH DEPARTMENT DATA UNFORTUNATELY WERE UNRELIABLE BECAUSE THEY WERE FLAWED BY ERRORS AND INTERNAL INCONSISTENCIES.

(SLIDE #8 - FETAL, NEONATAL AND INFANT DEATH RATES BY MONTH 1979)

(SLIDE #9 - FETAL, NEONATAL AND INFANT DEATH RATES BY QUARTERS 1977-79)

WITHOUT CAREFUL COMPILATION OF DATA, SOME MATHEMATICAL IMPOSSIBILITIES WERE FOUND IN THE DATA RELEASED BY THE HEALTH DEPARTMENT. FOR 10 MILES AROUND TMI, THE TOTAL FETAL DEATH RATE FOR JANUARY IS LOWER THAN THE TWO COMPONENTS WHICH COMPRISE THE TOTAL. ALSO, THE NEONATAL AND INFANT DEATH RATES FOR OCTOBER AND NOVEMBER VARY, EVEN THOUGH THE TWO COMPONENTS

(Slide #8)

FETAL, NEONATAL, AND INFANT DEATH RATES BY MONTH: PENNSYLVANIA, TEN MILE TMI AREA COMMUNITIES (INCLUDING AND EXCLUDING HARRISBURG CITY) AND HARRISBURG CITY, JANUARY - DECEMBER, 1979

Reported by Pennsylvania Department of Health

Month	Geographic Area				Geographic Area			
	Pa.	TMI (10 Mile)	Harrisburg City	TMI (Excl. Hbg.)	Pa.	TMI (10 Mile)	Harrisburg City	TMI (Excl. Hbg.)
	Fetal Death (Total) Rates				Fetal Death (Excluding Abortions) Rates			
January	24.4	29.9	31.9	33.3	15.3	26.9	21.5	33.3
February	22.3	23.4	45.0	10.6	12.5	23.4	45.0	10.6
March	25.4	21.9	48.5	9.2	13.1	13.8	39.2	9.2
April	23.3	16.5	32.3	9.5	13.0	16.5	32.3	9.5
May	25.1	11.2	9.3	12.0	15.5	8.5	-0-	12.0
June	22.7	9.3	19.2	4.5	13.4	9.3	19.2	4.5
July	20.8	13.4	29.4	7.4	12.9	13.4	29.4	7.4
August	22.8	15.3	20.6	13.1	13.3	15.3	20.6	13.1
September	22.8	18.2	44.2	4.6	13.2	18.2	44.2	4.6
October	21.0	18.8	42.1	8.9	11.7	18.8	42.1	8.9
November	20.4	21.3	42.1	12.8	12.3	21.3	42.1	12.8
December	24.6	6.5	-0-	9.4	15.3	6.5	-0-	9.4
Jan. - Dec.	23.0	17.1	30.6	11.1	13.4	16.3	28.2	11.1
	Neonatal Death Rates				Infant Death Rates			
January	9.8	21.5	33.0	17.1	14.8	21.5	33.0	17.1
February	10.0	10.3	28.3	-0-	13.7	13.7	28.3	5.4
March	8.2	19.2	40.8	9.3	11.5	22.4	40.8	14.0
April	10.7	20.1	33.3	14.4	14.1	20.1	33.3	14.4
May	9.8	17.0	18.9	16.3	14.1	17.0	18.9	16.3
June	10.7	18.7	39.2	9.1	13.2	18.7	39.2	9.1
July	10.0	5.4	10.1	3.7	11.9	10.8	10.1	11.1
August	7.3	6.2	-0-	8.8	10.2	12.5	-0-	13.3
September	9.8	12.3	9.3	13.9	12.9	15.4	9.3	18.5
October	9.9	9.6	11.0	9.0	13.7	12.7	11.0	9.0
November	10.5	6.2	22.0	-0-	14.8	9.3	22.0	-0-
December	10.9	13.1	31.3	4.8	16.1	19.6	31.3	9.5
Jan. - Dec.	9.8	13.2	23.0	8.9	13.3	16.1	23.0	11.5

*Note: Figures for 1979 are provisional.

(Slide #9)

FETAL, NEONATAL, AND INFANT DEATH RATES BY QUARTER: PENNSYLVANIA AND TEN MILE TMI AREA COMMUNITIES, 1977 - 1979

Reported by Pennsylvania Department of Health

Year/Quarter	Fetal Deaths-Total 1)		Fetal Deaths - Excluding Abortions 2)		Neonatal Deaths 3)		Infant Deaths 3)	
	Pa.	TMI (Ten Mile)	Pa.	TMI (Ten Mile)	Pa.	TMI (Ten Mile)	Pa.	TMI (Ten Mile)
1977								
Jan.-March	28.0	17.7	13.4	16.6	10.7	12.4	14.7	14.7
April-June	25.2	18.8	12.4	9.5	11.1	8.5	14.4	11.7
July-Sept.	24.9	25.0	13.1	22.0	10.1	6.1	12.9	9.2
Oct.-Dec.	25.1	23.6	12.7	16.6	10.1	10.5	13.7	14.7
1978								
Jan.-March	26.3	15.9	13.0	12.8	9.9	8.6	14.3	14.0
April-June	28.0	22.3	14.3	15.0	11.1	7.6	14.0	9.8
July-Sept.	24.5	19.1	13.4	15.3	9.3	1.0	11.8	4.9
Oct.-Dec.	25.2	22.2	14.1	14.9	10.5	10.8	13.6	15.1
1979								
Jan.-March	24.1	23.2	13.6	23.1	9.3	17.2	13.3	19.4
April-June	23.7	12.2	14.0	11.2	10.4	18.6	13.8	18.5
July-Sept.	22.1	15.5	13.1	15.5	9.0	7.9	11.7	12.8
Oct.-Dec.	21.9	15.7	13.0	15.7	10.4	9.6	14.8	13.8

1) Death rates per 1,000 deliveries (live and fetal deaths).
2) Death rates per 1,000 deliveries (live births and fetal deaths - excluding abortions).
3) Death rates per 1,000 live births.

Notes: Data for 1979 are provisional.

(Harrisburg and outside Harrisburg) which should comprise the total are identical. Furthermore, tabulation of neonatal and infant death rates for Harrisburg during 1979 are identical during the entire year. We are led to believe then that all infant deaths in Harrisburg, i.e., those in the first year of life, occurred neonatally in the first 28 days of life.

On slide 9, the second quarter neonatal death rate is higher than the sam quarter infant death rate even though slide 8 shows the two rates during the same period to be identical.

Yet to be explained is why five-and-ten mile infant death rates during the six months following the accident climbed sharply compared to the same period in previous years. The increase could be a normal statistical variation or could be induced by cause. Some of these findings are statistically highly significant and surely warrant careful attention if not further study. Later data reveal, increases in neonatal deaths after the accident may be even more significant than increases in infant deaths.

(Slide #10 - Infant Death Rates - April-September, 1979)

Five-mile rates were 6.7, 2.3 and 16.2 infant deaths per thousand live births for time frames from April through September in 1977, 1978 and 1979, respectively. Within then miles--including Harrisburg--death rates were 10.5, 7.2 and 15.7 during like time frames. Statewide levels for the same three years were 13.9, 13.5 and 13.6, respectively. The health department subsequently blamed the 1979 elevation above the statewide level in the ten-mile rate on high infant mortality among Harrisburg's blacks. But it is also known that minority data were present in 1977 or 1978 before the nuclear accident occurred. Had the infant death rate remained unchanged or even decreased, I trust those findings would have been well publicized.

INFANT DEATHS PER 1,000 LIVE BIRTHS [A]

(ACTUAL DEATHS IN PARENTHESES)

	5 MILES FROM TMI	10 MILES FROM TMI	ALL PENNSYLVANIA
1977	6.7 (3)	10.5 (20)	13.9 [B]
1978	2.3 (1)	7.2 (14)	13.5 [B]
1979	16.1 (7)	15.7 (31)	13.6 [C]

[A] APRIL THROUGH SEPTEMBER

[B] ANNUAL RATES

[C] JANUARY THROUGH SEPTEMBER 1979

According to a newspaper report, a Health Department spokesman also reported that a radiation effect--reversing the sex ratio among newborns--did NOT occur in the months after the accident. Unfortunately, the data necessary to draw this conclusion were not complete. The radiation effect is upon post-meiotic spermatogenesis after the TMI accident. It is customary to count male-female sex ratios in exposed persons for 50 days after exposure and prior to conception. Accordingly, a decrease in the proportion of male births from radiation can only be found by counting the sex distribution for about four weeks on either side of the 320th day after the March 28, 1979 accident. These data were not available when the story was released.

Also of concern is the omission of 88 infant deaths from Department of Health data.

(Slide 11 - Comparison of Federal Vital Statistics with Health Department Data)

An unexplained absence of 88 infant deaths from Pennsylvania Health Department data occurred in the third quarter of 1979. This reduced number of infant deaths is found by comparing it to the number listed in the Federal Government's Vital Statistics for 1979. This discrepancy raises further questions about the reliability of health department data.

In light of those many discrepancies, it is difficult, if not impossible, to understand how, in May of 1980, the Health Department could state, "After careful study of all available information we continue to find no evidence to date that radiation from the nuclear power plant resulted in an increased number of fetal, neonatal or infant deaths."

The release of inexact data once again reflects upon the lack of health input into planning for the next nuclear accident. And there has been no public correction of these many errors.

NUMBER OF LIVE BIRTHS AND INFANT DEATHS REPORTED IN PENNSYLVANIA AFTER THREE MILE ISLAND ACCIDENT OF MARCH 29, 1979

A COMPARISION BETWEEN U.S. VITAL STATISTICS AND DATA FROM PA DEPARTMENT OF HEALTH (DOH)

	1979 D/HHS* LIVE BIRTHS	1979 D/HHS* INFANT DEATHS	1979 PA DOH** INFANT DEATHS	EXCESS (DEFICIT) OF PA OVER U.S.
APRIL 1 - JUNE 30, 1979	38,014	527	525	(2)
JULY 1 - SEPT. 30, 1979	42,873	589	501	(88)
OCT. 1 - DEC. 31, 1979	38,303	565	567	2

*U.S. MONTHLY VITAL STATISTICS REPORTS
D/HHS NATIONAL CENTER FOR HEALTH STATISTICS

**DATA RELEASED BY PA DEPARTMENT OF HEALTH, APRIL, 1980

ALL 1979 FIGURES ARE PROVISIONAL

Assuming that the mathematical impossibilities, tabulation of erroneous data, the presentation of incomplete data, and the State's reporting of 88 fewer infant deaths than that reported by the Federal government were all accidents of compilation, or else carelessness, it must prompt us to urge state and federal health agencies to improve their efforts to collect health data before, during, and after nuclear accidents.

Although I do think the available data are non-conclusive in their present form, such unusual patterns of hypothyroidism and infant death rates following the nuclear accident at TMI warrant complete candor and disclosure, not delay and denial. A lack of confidence in [redacted] these findings [redacted] prompts me to urge an investigation of Pennsylvania health data following TMI by a group of qualified epidemiological investigators.

Unless departments of health are removed from the political arena, they will probably not be able to operate much differently from how we had to operate in response to TMI. For until health related activities of state government are brought under the wing of competent health departments, we will continue to grope for direction and support in our efforts to address the health impacts of such an accident. But, perhaps there is a way that this can be done. Perhaps there is a way to bring a common effort to whatever commitments to public health may remain in state government. I don't think it can be accomplished under the present structure.

The health industry has grown to such tremendous scope and size that it poses infinite temptations for political control. And any one individual entrusted with the responsibility of overseeing such a massive industry from within state government is going to be subjected to unbelievable political pressures from those who seek to share in such control.

It is only fair to say the Governors who generally have no health professional qualifications are now victims of the politics affecting the health industry. There are just too many factions pulling and tugging at politicians for their own better interests. And these forces exert tremendous pressures on anyone trying to participate in a rational decision making process. That pressure is transmitted to secretaries of health who serve at the pleasure of the Governors.

In recent years, it has become fairly routine for new Governors--and sometimes new mayors--upon election to replace the entire administrative leadership in health departments. If, in fact, we are going to accept some degree of politicization of health departments, perhaps we should follow the trend in the executive and judiciary branches in Pennsylvania and elect a state surgeon general on the popular ballot--along with the judges, the Treasurer, the Auditor General, and now, the Attorney General. As with the judiciary, a ten year term for the chief health officer could promote professional performance.

Or perhaps health activities now conducted throughout state government could be placed under the direct control of a health commission selected by the Governor from a panel of physicians nominated for a 5 to 10 year appointments by a statewide panel of medical school deans and leaders of medical professional societies.

Because of the magnitude of the health care industry and the wide dispersion of public health services, including radiation health, the chief health officer cannot effectively operate professionally under the direct supervision of the Governor. Nor should the Governor be subjected to the constant political pressures exerted by special interests within and outisde the health industry.

THE REALITY OF POLITICS SAYS THAT WITH HIGH DOLLAR VOLUME, SPECIAL INTEREST PRESSURES ARE EXERTED FROM A MYRIAD OF DIRECTIONS IN BOTH PUBLIC AND PRIVATE SECTORS, THE COMMITMENT TO PUBLIC HEALTH CAN QUICKLY CRUMBLE IN THE PROCESS.

