OPTIONAL FORM NO. 10
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UNITED STATES GOVERNMENT

Memorandum

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TO : Charles L. Dunham, M. D., Director
Division of Biology and Medicine

DATE: September 13, 1962

FROM : Harold Knapp, Fallout Studies Branch
Division of Biology and Medicine

Harold Knapp

SUBJECT: TRANSMITTAL OF REPORT ON RADIOIODINE

The attached report on Average and Above Average Doses to the Thyroids of Children in the United States from Radioiodine from Nuclear Weapons Tests is forwarded for your review and further disposition. It is my suggestion that if scientific review indicates no major errors, and if a general scrutiny indicates the conclusions to be properly qualified and in reasonable perspective, then a corrected version be submitted for publication as a TID document.

It should be noted that the possibility that some children in the communities surrounding the Nevada Test Site may have received thyroid doses of hundreds of rads is genuinely disturbing. It should also be noted that this result, and for that matter all the material in the paper, can be very simply developed from information and data in the public domain. There are many reasons why the present calculations have not been made before, but the crucial one is that in spite of all the money spent on fallout research, there have been almost no analysts engaged in careful, comprehensive evaluations of fallout problems. Under these circumstances we managed to miss the obvious in a haystack. In this case the obvious amounts to applying the same calculations to Nevada test fallout that Dr. Dunning has long applied to calculation of thyroid doses to children in the event of nuclear war (see, for example

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the computations by Dunning on pages 445 - 448 of the JCAE 1959 hearings on the Biological and Environmental Effects of Nuclear War).

The unexpected high levels of I-131 in milk during the fall of 1961 and the spring of 1962 has stimulated a great deal of interest in this nuclide outside the AEC and the PHS. The St. Louis Committee for nuclear information has been analyzing past results, and the SANE people have picked up iodine as the focal point of their criticisms. However the UN report and the JCAE hearings in June failed to bring out that iodine may in fact be the most important single nuclide, or that it might be a limiting factor in the conduct of future tests at the Nevada Test Site. It remained however for the perspicacious Dr. Ralph Lapp to recognize the essential character of what has been overlooked in the past, and to publish an article on Nevada Test Fallout and Radioiodine in Milk in the September 7, 1962 issue of Science (attached as Enclosure (1) to this memorandum). We are lucky that he has so far only thought to examine the Troy-Albany hot spot of April 26, 1953 (over which he has badgered the Commission before) instead of the possibly more serious problem of cumulative exposures in offsite communities around the Nevada Test Site. It is, however, a much easier step to think of this latter problem once the iodine possibilities of the Troy-Albany incident are understood than it is to think of the Troy-Albany problem in the first place, so we should not consider it unlikely that over a period of a few weeks or months (or maybe just days) that someone will think to make some calculations on Nevada iodine. (This likelihood is increased by the fact that the Wall Street Journal has published the highest measured milk level evermeasured (8510 μμc I-131/liter) as coming from Heber Valley, 70 miles SE of Salt Lake City). Again, it is easier

to think of and make the calculations than it is to think of all the qualifications that go with them, so there is some incentive for the AEC to be the first to raise the problem.

I have no doubt but what the present paper can benefit greatly by careful review. However the basic calculations have already been gone over carefully by Dr. Dunning and others, and I should judge the likelihood of any major errors to be quite small. It is my recommendation that the existing report be forwarded to the General Manager and the Commissioners for their information and comment, and also to the following groups and individuals:

a. The following scientists within the Government or on contract to the AEC

Dr. Lester Machta
Dr. Wright Langham
Dr. John Harley
Dr. Cyril Comar
Dr. Titus Evans
Mr. Robert List
Professor Merrill Eisenbud
Dr. William H. Beierwaltes
Dr. Robert Reitemeier
Dr. Carl F. Miller
Dr. Edward Freiling
Dr. Karl Morgan
Dr. Scott Russell
Dr. Arthur Wolff
Dr. C. Straub
Dr. Willard Libby
Dr. Vay Shelton

b. The following official groups

The Federal Radiation Council Working Group

The Division of Radiological Health, U. S. Public Health Service

The Director, Los Alamos Scientific Laboratory

The Director, Lawrence Radiation Laboratory (Livermore)