SO NOW WE COME TO THE LAST SERIOUS ISSUE. WHAT HAPPENS IN THE EVENT OF ANY FUTURE NUCLEAR ACCIDENTS? HOW DO WE PROTECT THE PUBLIC'S HEALTH? SHORT OF IMMEDIATE CESSATION OF ALL NUCLEAR ACTIVITY WHICH I THINK IS WELL NIGH IMPOSSIBLE, THE NATION MUST BE PREPARED NOT TO REPEAT THE MISTAKES TO TMI AND TO BE FAR BETTER PREPARED THAN PENNSYLVANIA IS AT THE PRESENT TIME.

BUT LET ME WARN THAT THE PEOPLE OF PENNSYLVANIA ARE NO BETTER OFF TODAY AND PERHAPS WORSE OFF THAN THEY WERE THE DAY BEFORE THE RADIATION RELEASE AT TMI ON MARCH 28. THERE IS STILL NO DIVISION OF RADIATION HEALTH. NO RESOURCES FOR HEALTH RADIATION PREPAREDNESS. NO POTASSIUM IODIDE FOR DEPLOYMENT IN CASE OF ANOTHER ACCIDENT.

THE PEOPLE OF PENNSYLVANIA ARE UNIQUELY SENSITIZED TO THE PSYCHOLOGICAL STRESS OF A NUCLEAR ACCIDENT. WERE THERE TO BE ANOTHER ACCIDENT IN ANY ONE OF PENNSYLVANIA'S NUCLEAR REACTORS IN OUR PRESENT STATE OF UNPREPAREDNESS, IRREPARABLE PSYCHOLOGICAL DAMAGE COULD OCCUR.

THE LACK OF PUBLIC HEALTH PREPAREDNESS FOR ANOTHER NUCLEAR ACCIDENT HAS BEEN REPEATEDLY CITED--BUT TO NO AVAIL.

BASED UPON SOME OF THE LESSONS LEARNED FROM TMI, LET ME SUGGEST SOME ITEMS FOR CONSIDERATION BY PUBLIC HEALTH DEPARTMENTS IN PLANNING FOR A RADIATION EMERGENCY.

Every health department should have access to expertise in radiation medicine. One good model can be found at Massachusetts Institute of Technology, where a well regarded specialist in internal medicine is permanently appointed to chair a committee composed of radiologists, environmental health specialists, nuclear engineers, radiobiologists, nuclear medicine specialists, nuclear physicists, and radiation health physicists. A similar committee under state government auspices might be called upon to oversee health training programs for employees, community physicians, and other health care providers and be available to assist in the management of a nuclear accident were one to recur.

Every health department should be informed about preventive or protective programs in order to avoid or alleviate radiation induced diseases. In this regard, potassium iodide is recommended to be available for deployment and distribution to all persons at risk of exposure to a radiological emergency.

Both state and local health departments in the vicinity of a nuclear reactor should initiate or work cooperatively with the management of the plant to conduct radiation drills simulating radiologic emergencies. Through such an exercise students could learn a great deal about disaster management.

Every health department should develop a radiological emergency response plan for the health aspects of a nuclear accident. The plan should encompass overall evacuation and special procedures for specific sectors of society, particularly institutionalized or home-bound patients.

Health departments should promote age-specific continuing health education programs pertaining to radiation for all age groups, especially for puberty and pregnancy.

OPEN COMMUNICATION WITH THE MEDICAL COMMUNITY, THE RELIGIOUS COMMUNITY AND THE GENERAL PUBLIC WILL HELP TO DELIMIT PSYCHOLOGICAL DAMAGE WHICH WE HAVE SEEN RESULT FROM THE TMI ACCIDENT.

ABOVE ALL, THE PUBLIC HAS THE RIGHT TO KNOW THE RISKS AND DANGERS FROM A RADIOLOGICAL EMERGENCY AS WELL AS FROM ALL OTHER CATASTROPHES THAT CAN AFFECT THE PUBLIC HEALTH.

AS SOON AS POSSIBLE AFTER THE ACCIDENT, IT SHOULD BE ANNOUNCED THAT HEALTH DATA SHALL BE COLLECTED AND RELEASED PROMPTLY TO THE CITIZENRY AFFECTED BY THE EMERGENCY. THE MEDICAL CONSEQUENCES, WHATEVER THEY MAY BE, SHOULD BE PROMPTLY INTERPRETED AND FURTHER STUDIES DONE AS INDICATED. THE PUBLIC HAS BECOME INCREASINGLY SOPHISTICATED IN INTERPRETING DATA ABOUT RADIOLOGICAL EMERGENCIES.

ONLY THROUGH EFFORTS TO DEVELOP A SOUND SYSTEM OF PUBLIC HEALTH THROUGHOUT THE COUNTRY WILL WE EVER BE ABLE TO ADDRESS EFFECTIVELY THE MANY HEALTH PROBLEMS THAT COULD RESULT FROM ANOTHER NUCLEAR ACCIDENT. AND UNLESS WE DO ADDRESS THESE PROBLEMS—AND ADDRESS THEM NOW—WE MAY WELL FIND OUT HEALTH TO HAVE DETERIORATED TEN OR TWENTY YEARS HENCE PONDERING THE SAME PUZZLES THAT ARE CONFRONTING US HERE TODAY.

THANK YOU.

The Nuclear State in Ascendancy

By Anna Mayo

Has anybody here seen my old friend Gordon?
—Can you tell me where he's gone?
We just couldn't gag him, so we had to bag him.
—I just looked around and he was gone.
—From a skit presented at the 1980 Harrisburg press corps show, to be sung by Dick Thornburgh to the tune of "Abraham, Martin, and John".

Dick Thornburgh is the present governor of the great—and berserk—Commonwealth of Pennsylvania. In October 1979, Thornburgh fired Dr. Gordon MacLeod, his secretary of health, who had sought to provide the public with straight information on the health effects of the nuclear accident at Three Mile Island six months earlier. Since the firing, and with the connivance of the pronuclear media—in particular, as we shall see, *The New York Times*—the Thornburgh administration has engaged in systematic suppression and manipulation of health data under the banner of "preventing community breakdown"—business failures, sinking property values, people fleeing the area, riots, civil war, and so on.

The firing stunned MacLeod. Only a few months earlier, Thornburgh had wanted him badly. He would have preferred to stay in academia, but the governor wouldn't take no for an answer, needing MacLeod as a symbol of campaign promises fulfilled, of depoliticization of the health department, of clean government, of a new era of reform.

Bullshit, of course: one straight-arrow cabinet official was hardly going to change the character of a state government historically encrusted with patronage and corruption, where lottery scandals have come to be expected, and elected officials have, over the years, checked in and out of nearby Allenwood Penitentiary so fast it's known as Harrisburg East.

MacLeod, at least, was a class act. He came from the rarefied, high-level teaching hospital world—he had been a

women and preschool-age children (also at risk), from a five-mile radius around the plant. (The official presidential commission report on Three Mile Island reconstructs the call just as MacLeod recalls it, though Thornburgh press aide Roland Pages, a former *New York Times* man, denies it took place. "If it did take place, and I doubt it," he said, "there wasn't necessarily some mythical person from the lieutenant governor's office participating. And if there *was* somebody, he didn't necessarily tell the governor what MacLeod recommended, if he did recommend anything.") Not until late the next morning, nearly a full day and an unknown number of curies of radioactive iodine after MacLeod's warning, when Joseph Hendrie, chairman of the U.S. Nuclear Regulatory Commission, told Thornburgh on the phone from Washington that if *his* wife were pregnant he'd get her the hell out, did the governor make his reluctant, not-to-panic announcement

TMI (Kemeny) Commission. MacLeod enumerated several serious "misstatements" and "misrepresentations" in a letter to the Kemeny body. (For instance, one state committee report omitted data from a presumably high release of radioactive iodine that occurred in mid-April when the TMI auxiliary building charcoal filters were being replaced.)

MacLeod called Environmental Resources secretary "Cliff" Jones to recommend that whoever in his department was responsible for the "misstatements" be reprimanded. Jones became furious. Later, the closest thing to a reason the governor would offer for firing MacLeod was that he had been discussing the latter's "differences in institutional style" with Jones and several other members of the administration. What did he mean by *that*, MacLeod asked. "It's hard to explain," Thornburgh responded. "It's just that we operate differently."

His tour of public service formally over,

frightening physical damage to human and animal infants persist.

None of these allegations have held up under careful scrutiny by disinterested authorities. The only real health damage detected so far has been psychological. For example, a report made public yesterday says that many of the community's residents remained distressed for months and resorted to sedatives and alcohol for relief. Their anxiety could only have been heightened by the "experts" and critics who have issued alarming statements about radiation hazards based on scant or distorted data.

The most worrisome charge has been that radiation from the crippled reactor has already caused an increase in infant mortality and thyroid defects in newborn babies. Those fears were effectively laid to rest by state and Federal health investigators, as reported in the Times by Jane Brody. The concern about infant mortality was based largely on raw statistics showing an increase in the number of infant deaths within a ten-mile radius of the reactor after the accident. But those numbers in themselves are meaningless; there was also an increase in the total number of births. The *rate* of infant deaths remained normal.

Similarly, the concern over thyroid disease was based on unevaluated statistics showing, in three counties, a possibly abnormal number of children born with thyroid defects. But on investigation, most of these cases were attributed to hereditary defects or other circumstances predating the nuclear accident. Four counties equally close to the reactor, or closer, had no such cases at all.

government, of a new era of reform.

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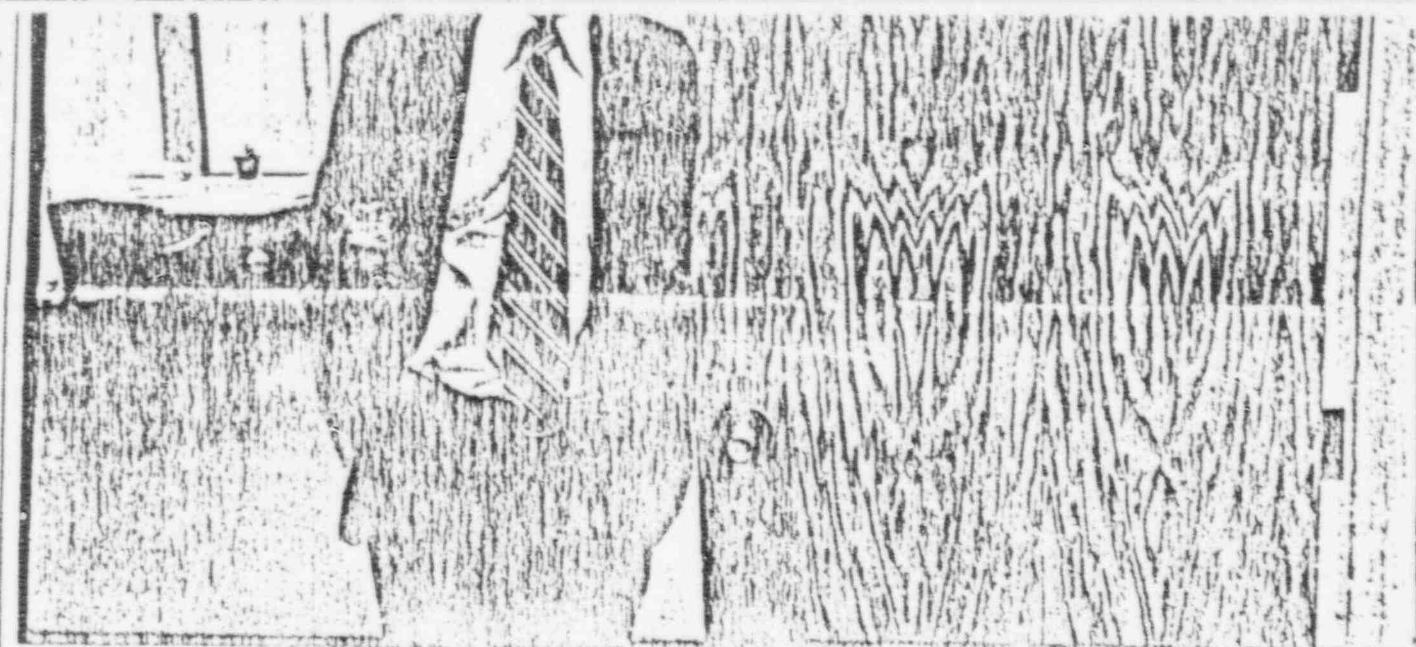
MacLeod, at least, was a class act. He came from the rarefied, high-level teaching hospital world—he had been a Massachusetts General-Harvard Medical School Fellow, chief of the Yale Diagnostic Clinic of Internal Medicine, assistant to Eliot Richardson when he was secretary of health, education, and welfare, and is now fellow of the American College of Physicians, immediate past president of the U.S. Medical Administrators' Conference, chairman of the Department of Health Services of the University of Pittsburgh and faculty member of its School of Medicine.


BILL KENNEDY

Pennsylvania's Gordon MacLeod: fired for making public health information public

"When the governor called me in," MacLeod recalled in a recent telephone interview, "I assumed he wanted to discuss a nursing home investigation we were involved in at the time—some workers had barricaded themselves and patients in a home in Philadelphia. But when I got into his office, he started telling me a rambling anecdote, something about a derelict who took some checks from the governor's mansion which were later found in a church—it didn't seem to have any point. I thought, maybe he feels like passing the time of day, when all of a sudden, out of nowhere, he asked for my resignation."

MacLeod had been sworn in as secretary, the state's highest health post (supposedly), on March 16, 1979. Twelve days later, radioactive hell broke loose on an island in the noble, if contaminated, Susquehanna River.

Physician MacLeod was acutely aware that fetal exposure to radioactive iodine may cause infant death or mental retardation and stunted growth. The day after the accident, in one of those hectic four-way conference-call screaming contests that were the modus operandi of the crisis period, he strenuously urged the lieutenant governor's representative, John Pierce (who, he understood, carried reports of all high-level meetings to the governor), to advise the governor to evacuate pregnant that "in case the situation got worse"—he avoided any suggestion that the situation was already dangerous—it would be "wise for pregnant women and pre-school children to evacuate."

MacLeod was not so sure all was well. Because of instrument malfunctioning at TMI, radiation levels went unmeasured. And he was haunted by the story of the *Newsday* reporter who, upon returning to Long Island after covering the accident, became concerned over the irradiation of the fetus she was carrying. On her physician's advice, she had an abortion, then wrote Harrisburg health officials, offering to ship them the aborted fetus for examination.

Throughout the spring and summer MacLeod set up studies to determine if there had been any health effects from the accident and worked up a HealthDepartment reorganization plan. "The governor *seemed* enthusiastic," MacLeod recalled. But the regulars carousing at Catalan's Restaurant guffawed at the professor from Pittsburgh: "MacLeod the Cloud" they called him, or "the Lone Eagle." *They* knew he'd never last.

On October 4, the governor's special TMI investigatory commission convened. Drafts of committee reports were circulated for comment prior to dispatching final copies to President Carter's "his people" forced out with him, MacLeod returned to Pittsburgh's academic life. But the purge was incomplete. One February morning he was awakened by a confidential call from Harrisburg; there had been a rise in thyroid defects among babies born since the accident . . . the information should have long since been released . . . it would be held back indefinitely. "For several days I made every effort to get the data out officially," MacLeod said. "Finally, I tipped off a UPI man and he was able to obtain the figures. The story went on the wire and received wide play."

In March the minister of Pittsburgh's First Unitarian Church invited MacLeod to speak on "TMI, One Year Later." From the pulpit, MacLeod disclosed that the infant death rate in the vicinity of the reactor had risen sharply and that according to a high DOH source these data, then six months old, were also not going to be released.

He had hit a nerve. The nuclear establishment unleashed its dogs. On April 19 *The New York Times* ran an unusually hysterical editorial:

> Those scare stories about radiation damage from the accident at Three Mile Island look increasingly farfetched. Federal officials have said all along that little radiation escaped, posing virtually no threat to public health. Their judgment has been supported by all major investigations of the accident. But rumors of
>
> Reports of bizarre deformities among farm animals and wildlife have also been circulating. Worried farmers and at least one veterinarian have described animals born with legs or eyes missing, stillbirths, spontaneous abortions, defective bone structures and strange sudden deaths. Many blame the reactor. But the Pennsylvania Department of Agriculture investigated 100 farms within five miles of the reactor last May and found only five with any unusual problems among the livestock. These were attributed to viral infections or to feed and poor nutrition; there was no evidence of radiation damage.
>
> Several long-term studies are still under way. But for now the public can draw considerable reassurance from these negative findings. It is not only apologists for the nuclear industry who say that radiation damage has been negligible; so do health officials whose main concern is the public's safety, and agriculture officials whose mission is protecting farmers and livestock.
>
> What is not at all reassuring is the behavior of "experts" who have inflamed public fears by dealing recklessly with statistics. Dr. Gordon MacLeod, who was Pennsylvania's Secretary of Health at the time of the accident but was later forced to resign by the Governor, irresponsibly publicized some of the raw data suggesting the existence of health problems. And Dr. Ernest Sternglass, a perennial campaigner against nuclear power, is accused by neutral health authorities of mishandling data to demonstrate health damage. Even in nuclear fables there are people who cry wolf.

"I opened the morning paper and there this thing was," said MacLeod. "What made me angriest was the *Times* editorialist had never called me. And a reporter named Jane Brody had referred to my statements in a news story before the editorial—which I only saw later on—and she had never called me either."

Continued on next page

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MacLeod dashed off a letter to the paper with a note to Max Frankel, editorial page editor: "Dear Mr. Frankel: Does a person castigated by the *Times* have a right to reply? In all fairness the *Times* should retract its obloquy and correct the mistakes in Ms. Brody's article. . . ." (MacLeod was also aggravated by the *Time's* failure to print an earlier letter in which he had corrected misstatements in an April 2 article by *Times* reporter David Burnham.)

Neither letter having appeared, MacLeod phoned repeatedly to the *Times* letters page editor, whose secretary finally told him his second letter was being held up by science editor, William Stockton. "I finally got Stockton on the phone," said MacLeod. "He said, 'Oh, I know all about you.' His tone was *not* welcoming. I had the impression he did not want to print my letter. He said that if I wanted it published, I would have to rewrite it, leaving out a correction I had made of a point in Brody's article and also my infant mortality data, that is to say, the crux of the whole argument. I asked him why, and he said he found my data 'confusing'. I had him talk with a biostatistician here at the university, Dr. Howard Rockette. When I spoke to Stockton later, he told me Rockette had convinced him my data were sound. But he still found them too 'confusing' to print."

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Q: Dr. MacLeod, the *Times* editorial claimed your data on infant deaths was "meaningless" since there was an increase in the *total* number of births so that the *rate of* infant mortality remained the same. It said, as Burnham's article had, that you failed to consider the *total* number of births.

A: But of course I did. Births simply do not go up and down significantly from year to year. As a matter of fact, in the five-mile radius around the reactor there was actually an insignificant *decrease* in the total number of births. But I certainly would not use it to bolster my argument any more than I would expect the Health Department to do what it is doing, which is to use a statistically insignificant increase in the total number of births in the 10-mile radius to justify its argument. Either way is wrong.

Q: You say the *Times* refused to print a criticism you made of Brody's article.

A: Brody claimed that the normal 106 male to 100 female ratio per 1000 births was not reversed following Three Mile Island. British studies have shown that it can be reversed (presumably on account of irradiation of the testicles). In my uncut letter, I pointed out that when Brody said there was no reversal she did not have the full data on which to base her statement. And they say I'm irresponsible!

Q: What data should she have waited for?

A: The way to determine if there has been sex reversal after exposure to radiation is to allow 50 days—that's the time it takes for the radiation to affect the adult male sperm formation, then add 270 days for pregnancy, giving you 320 days. You count all babies four weeks before and four weeks after this. Thus, you wouldn't have been able to observe sex reversal until March 11. [Brody's article quoted statistics gathered in January.]

Q: Would you comment on Brody's statement that the Health Department data shows 31 deaths in the six months following the accident as against 20 during the corresponding period in 1978 and 14 in 1977?

A: She has it wrong. The sequence was 20 deaths in 1977, 14 in 1978, and 31 in 1979. In other words, before the accident the infant death rate was going down, as it was in the rest of the country.

Q: The *Times* editorial claims that Pennsylvania Agriculture Department studies done in May 1979 show that radiation did not affect farm animals.

A: Most of the reported animal effects showed up *after* May. In the case of adult animals, they could have taken time to develop. And few animals exposed to radiation in utero during the accident would have been born in May.

Q: The *Times* accuses you of "irresponsibility" and "inflaming public fears."

A: Public fears are inflamed when a health department holds back and distorts information. If it becomes politicized, the department loses credibility. How can one believe anything it says? I personally do not oppose the development of nuclear energy, but I do believe the public should know what the health effects will be. I released the infant mortality rates because I was told that they would otherwise have been suppressed. I disclosed the information on thyroid defects primarily to encourage early detection lest an untreated infant become a cretin. Not to release such information is irresponsible. After all, *public health data belong to the public.*

●

imes reporter David Burnh..n, dis-ing his article, said he had talked to Leod "early one morning" and found "persuasive," but "as the day wore had become convinced that MacLeod wrong by the "hard figures" provided him by the Pennsylvania DOH. nham had defined "perinatal deaths" leaths owing to miscarriages and elec-abortions up to the age of 28 days *after* h. Asked whether this was perhaps a graphical error, he bumbled: "I can't ly say . . . I don't remember. Say, what perinatal deaths anyway?" Burnham missed the essential point: The Penn-ania DOH had added in fetal deaths, ch are not known to be affected by low-l radiation, as infant deaths are. Thus, ame up with a reassuringly low total th rate.

Also, Burnham had swallowed the H's exclusion of Harrisburg infant ths on the grounds that Harrisburg has rge black population with a high infant th rate owing to malnutrition, poor dical care, etc. But what new factor had sed the 1979 infant death rate to in-ase beyond the two preceding years?

"I only had one day to write the arti-" Burnham said. "It's the sort of piece t shouldn't be written in a day. Well, way, I got it out."

It did need more time, and considering rnham's long record of accurate nuclear ortage and that he wrote the MacLeod ce under the stress of a major career nge—it was the eve of his resignation m the *Times*—he would have been off hook. Except that he uncharac-istically shouted, "This guy Mac-od's off the wall! I hope you print that! was totally irresponsible to get up in a *rch* and make that speech when he in't have the complete data! You have to realize that there's terrible fear in that community!"

In another interview, *Times* science writer Jane Brody was asked if she still felt her statements about TMI health effects were correct.

"My *feelings* have nothing to do with it," she replied. "I write about scientific *facts*, not about what I *feel*."

Why didn't she interview MacLeod?

"Why should I have?" she asked sharply. "He never did any scientific investigation. I only interview scientists." [As an M.D., MacLeod has had training in epidemiology. In fact, over the years it has been one of his special interests.]

Brody had quoted a scientist from the Federal Center for Disease Control in Atlanta to the effect that "all other areas of the United States that have screening programs" had higher rates of hypothyroidism than Pennsylvania." But Montana and Idaho have much lower rates.

"The CDC scientist was talking about *national* composites," said Brody, sounding as though she was about to hang up.

Continued on next page

She was told that my editor had asked that she be interviewed so she could give her side of the story.

"Oh, so you were going to try to get away with not letting me tell my side. *That's* the kind of reporter you are!"

New York Times science editor William Stockton was cooler in tone. Asked if he had told MacLeod to delete his infant mortality data because it was "confusing," he replied that no, "not because it was confusing, but because it was incorrect. It was wrong." He denied telling MacLeod that biostatistician Rockette had convinced him of the significance of MacLeod's infant mortality statistics. "Rockette was on the fence," he said, "and we talked with some of our people and it became apparent that MacLeod was wrong. We checked the story before publication and we've checked it since and we stand by it."

(Rockette told the *Voice* that while he could not say what the health implications of the data were, there was *no* question but that they were statistically significant.)

Wasn't it true that the data base for sex determination was incomplete when Brody wrote her article?

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"We stand by our story. But . . . [he hesitated for a fraction of a second] . . . er . . . we intend to do another story this fall when the data is complete."

●

Suppression of information can be seen as an intrinsic feature of Harrisburg's new paramilitary style. From the start, the Thornburgh administration has been studded with ex-FBI agents and retired army colonels. At the time of the accident, for example, the chief of the Pennsylvania Emergency Management Service was Colonel (U.S.A. Ret.) Oran K. Henderson. "Hen" had been commander of the brigade involved in the My Lai massacre. Absolved of responsibility for that episode, he retired to the Pennsylvania job. In a legislative committee hearing last spring, "Hen" made the mistake of insinuating that the governor had erred in rejecting his recommendation for mass evacuation. The old Mylai veteran resigned before he was fired.

To replace Henderson, Thornburgh called up big brass: Lieutenant General Dewitt C. Smith, commandant of the prestigious U.S. Army War College in Carlisle, 20 miles west of Harrisburg, a graduate school for future generals, and, although not much mentioned, CIA agents. Before the War College post, Smith graced the Pentagon as a top aide to Secretary of Defense Cyrus Vance and General Maxwell Taylor. Ominously for the future of Harrisburg, the press release announcing his appointment puffs his long record of combat experience as an essential requirement for upcoming nuclear emergencies.

Another fresh recruit from the military is MacLeod's successor as health secretary, Dr. Arnold Muller, an ex-army major who, although his official curriculum vitae somehow omits mention of it, moonlights as a physician (security-cleared) at the War College. Some wonder how Muller can find time to carry out his duties as secretary, for while his War College gig is weekends only ($10,000 per annum), he also continues to act as chairman of the Division of Emergency Medicine ($21,000) at Hershey Medical Center.

Thornburgh's lieutenant governor—he thinks of him as a son—is William Worthington Scranton III. Scranton III's actual father is former Pennsylvania governor William Scranton, member of David Rockefeller's Trilateral Commission and of the board of *The New York Times*.

When Thornburgh is out of town conventioneering, two members of his cabinet call the shots—his secretary of environmental resources, "Cliff" Jones, who was influential in the firing of MacLeod, and his secretary of budget and administration, Robert Wilburn. Jones used to be a paid executive for various industry booster organizations (e.g., the Greater Hazleton Chamber of Commerce and Can-Do Inc.) He was also state Republican chairman and derives his power in state government from his awesome success as a fund-raiser for the Grand Old Party. Blond and jutjawed Wilburn—reporters hanging out in the Senate Saloon call him "Captain America"—is a former vice-president of David Rockefeller's Chase Manhattan Bank, prime source of funding of the development of capital intensive nuclear power.