Chief, Defense Atomic Support Agency

Manager, Nevada Operations Office

The National Academy of Sciences - National Research Council Committee on the Pathological Effects of Atomic Radiation

The Advisory Committee on Biology and Medicine, U. S. Atomic Energy Commission

The National Advisory Committee on Radiation, U. S. Public Health Service

The Military Liaison Committee, U. S. Atomic Energy Commission

The Special Assistant to the President for Science and Technology

c. Fourth that serious consideration be given to submitting the report for comment and criticism (together with the request that material be used only for scientific discussion until there has been an opportunity for correction and publication) to the following persons and groups:

Dr. E. B. Lewis
Dr. John M. Fowler
Dr. Ralph E. Lapp
Dr. Barry Commoner
Dr. Walter Selove
Dr. Tom Stonier

I'm not sure whether this would be a very naive action or a very shrewd one. I'm inclined to favor it on the grounds that any or all of these people are capable of developing the same conclusions, and that on the whole, the Commission's position is bettered if we are candid about our problems, and demonstrate that we think of them first, rather than having belated admissions dragged out of us.

I will shortly forward to you my recommendations based on the report. These will include specific suggestions for:

a. further research on the distribution, deposition, uptake, radiation exposure, and biological effects of radioiodine in fallout,

b. further studies of the exposure of thyroids of children from communities in the vicinity of the Nevada Test Site,

c. the collection of radioiodine data for monitoring and research by the AEC and the USPHS,

d. an unsolved problem concerning the hazard from radioiodine in the event of nuclear war,

e. radiation protection guides and maximum permissible concentrations, and

f. additional factors to be taken into account in the conduct of further nuclear tests at the Nevada Test Site.

The largest uncertainties in the report center on 3 points:

1. how well the relations between unit area deposition of I-131 and the resulting concentration of I-131 in milk which were developed from data collected following the Windscale reactor accident apply to the herbage and grazing conditions in areas surrounding the Nevada Test Site,

2. the degree of variation in milk levels for a given unit area deposition of I-131, depending on whether the iodine is deposited as dry fallout, in a fog or by a light rain, or in a heavy shower,

3. the physical and chemical form of iodine in fallout occurring, say, within 300 miles of the Nevada Test Site, and the extent to which this iodine is fractionated from other fission products (e.g. Zr^{95} and Sr^{90}).

The conclusions of the paper which are at once most important and most uncertain have to do with fallout from the Nevada Test Site. It may be possible to directly check the calculations by analysis of whatever simultaneous measurements of milk levels and external gamma levels may have been made by Oliver Placek of the USPHS (on contract to the AEC) in his offsite monitoring program, or in correlating the measurements of external dose rate and milk levels in the Spokane-Seattle area resulting from the debris deposited by the venting of the Des Moines shot. Such data, and possibly other information collected by Carl Miller, Kermit Larson, or Ed Freiling following Small Boy and Sedan, may tell us what we want most to know rather simply, directly, and cheaply. We won't know till there is time to look, though. Before I do any looking I want to finish thinking about what to look for, and where, and how. These thoughts will be included in my recommendation based on the report.

I would think it a mistake for the Commission to attempt to withhold the report from other government agencies pending further study. If the conclusions are incorrect or misleading at this stage, then they can all be blamed on me; if they are essentially correct we at least have the advantage of telling unpleasant news ourselves, and we are not vulnerable to a charge of having suppressed or misrepresented information on fallout, or worse still, of not being competent to find our own problems.

Enclosure 1

ENCLOSURE 1

Reproduced from SCIENCE magazine, 7 September 1962, Vol. 137, No. 3532, pages 756-758.