Thornburgh himself used to be an attorney and adviser to the Mellon family of Pittsburgh's premier corporation, the Aluminum Company of America, a major user of nuclear-generated electricity. Keeping up with the Rockefellers, the Mellon family contributes to the Republican Party and has its own Big Bank (heavily into nukes), of which Thornburgh is, naturally, protective (immediately after his election, he wiped out the modest reforms of the previous administration and stacked the State Employee's Retirement Board with appointees who reinstated Mellon Bank as stateworkers' pension fund manager). A self-styled "Rockefeller liberal," darling of *The New York Times*, former deputy attorney general under Gerald Ford (invited to stay on by Trilateral Commission president Jimmy Carter), Thornburgh, not incidentally, is also a close personal friend of Robert Kirby, chairman of the board of Westinghouse, World's Largest Manufacturer of Nuclear Reactors.

This, then, is the public servant who will decide such life and death matters as whether public information shall be made public, whether, in future crises, evacuation is advisable, whether a cleanup procedure that is cost effective is preferable to one that is less dangerous, and whether the state will countenance operation of the four power reactors now in service, completion of four more under construction, and restart of the two lemons on Three Mile Island.

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Prevent community breakdown? In Harrisburg, community breakdown has already happened. The TMI cleanup process now underway entails large releases of radiation. The possibility of another major crisis is very real. Hundreds of families have fled the area. Others would like to split but are unable to sell their homes. At some point they might *have* to go, they feel, so they keep their savings in the bank. As a result, sales of consumer goods are off, small businesses are in trouble, and newspaper advertising revenues are down.

There are no riots—instead, people turn anger in against themselves and their families. The incidence of alcoholism, wife- and child-beating, and other disturbing psychological reactions has increased.

The critics maligned by the *Times* did not cause the breakdown. They are only the messengers who brought the bad news.

Doctors do not as a rule challenge the establishment of which they are so comfortably a part. But the MacLeod firing gnawed at principles basic to the effective practice of medicine. In December, the House of Delegates of the Pennsylvania Medical Society vindicated MacLeod through a special commendation for his handling of the TMI crisis. The Allegheny General Hospital invited him to grand rounds, the American Public Health Association, public health equivalent of the American Medical Association, invited him to speak at its annual conference, and in the spring he was feted at the annual conference of the Allegheny Health Department. When his successor, the major-doctor, said combatively that *he* would not release any TMI information until it was "absolutely clear" to him, the eminent physicians there assembled made it known, in a dignified, throat-clearing manner, that they deplored his approach.

As yet MacLeod, like the majority of old boy docs, does not oppose the use of nuclear power. "I may change my mind eventually," he muses. "The other day a reporter from Canada asked me a very provocative question. He wanted to know what would make me antinuclear. I thought it over. Finally, I told him that if I ever become convinced that nuclear energy would harm future generations, then I would oppose it."

The pro-nuke machine in Harrisburg has no room for people with limits. What the nuclear state in ascendancy demands is fanatic loyalty, willingness to take casualties, military secrecy, an end to democratic forms, the cold embrace of tyranny. ■

Mary
FYI
Judy

Letters

An N.R.C. Plan to Allow Just a Little More Cancer

To the Editor:

In recent weeks, the Nuclear Regulatory Commission has, without fanfare, proposed certain changes in its regulation of low-level radioactive waste disposal that may set a precedent for future distribution of large quantities of contaminated materials without licensing, monitoring or any follow-up studies of possible consequences for public health. To our knowledge, the press has not been made aware of the implications of these proposed changes, and we believe that your readers may wish to submit comments to the N.R.C. and to elected officials.

The Oct. 8 Federal Register (45 FR 67018) proposes to deregulate certain medical and research wastes and permit their disposal in sewage systems and sanitary landfills. Liquid scintillation media containing tritium (with a half-life of about 12 years) and carbon-14 (with a half-life in excess of 5,000 years) in an organic solvent (toluene, which is highly toxic) would be deregulated, conserving some 400,000 cubic feet of licensed low-level waste disposal space for other radioactive wastes.

At present use rates, some 200,000 to 400,000 gallons of contaminated material are involved, 43 percent of the volume of low-level radioactive wastes from medical and research sources. In addition, animal carcasses containing small quantities of tritium and carbon-14 could be discarded in community landfills.

These two changes would reduce the costs of radioactive disposal by an estimated $15 million per year for the licensees.

A second Federal Register notice, on Oct. 27 (45 FR 70874), clarifies beyond any doubt the intent of the N.R.C. to "solve" the troublesome low-level radioactive waste problem by deregulation, dispersion, dilution and diffusion.

In it the commission proposes to allow the recycling of metals contaminated with technetium-99 (half-life, 210,000 years) and low-enriched uranium from the Department of Energy's gaseous diffusion plants. Contaminated scrap copper, iron and nickel would be permitted to be smelted and mixed with uncontaminated materials from other sources for subsequent use in all manner of consumer articles.

Appliances, toys, furniture, cars, coins, cooking utensils, machinery and construction materials are cited by the N.R.C. as possible consumer items that would be permitted to contain low-level radioactive contamination. The commission expresses some concern about "health effects" on foundry workers but concludes that the damage to the public would be "de minimus," which is an N.R.C. term meaning "very small if no one bothers to look for any damage."

A Draft Environmental Statement by the N.R.C. (NUREG-0518) stresses the financial savings that would result from this perverted form of conservation of scarce resources. Public comments on the draft will be received until Dec. 22.

Once established, such a policy of "dispersion and dilution" for solid low-level radioactive wastes would be readily extended to other contaminated materials from the nuclear power industry, not just medical, research and weapons-related radioactive wastes. It would pave the way for classifying other "low-level" but nonetheless dangerous radioactive materials as "safe enough for the landfill" or as "recyclable scarce resources."

There would then never be a comprehensive assessment of the impact upon people and their environment, because no one would be able to trace these contaminants. Just a little more cancer. A few more defective children.

This is grossly improper regulation, which wholly violates both the mandate of the Atomic Energy Act to protect the public health and safety and the requirements of the National Environmental Policy Act.

JUDITH H. JOHNSRUD
Co-Director, Environmental Coalition on Nuclear Power
State College, Pa., Dec. 9, 1980

Midland Daily News

10/150
Gan.

1st letter

Reply

In perspective

To the editor:

In reply to Miss Andrea K. Wilson's letter of Oct. 24, I would like to submit the following information.

On May 19, the Pennsylvania Dept. of Health released a report of infant, neonatal and fetal death rates that included statisites for the entire year of 1979, before and after the Three Mile Island (TMI) accident.

The figures in the report show the infant death rate (deaths under the age of one year) to be 11.5 per 1,000 live births within a 10-mile radius of TMI. The statewide figure for the same period of time was 13.3 infant deaths per 1,000 live births.

The neonatal death rate (deaths within the first 28 days of life) was 8.90 per 1,000 live births within a 10-mile radius of TMI. The statewide figure was 9.8 deaths.

Figures for fetal deaths (stillborn, miscarriages or voluntary abortions after 16 weeks of gestation) showed a similar trend. The total death rate within a 10-mile radius of TMI wa 11.1 per 1,000 live births. The statewide rate was 23.0.

Excluding voluntary abortons, the state fetal death rate was 13.4 per 1000 live births, while the 10-mile radius figure remained at 11.1

The Pennsylvania Dept. of Health stated that "after careful study of all information available, we continue to find no evidence to date that radiation from the nuclear power plant resulted in an increased number of fetal, neonatal or infant deaths."

I hope the above information will place the debate in clearer perspective for your readers.

L.R. HOWELL
4007 Washingto-

these data are based upon faulty data which I shall discuss at a seminar at Columbia University on Nov 22.
SKM

Consensus lacking

10-24-80

To the editor:

A year and a half ago the accident took place at Three Mile Island, and we all began to learn more about nuclear power. Perhaps most importantly, we have learned how much we still don't know.

There is general consensus in the scientific community that the radiation exposure to the public at TMI was not very high. But consensus is lacking on the effects of this low-level radiation.

Dr. Gordon MacLeod, Chairman of Public Health Services in Pennsylvania at the time of the accident, released these infant mortality statistics for the area surrounding TMI after the March 1979 accident.

Deaths Per 1000 Live Births

	5 Mi. Radius	10 Mi. Radius	All Pa.
1977	6.7	10.5	13.9
1978	2.3	7.2	12.9
Jan.-Sept 1979	16.1	15.7	12.6

Dr. MacLeod cautions against drawing hard-and-fast conclusions from such rough data, yet feels they warrant careful attention if not further study.

His main concern is that this information had not been made public until his disclosure a year after the accident. "Had the infant death rate remained unchanged, or even decreased, I trust that those findings would have been well publicized," he said.

Babies exposed to the radiation at their most critical fetal stage are now nearing one year old. Let us hope that there is an end to decisions being made about what the public "should" or "should not" know concerning radiation effects.

We are a thinking people, capable of careful analysis, and are more concerned when information is not forthcoming than when we are given the full story.

ANDREA K. WILSON
310 East Ashman

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Commonwealth of Pennsylvania

Department of Health

HARRISBURG

717-787-5264

October 27, 1980

Ms. Barbara Stamiris
5795 N. River
Freeland, Michigan 48623

Dear Ms. Stamiris:

Your recent letter to the State Health Department regarding infant mortality was first referred to Mr. Lindeberg, Press Secretary, who subsequently referred your inquiry to my office for reply.

Infant mortality is defined conventionally as the number of infants dying during their first year of life, which is usually expressed per 1,000 live births in a given year in a given population. However, this statistic does not really represent the true probability of dying of the original cohort (infants) born in a given year because of the following reasons: (a) some infants born in the previous year are included in the current death statistics; and (b) some infants born in the current year are included in the following year death statistics.

We do have more recent data on infant mortality rates (computed by the conventional method), i.e., we have analyzed the entire 12-month period of 1979 by quarters. Please keep in mind that these 1979 statistics are still provisional for the reasons mentioned above. Several important observations have been noted.

1. Infant mortality rate per 1,000 live births for 1979 gradually declined from 19.4 (January-March) to 18.5 (April-June) and 12.8 (July-September), and remained relatively stable for the fourth quarter, 13.8 within the 10-mile radius (including Harrisburg) of the TMI reactor.

2. A similar pattern was also seen for both 1978 and 1977 within the same geographic area, as well as for the State as a whole.

3. While the second quarter rate for 1979 was higher than the comparable period for 1978 or 1977, there was even a higher infant death rate already registered during the first quarter of 1979, immediately prior to the TMI accident. Thus, the high second quarter rate in 1979 cannot be attributable to TMI.

4. If Harrisburg (a large majority of population actually reside beyond the 10-mile ring) is excluded from the 10-mile radius, the infant mortality rate becomes much lower; this is primarily because of the large nonwhite population in Harrisburg, contributing to a higher average infant mortality rate.

5. If the TMI accident had a significant impact upon infant mortality, those infants born during the fourth quarter of 1979 (exposure in early period of gestation) would have had a greater risk of death. Our data do not support such speculation. In fact, the fourth quarter rate was lower for 1979 than for 1978 or 1977.

When all these observations are considered together, it cannot be concluded that the TMI accident has caused a higher infant mortality in the area.

I might also mention that our careful analysis of the available data indicates no relationship between the incidence of congenital hypothyroidism and the TMI accident.

I trust these remarks are useful for your purpose.

Sincerely,

George Tokuhata

George K. Tokuhata, Dr.P.H., Ph.D.
Director
Division of Epidemiological Research

GKT:h
cc: Mr. Lindeberg
Mr. Ireland
Dr. Gens
Dr. Reid

Questions Remain On Health Effects of Pa. Nuclear Accident

By Cristine Russell
Washington Star Staff Writer

When Dr. Gordon K. MacLeod left his post at the University of Pittsburgh recently to become Pennsylvania's secretary of health he hardly expected to be confronted with a major nuclear accident.

Once he was, he quickly found that the events at Three Mile Island forced him and other officials, including Gov. Richard Thornburgh, to do a difficult balancing act as they sought to protect public health without causing panic.

Decisions had to be made on whether to evacuate the area around the damaged plant, whether to administer a medication to protect against thyroid cancer, and what to tell the public about the health dangers.

GIVEN REPORTS of low-level but constant radioactive emissions from the plant, the state advised pregnant women and pre-school children to stay out of the five-mile radius of the accident. Evacuation orders were put in readiness but never triggered.

"We had to be careful not to alarm people overly," MacLeod recalled in an interview. "To have done more could possibly have been unproductive. If everyone had been ordered to leave it could have caused sheer havoc and panic.

"The recommendation for pregnant women and children was made as an excess of caution since we know that fetuses and young children are potentially more sensitive to low levels of exposure," he added.

Federal health officials appear to have agreed in general with the state actions, although the state did reject advice from the Department of Health, Education and Welfare that a drug called potassium iodide should be made available to workers and people living in the vicinity of the plant. It is intended to protect against thyroid cancer should radioactive iodine levels increase sharply.

Outside critics are also concerned not only that the radioactive emissions may have been higher than reported but that the public has been lulled into thinking that the situation at Three Mile Island is safer than it is.

At a press conference yesterday the Environmental Policy Center and several Washington-based anti-nuclear and environmental groups charged that there has been a "nuclear whitewash" of the health risks.

LAST WEEK at a Senate health subcommittee hearing, HEW experts predicted that, based on exposure information available to date, there would not be a single additional cancer in the general public due to the radiation released from the damaged plant.

But since that time low-level radiation has continued to be released, and the latest estimates from a team of federal experts are slightly higher for the total radiation exposure to the population in a 50-mile radius of the plant. But sources indicated yesterday the government's overall estimate of minimal long-term risk to the general public in the area of the plant remains the same.

Questions have been raised, however, about the fragmentary and sometimes conflicting information available to date on the actual exposure levels. And the risk estimates of low-level radiation exposure are themselves controversial.

John Villforth, the head of HEW's Bureau of Radiological Health, said yesterday that the federal team following the health consequences of the accident was taking these concerns into account and would adjust the risk estimates accordingly. But he did not feel that additional calculations now under way would "significantly" change the estimates already made.

MOST OF THE recorded emissions into the air have been radioactive gases such as xenon. In addition, low levels of radioactive iodine have been detected in milk samples in Pennsylvania in the past week. Health officials there continue to say that the levels picked up are so small that there is no concern about drinking milk.

And on Friday President Carter even felt it necessary to issue a statement from the White House saying federal officials have found "absolutely no danger" from food produced in the area of the crippled plant.

While the present and future health danger from the nuclear accident has largely been minimized by those in charge, even the officials involved feel that it would be foolish to be overly confident about the long-range health consequences.

Pennsylvania Health Secretary MacLeod personally feels that the "most important health effect is the stress of having lived through 10 days of tension, apprehension, and reports of a somewhat confusing nature at times."

In the meantime, given the events of the past week, few will feel reassured by the language in a promotional booklet put out before the accident by Metropolitan Edison, the utility responsible for operating the Three Mile Island plant.

It ends with "a word about safety . . . The record speaks for itself. The nuclear industry has logged millions of hours in operation. In all that time, there has been no instance of radiation injury to any workers in the commercial nuclear generating stations. There is also no evidence of radiation damage to plants, wildlife or people in the environs of a station."

August 28, 1979

Pittsburgh Post-Gazette

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If There Were Another TMI

Five months after the Three Mile Island nuclear incident, the state still does not have a cohesive plan for coping with such emergencies.

The Thornburgh administration admittedly has had its hands full since then; administration officials from the governor on down have had to devote a good deal of their time to testifying at various state and federal hearings on the March 28 accident. But it is still distressing, on the anniversary today of that event, to find not only that no comprehensive plan has been fashioned but also that administration officials seem to be unsure of just what their respective departments' roles should be in such emergencies.

After a hearing held last week by the state House of Representatives panel probing the affair, Rep. Ivan Itkin of Pittsburgh commented: "If an emergency was declared today, we'd have pandemonium."

Civil Defense agency plans, for example, call for all evacuation traffic to move in the same direction along four-lane highways. But State Police Commissioner Daniel Dunn told the committee he doubted that would be possible.

The Education Department's bureau of management services was asked by the committee who makes the decisions about closing and opening schools during a crisis. A spokesman said, "We do not have a required closing and opening plan."

A Civil Defense 20-mile evacuation plan calls for parents to stay away from schools and let their children be bused home. But another section of the same plan designates schools as pick-up points for people to gather for evacuations.

Penrose Hallowell, secretary of agriculture, was asked what he would tell farmers to do about their animals. "I can't answer that now," he replied.

Perhaps the most startling gap of all concerns the National Guard. Adjutant General Richard Scott told the House committee that many guardsmen could not be reached during the TMI incident to go on alert status for possible mass evacuation duty because they were moving their own families out of the area.

General Scott also told the House committee that the Guard has no protective clothing or adequate equipment to detect low-level radiation. In fact, Scott recently sent out a memorandum to his men: "You can assure your wives and families that the adjutant general of Pennsylvania will not, I repeat, will not assign Pennsylvania National Guard personnel to missions, or in areas, where the possibility exists that they might be exposed to dangerous levels of radiation or fallout."

That raises the question of just who in case of another nuclear accident would handle the emergency duties which are the Guard's peacetime reason for existence. In fact, that question was posed to Gov. Thornburgh when he appeared in Washington before President Carter's TMI investigatory commission.

Alluding to General Scott's memorandum, commission member Anne Trunk of Middletown, Pa., asked, "How far away would the National Guard be in the case of a more serious accident?" It turned out that Mr. Thornburgh was unaware of General Scott's report and couldn't answer the query.

All of this suggests that the administration should be pressing ahead with a comprehensive plan. At the least, the governor — who has held only two cabinet meetings since taking office in January — should call his department heads together to get a few common understandings.

Pennsylvanians can hope that there never will be an emergency requiring such a magnitude of response. But then that's what everyone thought before that Abbott-and-Costello affair at TMI last March.

last March

Eight Months Lost

Pgh Post Gazette 11/24/79

It's enough to make a psychologist weep — and a lot of other people, too.

The state is finally launching a study of the inhabitants of the area around Three Mile Island to assess the effects on their mental health of the March 28 nuclear accident there. The work will be done under the aegis of the state Department of Public Welfare with a federal contract of $375,000 from the National Institute of Mental Health.

Given the obvious usefulness of such a survey, it is all but incredible that it has taken eight months to get it launched. Public officials can't say they haven't been warned. In the aftermath of the accident, then-Secretary of Health Gordon MacLeod urged that a survey be launched immediately, while the events still were in the minds of residents. But the matter got tangled in jurisdictional disputes between federal and state authorities over who should conduct the survey and how and who should pay for it.

On May 4, in an editorial entitled "Five Weeks Lost?", this newspaper noted: "Time is especially of the essence in obtaining and recording information about the psychological effects of the Three Mile Island incident. Experiments have shown that as early as three weeks after hospitalization, some patients begin to be hazy about details of their stay in the hospital and their treatment there. For many the Three Mile Island accident and the uncertainty for four days thereafter made for a traumatic experience — all the more reason for early interviewing before memories fade or begin to distort what actually happened."

So what happens? Not five weeks but eight months have been lost.

It's hardly reassuring to have state Welfare Secretary Helen O'Bannon explain that "coming eight months after the Three Mile Island accident, at a time when the initial trauma has subsided, this study will be particularly valuable because it will examine mental health impacts from a long-range viewpoint."

Actually, questions should be raised as to why the grant was made to the Department of Public Welfare, rather than to the Department of Health. Presumably it was because mental health responsibilities in Pennsylvania lie with the DPW. But if this isn't a health matter, what is?

Fortunately, the study has been devised and will be directed by someone in the psychiatric field — Dr. Evelyn J. Brommett, an assistant professor of psychiatry and epidemiology at Western Psychiatric Institute and Clinic at the University of Pittsburgh. Dr. Brommett has hired 30 interviewers who will interview 700 persons living within 10 miles of Three Mile Island and another comparison group of 350 persons who live within 10 miles of the Shippingport reactor in Beaver County.

Dr. Brommett and her interviewers ought to be wished the best of success. But it is a tragic disservice to science that a one-time-only opportunity for immediate study of people caught in America's first such nuclear fiasco was missed — and by eight long months.

JAN 26, 1980

FROM CLEVELAND PLAIN DEALER

Nuclear accident precaution progress called nil

CINCINNATI (AP) — Preparations to deal with nuclear accidents are no better in the United States now than last March 28 when the Three Mile Island accident occurred, according to Pennsylvania's secretary of health at the time.

"And I do think we'll have nuclear accidents in the future," Dr. Gordon K. MacLeod told a seminar yesterday at the University of Cincinnati.

MacLeod resigned in a dispute over the handling of Pennsylvania's health services seven months after the accident. He is now a professor of medicine and health services administration at the University of Pittsburgh.

MacLeod criticized both federal and state governments for not providing stockpiles of potassium iodide, which he called an antidote for the accumulation of radioactive iodine in thyroid glands. The absorbtion of large amounts of radioactive iodine can lead to thyroid disease, he said.

The U.S. Department of Health, Education and Welfare ignored Pennsylvania's requests for the chemical for two years before the accident, McLeod said.

When the chemicals finally were sent — after the accident — the dosages were short and the equipment to administer them was wrong, he said, adding:

"Sadder yet to say, we still don't have a supply of potassium iodide in Pennsylvania or elsewhere in the country to be used in the event of another nuclear accident."

The General Services Administration gave HEW responsibility for planning such a stockpile, but the agency has not done that yet, MacLeod said.

"If the federal government is not ready to come forth with financial support for stockpiling potassium iodide, then we must find resources elsewhere, either from the utilities themselves or from state legislatures," he said.

★★★

Medical checks asked for people near 3 Mile Island

HARRISBURG, Pa. (AP) — A federal magistrate recommended yesterday that U.S. District Court consider a claim for medical detection services sought by people living near the Three Mile Island nuclear plant.

The claim for monetary damages, part of a class action suit filed on behalf of 650,000 people, seeks a screening for cancer and other injuries because of radiation exposure.

At the same time, the magistrate recommended that the federal court not certify class action claims seeking damages for negligent infliction of mental stress, present physical injuries and latent physical injuries.

Defendants named in the suit are General Public Utilities Corp., the plant's owner; Metropolitan Edison Co., the plant's operator; and Babcock and Wilcox Co., the plant's designer.

Magistrate John Havas pointed out that many area residents fear they were harmed by radioactive gases which leaked from the plant following the March 28 accident.

"The unknown but menacing qualities of radiation require the court to address the concerns which form the basis of these fears," Havas wrote in his report.

Any party involved has 20 days to file objections to Havas' report. The court must then decide whether to accept his recommendations.

Former Pennsylvania health secretary gives warning

MacLeod says US not prepared for nuclear accidents

By Deborah Taylor
NR Staff

"My main concern with respect to the public health aspect of nuclear energy is that we be prepared the next time we have a nuclear accident, and I do think we will have a nuclear accident in the future," said Gordon MacLeod, former Pennsylvania secretary of health, at a discussion held Thursday in the Environmental Research Center Auditorium.

The discussion sponsored by the Environmental Protection Agency and UC, used the Three Mile Island incident to exemplify the lack of public health preparedness in the event of another nuclear accident.

MacLeod, who received his medical degree from UC in 1960 and is now a professor at the University of Pittsburgh, became secretary of health in Pennsylvania 12 days before the accident at Three Mile Island (TMI). He resigned seven months later in a controversy over the health effects of that accident.

"I know of no nuclear plant in the country that would really be ready for the next nuclear accident."

According to MacLeod, TMI pointed out the deficiencies in Pennsylvania's department of health.

"Political, not professional decisions had carved up Pennsylvania's Department of Health," said MacLeod, who said there was not a single book on radiation medicine in the health department.

"In short, there was little or no capacity within the Department of Health, nor elsewhere in the state, to deal with the extraordinarily serious health problems facing us," said MacLeod.

When asked if he felt that the Pennsylvania health department was typical of other state health departments, he said, "My presumption is that some of these problems exist in other state health departments." MacLeod said he believes that if problems like this are not faced now we will be in no better position to deal with the health impacts of future nuclear accidents than Pennsylvania was to deal with those related to TMI.

"It seemed that no one outside of professional health circles could appreciate the potential for the health hazards of the TMI accident unless they saw people being carried off to hospitals vomiting from radiation sickness. There was no blast. No meltdown. So there was no health hazard," said MacLeod, "that's the attitude that seemed to reign among nuclear engineers and radiation health physicists throughout the accident."

While the departure of pregnant women and young children, both particularly susceptible to radioactive iodine, one of the most abundant of the fission products, was recommended by MacLeod almost immediately after the accident, the governor did not issue this directive until a day later because of a dispute between radiation health physicists, said MacLeod.

MacLeod raised the following questions to his audience: "What happens in the event of those future nuclear accidents?," and "how do we protect the public's health?" Short of immediate cessation of all nuclear activity which I think is well-nigh impossible, the nation must be prepared not to repeat the mistakes of TMI," said MacLeod.

"For the present time," he continued, "I know of no nuclear plant in the country that would really be ready for the next nuclear accident." MacLeod called for a self-examination by the officials in charge of the Nuclear Regulatory Commission, saying they were "going to have to ask themselves what is their function in the future, and I think the American public is going to force them to answer this."

"Short of immediate cessation of all nuclear activity...the nation must be prepared not to repeat the mistakes of Three Mile Island."

In the meantime, MacLeod called for the implementation of a number of safety measures, including understanding by the medical community of how to manage the physical and psychological consequences of an accident; a better informed public as to what it means to have an accident, preparation of potassium iodide for deployment and distribution around nuclear reactors; research for antidotes and clinical management against other fissionable products besides iodine; and the redesigning of hospitals as fallout shelters for treatment of patients with radioactive exposure.

"Unless we do address these problems, and address them now, we may well find our health to have deteriorated 10 or 20 years hence pondering the same puzzles that are confronting us here today," said MacLeod.

A-Plant Involved in Probe of Thyroid Ills

incorrect; compare with 4/8/79 Star in Wash. Star.

By Victor Cohn
Washington Post Staff Writer

A new controversy over the nuclear accident at Three Mike Island appears likely to arise from the discovery that an abnormal number of children were born with serious thyroid defects in three Pennsylvania counties in the latter part of last year.