Nevada Test Fallout and Radioiodine in Milk

Abstract. The iodine-131 dosage to infant thyroids as a result of Nevada testing is evaluated. The case of heavy fallout in the Troy, N.Y., area on 26 April 1953 is cited. The possibility is discussed that a thyroid cancer survey would provide a critical test of linear response versus threshold theory for radiation injury to tissue.

The resumption of nuclear testing at the AEC's Nevada Test Site has resulted in the injection of fission products into the air mass over the U.S. continent. The purpose of this communication is to call attention to localized tropospheric fallout of radioiodine as a short-lived contaminant of the milk supply.

A search of the unclassified literature reveals that in past testing at the Nevada Proving Grounds there have been instances of tropospheric fallout involving iodine-131 contamination far in excess of the levels recorded in the United States as a result of Soviet and U.S. off-continent tests during 1961–62. Such fallouts occurred in the Salt Lake City, New York, Chicago, Rochester, and Troy areas (*1*). Data pertaining to the Troy, N.Y., fallout are detailed enough to permit an estimate of the radioiodine hazard. Emphasis will be placed upon the 8-day iodine-131 activity as a contaminant of the milk supply. The presence of shorter-lived radioiodine and radiation dosage due to inhalation and solid food ingestion is not considered here.

On Sunday, 26 April 1953 a rain-out of radioactive debris occurred over Troy, N.Y. H. M. Clark of Rensselaer Polytechnic Institute reported a gamma radiation intensity of 0.4 mr/hr 1.1 days after arrival of the debris (*2*). In addition, a surface contamination of 1.6×10^7 disintegrations per minute per square foot was measured, corresponding to the activity 36 hours after detonation of the Simon test in Nevada. This explosion took place in the atmosphere (the bomb was mounted on a 300-foot metal tower) and produced a fission yield which has been reported as 43 kilotons (*3*) and also as 52 kilotons (*4*). The top of the bomb cloud reached an altitude of 45,000 feet, and its base was defined at 31,000 feet. The tropopause at the time was at 38,000 feet so that much of the cloud was trapped in the lower atmosphere.

The cloud trajectory took the radioactive debris eastward on an arc path over Pennsylvania, the Hudson Valley, southern Vermont, and Massachusetts (*5*). Severe rainstorms probably produced concentrations of fallout in these states, but the monitoring network was of too coarse a grid to define these fallouts. However, the Troy, N.Y., area was surveyed by an aircraft flying at 500 feet above the terrain on 1 May 1953. The reports of the Simon fallout were classified Secret (*6*). It seems quite probable that the extent of the contamination was considerable (*7*); it is also likely that contamination levels elsewhere exceeded those found in Troy.

I estimate that the level of iodine-131 contamination in Troy, N.Y., was in the range of 2 to 4 curies per square mile or, roughly, that 1/1,000,000 of the Simon test radioactivity fell on 1 square mile. This corresponds to approximately 1 $\mu c/m^2$. A single square inch of plant surface would be exposed to a fallout of 650 $\mu\mu c$ of iodine-131. Thus, leafy edibles marketed promptly after such a fallout could involve a substantial ingestion hazard. However, fresh milk is the most convenient food product to monitor, and it is also the main contributor to the diet of many infants. A pasture level of 1 $\mu c/m^2$ may be translated into a milk contamination of 100,000 $\mu\mu c$/liter. This is based upon British experience (*8*) with the iodine release (*9*) from the Windscale plant No. 1 on 10 October 1957.

Individuals in the 6-to-18-month age group would be expected to take up about 30 percent of the iodine-131 and retain it in a 2-gram thyroid (*10*). If these individuals consume 1 liter (*11*) of fresh milk per day, a thyroid dose (*12*) of 0.5 rad per year would be sustained if the milk averages 80 $\mu\mu c$/liter. Given a single-shot contamination like that of Troy, individuals drinking milk from the milkshed (assuming the cows received no dry feed) could have received a total dose of up to 30 rad. Depending upon the specific contamination of the milkshed and how the milk was pooled, a large fraction of the 0.5-to-1.5-year-olds (some 10,000 individuals) in the Troy-Albany-Schenectady area would have been at risk. If we take a 10-rad dose as a conservative estimate and assume that 10,000 infants were exposed, then the population dose is 100,000 infant-rads.