The condition is known as hypothyroidism, which arises when the thyroid gland is either absent or doesn't produce normal hormone levels. It can lead to grave mental retardation and stunted growth unless it is quickly treated.

State health officials confirmed yesterday that during the last nine months of 1979, 13 hypothyroid babies were born in three counties that might ordinarily expect three such births during that length of time. They said they are about to start an epidemiological investigation that "of course" will have to consider low-level radiation from the accident at Three Mile Island—located adjacent to one of the countise—as one possible cause.

But they—as well as Dr. Thomas Foley of Pittsburgh Children's Hospital, an authority on hypothyroidsm—all said that the conditions could have many possible causes.

They said they know of no cases of hypothyroidism ever caused by radiation at the low level emitted by the crippled reactor, though there is a well-established association between high doses of radioactive iodine—one chemical emitted by the disabled reactor—and thyroid disease. Radioactive iodine tends to concentrate in the thyroid gland, with destructive effects when the dose is high enough.

Radiation specialists from the President's Commission on Three Mile Island and the Nuclear Regulatory Commission said flatly yesterday that iodine emissions from the March accident were far too low to have had any such effect.

"There cannot be any connection: I can say that unequivocally," said Dr. Victor P. Bond, associate director of the Brookhaven National Laboratories for biomedical and environmental sciences, a member of the presidential commission task force on radiation health effects. "For thyroid effects the doses would have to have been thousands of times higher than they were."

Harold Peterson of the NRC's office of standards said a total of 15 curies of Iodine 131 was released from the plant by the end of April, giving a maximum radiation dose of the thyroids of area residents of 8 to 20 millirems.

Background radiation provides 100 millirem per year. Tests of area residents revealed no iodine in their bodies, and none was detected in area animals or in cows' milk, Bond said. To affect fetuses born since the accident would have required a pickup of iodine.

"We would certainly not expect any effect on fetal thyroids from these levels," Peterson said.

A spokesman for General Public Utilities Inc., parent company of the utility that owns Three Mile Island, said no iodine measurements taken were ever high enough to cause fetal thyroid problems.

However, several local groups have challenged the official radiation readings, alleging that insufficient monitors were in place or operating at the time of the accident. Wind currents might have carried radioactive particles over nearby monitors and deposited them in faraway areas without the normal dispersal effect, these groups have said.

None of the hypothyroid cases were in areas that have been described as in the main "plume" or downwind direction of the Three Mile Island radiation.

Six cases occurred in Lancaster County, which is east of Dauphin County, the reactor site. Four were in Bucks County and three in Lehigh County.

Ordinarily one baby in 5,000 is born with hypothyroidism. In 1978 (the last year for which full birth statistics were available yesterday) Lancaster County had 5,500 live births, Bucks County, 6,493, and Lehigh, 3,206.

Unusual clusters, mere statistical aberrations, sometimes occur in many diseases, said Dr. Arnold Muller, secretary of health in Harrisburg.

Also, said both Dr. Foley and Dr. Evelyn Bodin, a Pennsylvania health department pediatrician, a more logical explanation than radiation has been found in three and possibly four of the Lancaster County cases, the group most closely studied so far.

One had a familial or inherited condition and two had a misplaced thyroid gland, a condition not likely to be caused by radiation, Bodin said. The three other Lancaster County cases are still under study, but one was a twin whose twin did not get the disease "so it's untlikely" though not impossible, she said, that the cause in this case was environmental, since both babies were subjected to the same environment.

Another health authority said that many populations, such as the Amish, in Pennsylvania have a high concentration of genetically related diseases.

"I don't think there's any cause and effect" connected to Three Mile Island, Bodin said. Dr. Foley agreed, but called the timing "peculiar and curious," and said "the fact that it did follow the accident raises an issue" that must be settled.

The cases' existence was disclosed in an interview yesterday by Dr. Gordon MacLeod, who was Pennsylvania health secretary at the time of the nuclear accident.

MacLeod became the state's chief health officer on March 16, only 12 days before the accident. Last Oct. 10, he said—after criticizing the state's handling of the problem—that he was asked by Gov. Richard Thornburgh to resign. He returned to his job as a well-regarded professor of public health administration at the University of Pittsburgh.

MacLeod, too, agreed that "it is impossible" to assign any common cause to for the thyroid defects. But he said he was shocked that the health department had made no public announcement and had not started an investigation of possible causes. The first of the affected Lancaster County babies was born last June. Two were born in July, and one each in August, October and November.

MacLeod also said it is "urgent" to look for any possibly undetected cases in babies born at home among the Amish and other Pennsylvanians who often choose home deliveries.

Thyroid problems turned up among Marshall Islanders who were exposed to radiation from the fallout of a U.S. hydrogen bomb test in the Pacific on March 1, 1954.

The first cases discovered nine years later were two children, under 5 at the time of exposure, whose thyroid glands had disappeared.

Staff writers Walter Pincus and Joanne Omang contributed to this report.

B-10 Pittsburgh Press, Thurs., Feb. 21, 1980

Thyroid Illness In TMI Area Under Study

HARRISBURG (UPI) — Medical detectives are investigating the possibility — believed now to be remote — that an apparent growth in the rate of thyroid abnormalities was caused by the Three Mile Island nuclear accident.

The Pennsylvania Health Department said it had begun the investigation after a routine survey showed the incidence of hypothyroidism was five times greater in some areas near the nuclear plant.

Initial judgments by a variety of thyroid experts was that the Three Mile Island accident probably did not cause the occurrences because the radioactive emissions during the accident were too small to do such damage.

Other possible causes, such as heredity, industrial or medical radiation sources and chemicals in foodstuffs, were also under investigation by state epidemiologists, said Dr. George Tokunata, director of state health research.

"There is a remote possibility that radiation was the cause, and there are many other possible reasons. We don't have enough evidence to make any conclusions, except to say the rate (of hypothyroidism) is apparently higher than normal in this area," said Tokunata.

The remote possibility of a connection to Three Mile Island rested with cows that grazed on contaminated pastures. State authorities reported a radioactive iodine level of 41 picocuries per liter in milk from a nearby farm a few days after the nuclear accident. The federal health limit is 1,000 picocuries per liter.

Hypothyroidism is a disorder which can lead to mental retardation. It can be caused by radioactive iodine.

Dr. Thomas Foley of Children's Hospital in Pittsburgh, who monitors hypothyroidism as a consultant to the state, said he did not believe the latest occurrences were related to Three Mile Island.

He explained that some of the cases were differing types of hypothyroidism, indicating that a single environmental source such as nuclear radiation was not the cause.

The routine state survey revealed that the hypothyroidism rate in Lancaster County, adjoining the nuclear plant, was five times greater than normal. Five counties downwind from the nuclear plant also showed higher-than-normal rates.

State and Nation

CITIZENS' VOICE, WILKES-BARRE, PA., FRIDAY, FEBRUARY 22, 1980

Lag in Thyroid Probe Sharply Criticized

HARRISBURG (UPI) — Dr. Gordon MacLeod, the former state health secretary, Thursday criticized the Thornburgh administration because it delayed for three months in investigating a possible link of a thyroid disease to Three Mile Island.

Health Department officials acknowledged the three month lag at a news conference. A cluster of hypothyroidism cases in newborn babies near Three Mile Island were first discovered in October, but a medical investigation was not begun until this month.

Dr. Evelyn Boudin, the state's director of parent, child and school health, said the department delayed because it placed greater priority in dealing with the cases it had discovered. Health Secretary Arnold Muller was unavailable for comment.

State health officials, as well as nationally recognized thyroidologists, believe there is only a remote possibility of a link between the hypothyroidism and the releases of radioactive iodine in the Three Mile Island nuclear accident March 28, 1979.

"I am profoundly concerned about the fact that information was not made public until now," said MacLeod, a professor of health services at the University of Pittsburgh. "You should investigate as soon as you know about the clustering."

MacLeod said he agreed the chance of a link to the nuclear accident was not great, but was dismayed by the delay in probing to find other possible cases in the newborn population because it can be essentially cured if diagnosed early in life.

Hypothyroidism, which can be caused by radioactive iodine, is a disorder that can lead to mental retardation.

Other causes of hypothyroidism, such as industrial and medical radiation, food and heredity, were also being investigated by the Health Department's probe, slated to take two years.

The department first reported the cases Wednesday. It said there had been a total of 34 cases in the state, but that Lancaster County near Three Mile Island had reported seven cases, over five times the average of 1 in 5,000 live births.

Through a state Health Department program, virtually all newborn babies are screened for hypothyroidism. But MacLeod said the clustering of cases made it clear those who were not tested should have been sought out immediately for screening.

Health officials said attempts were being made to screen those not tested routinely by hospitals, such as babies born in homes or to parents who objected to the tests on religious grounds. The number of children involved was apparently no more than a few hundred.

MacLeod said the Health Department's delay was evidence the Thornburgh administration did not place emphasis on health-related effects of the Three Mile Island nuclear accident.

He criticized the administration for not establishing a radiation health bureau under the Health Department because "it must be sensitive" to such things as an increase in hypothyroidism cases.

POST-GAZETTE: Tues., Feb. 26, 1980—5

Don't Snub TMI-Thyroid Tie, Pitt's MacLeod Urges

By HENRY W. PIERCE
Post-Gazette Staff Writer

Former state Health Secretary Gordon MacLeod yesterday warned against a too-hasty dismissal of figures that may show an increase in thyroid defects among babies born near the Three Mile Island nuclear plant after the radiation leak March 28.

MacLeod, who said he reviewed the thyroid figures in detail for the first time yesterday, insisted that coincidence alone can't account for an apparent upsurge in cases in Lancaster, Lehigh, Berks and Bucks counties after March 28. All are relatively near the site of the Three Mile Island radiation leak.

"There's always a possibility some other factor, such as industrial toxins or contamination of the water, could account for it," he conceded.

But he pointed to these figures:

- Eight cases were reported statewide before March 28, and 26 more were reported during the remaining months of 1979.
- Of the 26 cases, 15 were in counties not far from Three Mile Island. Lancaster reported 6 cases, and 3 each were reported in Lehigh, Berks and Bucks Counties.
- By contrast, Allegheny and Erie counties reported only 1 case each after March 28.
- During the last six months of 1978, only 9 cases were reported throughout the state.

But a state health official, Dr. Evelyn Boudin, called MacLeod's interpretation "illogical" and stated flatly:

"We do not have a data base which is sufficient to make the kinds of claims being made."

Dr. Boudin pointed to an absence of thyroid defects from Cumberland and York counties, which also are near Three Mile Island, and in Montgomery County, farther east.

Dr. Boudin said, however, that state health officials are reviewing the data "the way we would in any public health program."

At least some cases appear to be a result of inheritance, she said.

It is known that radioactive Iodine 131, which was among the most feared of the substances released during the Three Mile Island incident, can cause thyroid abnormalities in babies.

What is not known is precisely how much of an increase it takes to cause damage. Studies have been carried out that suggest even a very small increase in the exposure levels will add slightly to the number of thyroid cases in a large population. But some authorities consider such figures inconclusive.

Dr. Donald Reid, deputy secretary of programs for the state Health Department, and Dr. George Tokuhata, Health Department epidemiologist, minimized any association between Three Mile Island and the thyroid defects last week.

Tokuhata said there was only a remo[illegible] possibility the defects were related to t[illegible] radiation leaks.

MacLeod resigned as health secretary O[illegible] 12 and returned to his job as professor [illegible] public health administration at the Universi[illegible] of Pittsburgh. Since resigning he has been [illegible] strong critic of the state's handling of t[illegible] health aspects of the Three Mile Island affai[illegible]

HEALTH CRUSADER FORCES A PROBE INTO BIRTH DEFECTS AFTER NUCLEAR ACCIDENT

By LESLIE KANE

A LONE health crusader has won his battle for an investigation into the possibility that the Three Mile Island nuclear accident is responsible for an alarming rise in babies born with serious thyroid defects, which can lead to mental retardation.

Dr. Gordon McLeod, former Pennsylvania secretary of health, has been told that state officials have begun what is expected to be a two-year probe to find the cause of the defects.

He claims health department officials became aware of the cluster birth defects after he resigned last October, but mysteriously had kept the information from the public.

Dr. McLeod, now professor of public health administration at the University of Pittsburgh, said the number of babies born with thyroid defects from two to eight months after last March's accident was astounding.

Thirteen babies born in five counties near the nuclear plant were suffering from hypothyroidism, a condition in which the thyroid gland is missing or produces too little hormone.

Normally, only three babies would have been born in those areas with such a condition during that time, Dr. McLeod claimed.

He said previous tests had shown that radioactive iodine can cause hypothyroidism, which can lead to both grave mental retardation and stunted growth.

Dr. McLeod believes public awareness of the dangers of the defect is important, especially because many of Pennsylvania's estimated 140,000 members of the Amish religious sect favor home births.

This could reduce chances of the defect being found before it causes permanent damage, he pointed out.

"It is a correctable disease if found early," Dr. McLeod said. "After the child has been treated for two years, the negative effects can be prevented."

While he stressed that his resignation as secretary of health was unrelated to the thyroid issue, Dr. McLeod said he became frustrated and angry when he found that state officials were withholding information about the birth defects.

"I can't imagine why the Health Department did not investigate the cases. I asked it to release the information and it did not do so.

"I told them I was profoundly dismayed people did not have this information."