E. B. Lewis has estimated that a ten-fold-higher dose of 10^6 infant-rads would produce about 10 to 100 cases of thyroid cancer over the first 20 years of the exposed population (*13*). Currently, in the case of Troy, N.Y., the 1953 fallout might yield up to five cases of thyroid cancer if the dose-response curve is linear and no cases if a threshold exists above 10 rads. The National Office of Vital Statistics provides the figure of 0.6 case of thyroid cancer per 100,000 per year. In the case of Troy, one would, therefore, expect one case or less of thyroid cancer due to spontaneous causes. It would appear useful to have the Public Health Service conduct a thyroid survey of the 9–11-year age bracket of those who were resident in the Troy-Albany-Schenectady area during April and May 1953. The 7–9- and 11–13-year age groups could serve as control groups for the survey. Additional surveys might be made in the Salt Lake City area. Should a statistically significant number of thyroid cancers be discovered and the case histories correlate with the intake of fresh milk in the April-May period, the results could be of critical importance to the linear response theory. Even though the delay time involved in the appearance of thyroid cancer is long and may complicate the study, one must also consider the possibility that fetal uptake of radioiodine from the milk-drinking mother may be associated with a com-

parable rad dose and a greater radiosensitivity than for the 6-to-18-month group. Thus, babies born in the late summer and autumn of 1953 might have sustained high thyroid dosage, and they would be a critical age group to survey.

The presently accepted annual RPG of 0.5 rad for the infant thyroid has been approached during past years in several U.S. communities (*14*). For the period April 1957 through May 1962, the Committee for Nuclear Information (St. Louis) cites a 1.89 rad total dose for Salt Lake City and 2.34 rad for St. Louis (*15*). In general, this irradiation has been caused by radioiodine deposited by tropospheric fallout from off-continent tests. The combination of Siberian and Pacific test fallout with Nevada fallout makes it probable that some American communities will exceed the annual radiation limits defined by the Federal Radiation Council.

The problem of dealing with milk contamination is complicated by the uncertainties of future contamination. The Federal Radiation Council has stipulated three ranges of contamination and a corresponding "graded scale of action" which involves "consideration of control measures designed to limit intake" (*16*). Range III for iodine-131 has an upper limit of 1000 $\mu\mu$c/liter of milk. This upper limit has been exceeded in certain U.S. milksheds during the past year. For example, milk contamination levels in Utah during July 1962 ran over 2500 $\mu\mu$c/liter (*17*). Such levels are still more than an order of magnitude lower than those which I have estimated for the Troy fallout.

Radioiodine appears to have been underestimated as a radioactive hazard in bomb fallout. Concentration of the agricultural contaminant by grazing cows and the quick transport of short-lived iodine-131 in the food supply and subsequent concentration of the radionuclide in the infant thyroid involves a series of events which deserve more careful study. Even so, the radioiodine dosage to infant thyroids in some localities has exceeded the radiation dosage to any active body organ in humans from nuclear test fallout. Indeed, the level of irradiation may have already reached a point in some areas where biological injury to humans may be associated with fallout.

Control of the iodine-131 hazard can be exercised at the point of injection of the radionuclide into the atmosphere and also at the point of injection of the radionuclide into the food supply. The former involves limitation of nuclear testing and the latter involves countermeasures affecting the farmer and dairy industry. With regard to countermeasures, the issue appears to be complicated administratively (18), but technically the short life of iodine-131 allows for alternative use of milk where the time delay in marketing the dairy products effectively eliminates the radiation hazard. However, the dairy farmer may incur financial losses due to nonpremium marketing of grade A milk. Bills have been drafted in Congress to compensate the farmer for justifiable losses. Compensation would also be involved where dairy farmers switch to dry feed, as was the case (19) on 23 August 1962 in Minnesota. Amendments (20) to the pending farm bill (H. R. 1239) cover such cases.