Dr. McLeod described as a matter of luck the fact that the birth defect cluster was discovered.

Pennsylvania has conducted a routine screening program for hypothyroidism since 1978.

After the Three Mile Island accident, the screening revealed there were seven cases alone in Lancaster and Lebanon counties, the two countries directly downwind of the nuclear facility, Dr. McLeod said.

"Basically, the major concern is that maybe 1 percent of babies born at home have this condition and their parents aren't aware of it," he added.

"We would want to find these other newborns as soon as possible and run tests on them."

The professor explained that radioactive iodine fell from the sky onto the grass eaten by cows and got into the cow's milk.

The milk is subsequently drunk by the pregnant mother and circulated to the fetus, which concentrates iodine at 10 times the rate of an adult.

Some health authorities argue that the level of radiation released by the Three Mile Island accident was too low to cause the thyroid defects.

Dr. Victor P. Bond, associate director of the Brookhaven National Laboratories, Upton, N.Y., and a member of the presidential commission task force on radiation health effects, said: "For thyroid effects, the doses would have to have been thousands of times higher than they were."

He added that tests revealed no iodine in bodies of residents living near Three Mile Island and none in animals or cow's milk.

Dr. Thomas Foley of Pittsburgh Children Hospital, an authority of hypothyroidism, said at least four of the Pennsylvania cases were probably unrelated to radiation, but admitted an investigation was needed.

"The fact that the outbreak did follow the accident raises an issue that must be settled," he said.

Baby death rate rose after TMI, state discloses

By Vernon Loeb
Inquirer Harrisburg Bureau

HARRISBURG — The State Health Department has reported a significant increase in infant deaths near the Three Mile Island nuclear plant and is investigating whether there is any relation between the deaths and the nation's worst nuclear accident there.

The Three Mile Island (TMI) accident began March 28 last year, and Monday the department released figures showing that 31 infants died within 10 miles of the plant from April 1 to Sept 30. In the same six-month period of 1978, there were 14 infant deaths, and there were 20 in the same period in 1977, the department said.

Health officials also found that within five miles of the plant seven infants died during that six-month period last year, compared with one such death in 1978 and three in 1977.

On the other hand, the department found that the number of stillborn infants decreased from four during the six months in 1977 and six in 1978 to three last year.

State health officials said they hoped to finish an analysis this week that might tell them what, if any, the relationship between the accident and the increased infant death rate might be and what role might have been played by psychological stress during pregnancy and the release of low-level radiation from the nuclear plant.

"There are any number of ways that a child could have died that would have no relation to Three Mile Island," a Health Department official said. "Statistically, those figures aren't worth anything."

State officials have not disclosed the cause of any of the infants' deaths. Because it is just possible that the deaths are related to the accident, the official said, "everything is being triple-checked."

The data on increased infant mortality around TMI is reminiscent of the department's disclosure that a higher than normal incidence of hypothyroidism — a birth defect that can lead to mental retardation — was found last year in Lancaster County, downwind from the nuclear plant.

Hypothyroidism, a disorder in the thyroid gland, can be caused by the kind of radioactive iodine released during the nuclear accident. Health officials, however, said they do not believe that the increase in hypothyroidism was related to the accident.

"I personally don't think we're on to anything conclusive," said Dr. Gordon K. MacLeod, health secretary during the TMI accident, referring to the increased incidences of infant mortality and hypothyroidism near the plant. MacLeod, a professor of health-services administration at the University of Pittsburgh, said that "enough information continues to trickle in to raise the fundamental question" about whether the state is doing enough to examine the health effects of the accident.

An outspoken critic of government's response at all levels to the health questions raised by the accident, MacLeod was dismissed by Gov. Thornburgh last fall, and he has said he believes his dismissal was caused by his statements.

"The whole emphasis both locally and nationally has been to downplay the health concerns of this accident," MacLeod said.

LONG DISTRESS FOUND OVER ATOM ACCIDENT

Persistence of Anxiety Surprises Expert in Study of Residents Near Three Mile Island

By BEN A. FRANKLIN
Special to The New York Times

HARRISBURG, [illegible] April 17 — The State Health Department today released the results of a psychological study disclosing what its author called a "surprising" persistence of anxiety among a large part of the population near the disabled Three Mile Island nuclear reactor.

"What began as a brief crisis has become a continuous and, for some, a chronically disturbing situation," the 55-page report said.

The study said that the health effects of this "distress" included increases of 113 percent in the number of persons using sleeping pills and 88 percent in those using tranquilizers. Also, 14 percent used more alcohol and 32 percent smoked more cigarettes, it said.

The study director, Peter S. Houts, a behavioral scientist at the nearby Hershey Medical Center of Pennsylvania State University, told a news conference that another finding of the survey's telephone interviews was that nearly 13 percent of the 37,000 people living within a five-mile radius of Three Mile Island had become antinuclear activists.

The State Secretary of Health, Dr. H. Arnold Muller, said that this kind of "emotional involvement" reported in the survey dropped to 3 percent among people 15 miles from the reactor and to less than 1 percent beyond 25 miles. He called the 13 percent figure in the group closest to the plant "very large" and "very significant."

Majority Oppose Reactivation

In the five-mile radius of what Dr. Muller called "this radioactive citadel," the report said that, based on interviews conducted in January, 60 percent did not approve of reactivating the plant and 54 percent said they would "evacuate immediately" in another nuclear crisis.

The survey, financed in part by a $52,000 grant from the electric utility industry, involved two waves of telephoned interviews, the first last July and a second in January. The Three Mile Island accident and the weeks of tension that followed it began on March 28, 1979.

"I was very surprised to see that the distress of these people had lasted into July," Mr. Houts said today. "In January, I was even more surprised."

Twenty percent of the respondents who live within 10 miles of the plant reported in January that the accident had "disrupted their lives during the previous nine months." The figure was 10 percent for those living within 15 miles. Based on these percentages, the survey suggested that as many as 40,000 people had experienced some form of stress reaction.

"The distress, as we define it, has persisted nine months, out to a distance of 15 miles," Mr. Houts said.

'Psychosomatic Effects'

Among the 1,000 persons questioned in the latest survey last January, the report said that, when asked about "physical symptoms of stress," nearly half said they had experienced one or more of what Mr. Houts today called "psychosomatic effects" — headache, for example, or diarrhea, loss of appetite, sweating or rash.

"These are not at all symptoms that would cause them to be referred for psychiatric care," he said.

Both the President's commission on the Three Mile Island accident and a similar panel appointed by Gov. Dick Thornburgh concluded months ago that health effects related to radiation were expected to be barely measurable but that mental health effects were likely to be the lasting public impact here.

THE NEW YORK TIMES, Friday, April 18, 1980

Nuclear Fabulists

Those scare stories about radiation damage from the accident at Three Mile Island look increasingly far-fetched. Federal officials have said all along that little radiation escaped, posing virtually no threat to public health. Their judgment has been supported by all major investigations of the accident. But rumors of frightening physical damage to human and animal infants persist.

None of these allegations have held up under careful scrutiny by disinterested authorities. The only real health damage detected so far has been psychological. For example, a report made public yesterday says that many of the community's residents remained distressed for months and resorted to sedatives and alcohol for relief. Their anxiety could only have been heightened by the "experts" and critics who have issued alarming statements about radiation hazards based on scant or distorted data.

The most worrisome charge has been that radiation from the crippled reactor has already caused an increase in infant mortality and thyroid defects in newborn babies. Those fears were effectively laid to rest by state and Federal health investigators, as reported in The Times by Jane Brody. The concern about infant mortality was based largely on raw statistics showing an increase in the number of infant deaths within a ten-mile radius of the reactor after the accident. But those numbers in themselves are meaningless; there was also an increase in the total number of births. The *rate* of infant deaths remained normal.

Similarly, the concern over thyroid disease was based on unevaluated statistics showing, in three counties, a possibly abnormal number of children born with thyroid defects. But on investigation, most of these cases were attributed to hereditary defects or other circumstances predating the nuclear accident. Four counties equally close to the reactor, or closer, had no such cases at all.

Reports of bizarre deformities among farm animals and wildlife have also been circulating. Worried farmers and at least one veterinarian have described animals born with legs or eyes missing, stillbirths, spontaneous abortions, defective bone structures and strange sudden deaths. Many blame the reactor. But the Pennsylvania Department of Agriculture investigated 100 farms within five miles of the reactor last May and found only five with any unusual problems among the livestock. These were attributed to viral infections or to feed and poor nutrition; there was no evidence of radiation damage.

Several long-term studies are still under way. But for now the public can draw considerable reassurance from these negative findings. It is not only apologists for the nuclear industry who say that radiation damage has been negligible; so do health officials whose main concern is the public's safety, and agriculture officials whose mission is protecting farmers and livestock.

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What is not at all reassuring is the behavior of "experts" who have inflamed public fears by dealing recklessly with statistics. Dr. Gordon MacLeod, who was Pennsylvania's Secretary of Health at the time of the accident but was later forced to resign by the Governor, irresponsibly publicized some of the raw data suggesting the existence of health problems. And Dr. Ernest Sternglass, a perennial campaigner against nuclear power, is accused by neutral health authorities of mishandling data to demonstrate health damage. Even in nuclear fables there are people who cry wolf.

Editorial

From the BULLETIN of the Allegheny County Medical Society, April 26, 1980, Vol 69, No. 8

Health decisions in the nuclear age

Technocrats, not health professionals, made most health decisions during the nuclear reactor accident beginning March 28, 1979, at Three Mile Island (TMI) — a sad commentary for the medical profession renowned for preventing disease, healing the sick, and restoring good health.

There was and still is no radiation health unit in the Pennsylvania Department of Health. A radiation protection unit — technical in nature — is located in the Department of Environmental Resources. It didn't and still doesn't employ a single physician. The Nuclear Regulatory Commission so disregards health preparedness for nuclear reactor accidents that it also doesn't employ any physicians, let alone specialists, in radiation medicine.

As then Secretary of Health, I recommended and eventually urged in the strongest possible terms that pregnant women and young children leave an area within five miles of the Three Mile Island plant. But — the Commonwealth's radiation physicists and nuclear engineers, ignoring the health consequences of psychological stress, did not agree with this decision. Like so many other technicians responsible for monitoring the adverse effects of technology, they thrust themselves into the position of making medical judgments. Non-medical judgment was accepted in this matter, which indeed should have been decided on no other basis than the public's health. Finally, it took the endorsement of the Nuclear Regulatory Commission's chairman, Joseph Hendrie, a nuclear engineer himself, for the directive to be issued for pregnant women and young children to leave the area. If his wife were pregnant, he said, he would recommend that she leave the area.

Isn't that interesting. A physician warns of potential health impacts of radiation and the warning goes unheeded. An engineer supports the warning and it is accepted. Again, a technocrat makes a medical decision without regard for the public's health. There is obviously a need for both nuclear engineers and physicians to be involved in handling nuclear accidents — nuclear engineers should work with the nuclear hardware — physicians should work with radiation health. But, like so many other technicians responsible for monitoring and managing the adverse effects of technology, technocrats from the

[Continued on page 159]

Department of Environmental Resources and the Nuclear Regulatory Commission have thrust themselves into the position of making medical and public health judgments prior to, during, and after the accident.

While I personally believe that nuclear power can be made as safe, if not safer than many other forms of energy. I also believe that society has the right to know the health effects from the production of nuclear energy.

Some technocrats have cavalierly dismissed out-of-hand any possible dangers from the TMI accident or problems inherent in the cleanup process. As a result, many engineers and physicists simply no longer have any degree of credibility with the people in the Three Mile Island area.

The rapid pace of our galloping technology requires us to face head-on increasingly complex issues of a medical nature. Health decisions must be made and concerns answered by a flow of solid information from physicians and public health professionals working cooperatively with nuclear engineers, radiation biologists, radiation physicists and the like.

Nuclear reactors have been shown to be relatively safe but they do have inherent risks, possibly for infants. While it has been predicted that low level radiation from TMI will have a negligible effect on the physical health of individuals, we must continue to analyze data of infant mortality.

In hopes of soothing the public's unrest over the contemplated cleanup process at TMI, the health department has somewhat prematurely concluded that there is no significant change in infant death rates before and after the accident. The infant death rate around TMI from 1977 through September 1979 has been specially tabulated by the health department. Data collected after September 30, 1979, are not yet available for tabulation. So, the infant death rate for those babies exposed to low level radiation during embryonic development in the first trimester of pregnancy is not yet known.

The chart below compares infant deaths per thousand live births over the past three years in those families living within 5 and 10 miles of TMI from April 1 to September 30. Pennsylvania's annual infant death rate is also listed.

While fluctuations in infant death rates occur, these patterns and trends certainly warrant careful analysis and possibly further investigation of the infant death rate in the fourth quarter of 1979.

Premature deemphasis on the health effects of the nuclear accident understandably increases anxiety about the release of radioactive gases in the TMI cleanup process. The citizenry around Three Mile Island has become quite sophisticated in handling data. Unfortunately, the people did not know that a special study of births and infant death rates was underway and that data could soon be made available. Lest resentment about not releasing health data lead to a loss of credibility for health professionals, **unusual variations in health data should be promptly announced and interpreted to the public around Three Mile Island. Increased emphasis in announcing community health data promptly and responsibly can only help to restore the well-deserved confidence we have had in our public servants.**

Gordon K. MacLeod, M.D.