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References and Notes

1. Testimony of M. Eisenbud, "Health and Safety Problems and Weather Effects Associated with Atomic Explosions," *Publ. Joint Committee on Atomic Energy, 84th Congress* (15 Apr. 1955), p. 22.
2. H. M. Clark, *Science* 119, 619 (1954).
3. *Effects of Nuclear Weapons* (GPO, Washington, D.C., 1962), p. 673.
4. "Fallout from Nuclear Weapons Tests" (hearings of the Subcommittee on Radiation of the Joint Committee on Atomic Energy) (1959), vol. 3, p. 2524.
5. I am indebted to Dr. James E. McDonald of the University of Arizona for an analysis of the air movements on 25–26 Apr. 1953.
6. AEC reports NYO-4552 and -4602, dated June 1954, were originally classified as secret. Report NYO-4602 (DEL), "The transport of atomic debris from Operation Upshot-Knothole," may be obtained in photostatic form from the Office of Technical Services, Washington, D.C., for $30.30. It is also available as a reference at the Library of Congress upon request on a rare materials form.
7. The 14th semiannual report of the Atomic Energy Commission (July 1953) states that "unusually heavy fallout" was noted in the Troy-Albany area and specifies a gross activity of 100 to 200 c/mi² and exposure of 0.1 r for the first 13 weeks after the arrival of fallout in that area.
8. H. A. Robertson and I. R. Falconer, *Nature* 184, 1699 (1959); P. R. J. Burch, *ibid.* 183, 515 (1959); R. J. Garner, *ibid.* 186, 1063 (1960).
9. According to Sir John Cockcroft (in a speech at Cambridge, England, 16 Sept. 1958), the meltdown of uranium in the reactor released about 20,000 c of iodine-131. Milk supply from farms in a 200-mi² area downwind from the reactor was discontinued.
10. This is a conservative value. Some investigators stipulate uptake of 45 or 60 percent.
11. A liter of milk per day is probably a little high. Infants who are switched from formula to whole milk generally take three 8-oz bottles per day, and many take an extra evening bottle.
12. Data on thyroid radiation dosage are given in the testimony of G. M. Dunning, in "Biological and Environmental Effects of Nuclear War" (hearings of the Joint Committee on Atomic Energy) (1959), pp. 445–448.
13. E. B. Lewis, *Proc. Natl. Acad. Sci. U.S.* 45, 894 (1959).
14. *Federal Radiation Council Staff Rept. No. 2* (Sept. 1961) stipulates (pp. 8–10) 0.5 rem/yr for population groups and 1.5 rem/yr for individuals. For the case of fallout, the 0.5 rem figure applies.
15. Data are taken from Table 1 of a letter, dated 7 June 1962, from Drs. E. Reiss, Barry Commoner, M. Peterson, K. J. Hohenemser, and J. M. Fowler to Dr. Luther L. Terry, U.S. Surgeon General. The letter is quoted with permission of Dr. Commoner.
16. From "Fallout Surveillance and Protection," (U.S. Public Health Service and Food and Drug Administration press memorandum) (26 Oct. 1961).
17. According to a New York *Times* report (2 Aug. 1962), Dr. G. D. Carlyle Thompson, Utah State Health Director, attributes levels of 1600 and 2050 $\mu\mu$c/lit. (on 20 and 25 July, respectively) to Nevada tests of 6 and 12 July. Dr. Robert C. Pendleton of the University of Utah reports iodine-131 concentrations higher than 2500 $\mu\mu$c/lit. on 14 July (personal communication).
18. See, for example, testimony of K. H. Morgan on "Problems of assessment and initiation of control measures" given before the Joint Committee on Atomic Energy in June 1962.
19. See statement of Senator Hubert H. Humphrey, *Congr. Record* (22 Aug. 1962), p. 16195.
20. Statement of Senator William Proxmire, *ibid.* (17 Aug. 1962), pp. 15887–92.

13 August 1962