Infant Death Rates

Year	5 Miles	10 Miles	All PA
1977	6.7	10.5	13.9
1978	2.3	7.2	13.5
1979	16.2	15.7	13.6

The opinions expressed in the Editorials are those of the writer and do not necessarily reflect the opinion of the Editorial Board, the BULLETIN or the Allegheny County Medical Society.

Unanswered Questions About Three Mile Island and Infant Deaths

To the Editor:

Your April 18 editorial accusing me of telling nuclear scare stories and dealing recklessly with statistics is flawed by errors of omissions and ignorance of the facts.

The editorial, based on Jane Brody's news story three days earlier, can only revive public distress over data handling by state and Federal officials. Had Jane Brody or your editorialist interviewed me, I could have told them immediately that I am not opposed to the use of nuclear energy. And I could have repeated that it is premature to blame the clustering of thyroid defects and the increase in infant deaths on the accident at Three Mile Island; but it cannot be ruled out yet, as Federal and state officials have tried to do.

More than a year after the nuclear accident I released raw infant-mortality statistics which were then six months old. My announcement prompted the state to release infant deaths per thousand live births within 72 hours. Although both statistical measures are at best crude monitors of infant deaths, they should have been made public months before. After all, public health data belong to the public.

These data, however, are inconclusive because they do not include babies exposed to radiation during the first three months of pregnancy, when the developing embryo is especially sensitive to radiation. Accordingly, the official conclusions based on existing data that there was no health impact from the accident will remain irrelevant until the Health Department releases infant death rates beyond September 1979.

Yet to be explained is why 5- and 10-mile infant death rates around Three Mile Island during the six months following the accident climbed sharply, compared with the same period in previous years. In fact, the increases in the 1979 infant death rates over 1978 were statistically highly significant. Such significant increases in infant death rates following a nuclear reactor accident warrants complete candor and disclosure, not delay and denial. Had a decrease in infant deaths occurred, I trust it would have been widely publicized.

Despite the shortcomings in Brody's article, she contradicts your editorial undermining me for recklessly linking thyroid defects to radiation released from the crippled reactors. She stated, "Dr. MacLeod, however, did not attribute the cases to the accident."

I had expressed concern about a three months' delay by the Pennsylvania Health Department in announcing an unusual cluster of 12 times the expected number of hypothyroid cases in the county immediately downwind of Three Mile Island. My advice was accurately reported at the time as made only to encourage early detection of thyroid deficiency from any cause in unscreened newborns lest an untreated infant become a cretin.

The credibility of an official denial that radiation from the accident could have any effect whatsoever on fetal thyroid glands was clouded by an error made by an epidemiologist from the Center for Disease Control. In the news article, Dr. Greenberg mistakenly states that Pennsylvania had fewer newborns with thyroid defects than "all the areas in North America with screening programs."

That simply is not true. In the February 1979 issue of Pediatrics, both Montana and Idaho had far lower rates of thyroid defects in newborns than Pennsylvania had following the nuclear accident. Also, Philadelphia and Pittsburgh have lower rates of thyroid defects in newborns than all of Pennsylvania.

As a public health professional, my plea continues to be for health data collection. I also urge the timely release of all findings with accurate and prompt interpretation of medical consequence to the citizenry. I am especially concerned about those citizens in central Pennsylvania who have lost confidence in the credibility of official statements since the accident over a year ago.

GORDON K. MACLEOD, M.D.
Pittsburgh, May 7, 1980

The writer is professor of health services administration and associate clinical professor of medicine at the University of Pittsburgh.

New York Times
May 20, 1980

Infant Deaths Lower At Three Mile Island

HARRISBURG, May 19 (UPI) — The state Health Department today released infant mortality figures for 1979 showing that death rates were lower in the area around the Three Mile Island nuclear plant than the rest of Pennsylvania.

Health Secretary Dr. H. Arnold Muller said the figures included data for the last quarter of 1979, which was not included in a similar report issued earlier this year.

Mr. Muller said the full report on 1979 infant, neonatal and fetal death rates compares statewide figures to those obtained in the area within 10 miles of Three Mile Island, excluding the city of Harrisburg. The city is not counted, because its normally higher death rate would skew the figures.

Three Mile Island was the scene of the nation's worst commercial accident on March 28, 1979, when Government officials said relatively small amounts of radiation were released into the environment.

"The October, November and December statistics reaffirm the findings for the first nine months of 1979," Mr. Muller said.

"After careful study of all available information," said Mr. Muller, "we continue to find no evidence to date that radiation from the nuclear power plant resulted in an increased number of fetal, neonatal or infant deaths."

The Health Department figures show that:

¶Infant death rates, or deaths under the age of one year, were 11.5 per 1,000 live births within 10 miles of Three Mile Island compared to 13.3 deaths per 1,000 live births in the rest of Pennsylvania.

¶Neonatal death rates, or deaths within the first 28 days of life, were 8.9 per 1,000 live births near the Dauphin County nuclear plant compared to 9.8 deaths statewide.

¶Fetal deaths, or stillborn, miscarriages or voluntary abortions after 16 weeks of gestation, were 11.1 per 1,000 live births near the nuclear plant, while the statewide rate was 23.0 deaths.

Excluding voluntary abortions, the statewide fetal death rate was 13.4 per 1,000 live births compared to 11.1 deaths near Three Mile Island.

Mr. Muller said the department would continue to monitor infant death rates throughout 1980.

Nuclear Waste Study

WASHINGTON, May 19 (AP) — The space agency awarded a contract to the Boeing Company today as a first step in determining if nuclear wastes can be rocketed deep into space for disposal.

The $296,000 contract kicks off a four-year program aimed at learning if potentially dangerous wastes can be fired into eternal orbit about the sun, into another solar system or elsewhere in the universe.

The program is a joint effort by the National Aeronautics and Space Administration and the Department of Energy.

A Danger-Laden Pit on Three Mile Island

To the Editor:

Recent discussions of krypton releases from Three Mile Island seem to have overlooked a potentially much more hazardous radioactive waste problem at the crippled plant.

Cooling water contaminated with cesium-137 is being continually pumped out of the damaged plant and stored in tanks. To assure sufficient tank capacity to allow cooling to proceed, the cesium is being removed from the stored water by a resin filtering process called Epicor-II. The Nuclear Regulatory Commission has described the resulting resinous radioactive wastes in a document called Nureg-0691.

This document repeatedly refers to the cesium wastes as "low-level" wastes suitable for disposal in shallow trenches at an existing "low-level" waste burial ground. However, I have looked carefully at the description of these wastes presented in Nureg-0691, and the cesium content of these wastes is hundreds of times higher than the N.R.C.'s own proposed upper limit for cesium content of wastes defined as "low-level."

Thus, by current proposed definitions of "low-level" wastes, the T.M.I. cesium wastes are not disposable in shallow trenches. They will need to be buried in deep geologic repositories, along with the rest of the nation's "high-level" wastes.

No suitable geologic repositories now exist. President Carter announced Feb. 12 that his new waste-management program will identify suitable sites for such repositories by 1985 and will actually have a repository operating by 1995. Thus, even if the President's program goes forward without any setbacks or delays, the T.M.I. wastes will need to be temporarily stored for at least 15 years.

Nureg-0691 correctly says that no suitable shipping casks now exist to transport these cesium wastes. Casks will have to be designed, then licensed by N.R.C. These wastes are accumulating at the rate of approximately 25,000 curies per year. They are being stored in a pit in the ground at T.M.I.

Perhaps focusing additional attention on this problem would speed up the process of removing these wastes. An island in the middle of a large river hardly seems an ideal storage depot for tens of thousands of curies of biologically active material for a decade or more.

PETER MONTAGUE
Director, National Campaign for Radioactive Waste Safety
Lawrenceville, N.J., June 11, 1980

TMI simulated accident bares flaws

HARRISBURG (AP) — At least two state agencies failed to follow the script during this week's simulated accident at the Three Mile Island nuclear plant, officials said yesterday at a critique of the drill.

Based on information from Metropolitan Edison Co., operator of the plant, the state Bureau of Radiation Protection (BRP) recommended an evacuation at 7:30 a.m.

However, the scenario written for the fake crisis did not call for such a recommendation until 2:30 p.m.

"We tried to play the exercise as if it was a real event. We did not want or receive any information on it ahead of time. That was a mistake," said BRP Director Tom Gerusky.

Oran Henderson, director of the Pennsylvania Emergency Management Agency (PEMA), said he feared that the evacuation recommendation would bring the simulated emergency to a premature close.

"It was a controlled exercise. There were certain objectives to be obtained at each step of the way," Henderson said.

The drill was designed to test the state's ability to respond to a nuclear emergency such as the March 28, 1979, accident that crippled a reactor at Three Mile Island. It was the nation's worst commercial nuclear power accident.

Gerusky said the information flow to his bureau was excellent, but the Health Department complained that it operated in a vacuum through most of the eight-hour exercise.

"We waited, and waited, and waited. We were ready to swing into action but we heard nothing," said Julie Cox, the Health Department's emergency management director.

"The Health Department should not have been sitting in that cubicle waiting for information," Henderson commented.

Maj. George Evans of the state police said one aspect of the communication situation on Wednesday "was an exact duplication of the March incident. The media and the public were being advised prior to state agencies."

Consequently, Evans said his office was not equipped to answer questions from the public. "That reflects on credibility, which is important in a disaster situation," he said.

Henderson, who has attributed communication problems to understaffing during the exercise, said the drill failed to accomplish all its objectives.

He said that may have been because the scenario was too complicated, the pace was too fast and too many agencies were involved. Smaller scale drills will be conducted in the future, particularly to test BRP teams and equipment, he said.

Steven Sholly, research coordinator for the Three Mile Island Public Interest Resource Center, contended the drill was "an academic exercise" that revealed serious flaws in the plans and the manner in which they are tested.

Hundreds Moved Permanently From Area of TMI, Study Finds

By United Press International

Hundreds of residents within a five-mile radius of the Three Mile Island Nuclear Generating Station moved away permanently after the 1979 accident at the facility, a state Health Department census indicates.

With the cooperation of the U.S. Postal Service, the state Bureau of Health Research this month began a study to track down residents who left the area, bureau Director Dr. George Tokuhata said.

Tokuhata, in disclosing the preliminary findings, said it was known that at least some of the persons who moved out of their homes near Three Mile Island did so because of emotional stress related to the nuclear accident.

"Obviously some people moved because of Three Mile Island. They said so," said Tokuhata, adding that the total number of persons who left the area within the five-mile radius "was in the hundreds."

Tokuhata said the preliminary findings suggested that many of those who moved out of their homes remained in the Harrisburg area. The nuclear plant is located 10 miles south of the state capital.

Interviewed during the census, which was completed last fall, were 36,000 of the 38,000 residents who lived within the five-mile radius. The official findings of the census will not be released until later this year.

Tokuhata explained the Health Department originally did not plan to conduct the "Mobility Study."

"But while analyzing the census data, and looking at these people who moved out, we got to talking that we really should find out more about the movers," he said.

Tokuhata said some persons may have given up good jobs and fine homes for reasons not justified by the facts of the aftermath of the Three Mile Island accident. Since the nuclear plant was brought to a safe shutdown a month after the March 28, 1979, mishap, it has not been in operation and its future is clouded.

Tokuhata said the results of the study may help social planners in community counseling in the event of another nuclear accident elsewhere.

TMI caused stress to mothers, study shows

By Henry W. Pierce
Post-Gazette Staff Writer

Mothers were psychologically upset by the Three Mile Island episode, but nobody is sure how poor old dad fared.

A study of residents near Three Mile Island showed mothers were emotionally hard-hit during the nuclear accident 19 months ago.

Compared with mothers in another nuclear community, the Shippingport area of Beaver County, they showed high levels of anxiety and depression.

But dad?

No one has a clear answer because, although mothers were studied as a separate group, fathers were not. The fathers were lumped with all the subjects in the other two groups studied — nuclear workers and clients of mental health clinics.

Results of the $375,000 project were announced yesterday at Western Psychiatric Institute and Clinic.

"The strongest mental health impact of the Three Mile Island nuclear accident — and events subsequent to it — has been on mothers living in the TMI area, especially those living within a five-mile radius of the plant," according to a statement issued by Western Psych.

The statement was modified somewhat during a later press conference when questions were raised about the effect on fathers. Might not fathers have been affected even more than mothers?

"These were the findings *from this particular study*," qualified Evelyn Bromet, principal investigator.

The one-year study was based on interviews with 624 Three Mile Island residents and 312 Beaver County people.

The researchers examined the accident's mental health effects in light of residents' prior psychiatric problems, emotional support from relatives and friends, and "other stresses associated with living near a nuclear power facility."

Not much difference was found in the mental health of the workers employed in the two regions.

Nor was there much difference in the amount of stress reported by clients at mental health agencies in each district.

But mothers and pregnant women showed more clinically identifiable symptoms at the time of the episode and one year later.

More of the TMI mothers sought help from psychologists and psychiatrists.

Those hardest hit were the ones who got least support from friends and who had sought help from a psychiatrist before.

Fathers were not studied separately from other men, Bromet said, because "we only had one interviewer per household — we couldn't afford more — and mothers were the ones who had been specifically warned by the governor to leave the area."

The study, financed by the National Institute of Mental Health, will be continued. "We don't know how long the symptoms will persist," Bromet said.