How much radiation did children receive from atomic testing in the fifties? What were the effects of this irradiation?

The discussion in the following pages of "Thyroid Irradiation in Utah Infants Exposed to Iodine 131" by Charles Mays, which appeared in our last issue, centers around these two questions and the problems involved in trying to answer them.

Obviously, it is desirable to find and treat any malignancies that might develop in any of these children. It is also important to find answers to the questions because of the light this could throw on the more general questions: How much iodine 131 produces thyroid damage of any kind? Thyroid cancer? In what proportion of exposed children? These questions are important, not only for past exposure, but for the evalution of possible future exposure from underground testing, atmospheric testing by other nations, Plowshare projects (nuclear explosions for peaceful purposes) or from reactor accidents.

How much?

A recent paper from the Lawrence Radiation Laboratory (reviewed on page 4) presents new estimates of the size of the dose and the number of children exposed; estimates which underscore the need for expanding the search for radiation effects. A procedure for checking these estimates, proposed in the Appendix to Dr. Mays' article last month, would use the long-lived iodine 129 as an indicator of the amount of iodine 131 originally present. This proposal is discussed further by Dr. Tamplin on page 3.

The question has been asked: If iodine 129 has a half-life of millions of years, why aren't we concerned about its biological effects? Doesn't it do more damage than the short-lived iodine 131? The answer is "No." Because it decays slowly, iodine 129 gives off much less radioactivity in a given amount of time than does iodine 131. Also, although it takes about seventeen million years for half the radioactivity of iodine 129 to decay (a physical half-life of 17,250,000 years), it is excreted from the body fast enough to make its *biological* half-life (the time it takes for half of it to disappear from the body) only about three months.

In pathological tissue from autopsy, the excretory process would have ceased with death. Because there is a known ratio of iodine 131 to iodine 129 at the time they are created in a nuclear explosion, the iodine 129 still present in the tissue can give a clue to the amount of iodine 131 that was formerly present. This is not unlike the use of another long-lived isotope—carbon 14—as an indicator of the age of archeological findings.

Tissue preserved after autopsies performed on people who died shortly after nuclear tests in the fifties could therefore be tested for iodine 129. This would tell us how much iodine 131 was in the same thyroids prior to death, and the approximate level of iodine 131 exposure to others still living, who were subject to fallout in the same locality in the same year. Autopsy tissue is probably available in Salt Lake City, if not in the smaller towns (CNI has not checked with Salt Lake hospitals, but such tissue would be available in St. Louis, and presumably also in other metropolitan medical centers). Such a study would not have to cover the whole geographical area of high exposure in order to serve as a check on estimates—such as those of Tamplin and Fisher — based on external radiation measurements. It takes whole thyroid to do an I-129 analysis.

What effects?

Dr. Conard, who has been studying the Marshall Islanders exposed to fallout from the Bikini test of March 1, 1954, summarizes the thyroid abnormalities found in these people (page 1). With one exception, all the abnormalities found have been in the group exposed to 700 or more rads of radiation from iodine 131. The children exposed to the lesser doses, and showing no abnormalities are too few in number, as Conard points out, to establish a threshold dose (a dose below which no abnormalities would be produced). They are also too few to draw conclusions from the Marshall Island experience that are applicable to the Utah-Nevada experience.

Six children in the Marshall Islands were exposed to 300-600 rads. On the basis of the assumption used by Mays (35 cancers per million children exposed to one rad of x-rays), one would expect only one case of thyroid cancer per hundred children exposed to 300 rads or one case per 50 children exposed to 600 rads. If iodine 131 is one-tenth as effective as x-rays in producing thyroid damage, one case of thyroid cancer per thousand children exposed to 300 rads would be expected or one case in 500 children exposed to 600 rads. It is therefore not surprising that no cancer has been found in the six children exposed to doses in this range.

Forty children were exposed to 55-125 rads. In this exposure range, one would expect a maximum of one case of thyroid cancer per ??0 children; a minimum of one case in five thousanc n.

Not unless many more children in the Marshall Islands had been exposed to iodine 131 fallout would the absence of cancer or other thyroid abnormalities there suggest that cancer or other thyroid abnormalities would be unlikely in the Utah children.

The comments from Dr. Wolff of the Radiological Health Department of the U.S. Public Health Service (p. 2) describe what is currently being done and what is planned in the search for pathological effects. The small expansion of the present field study in southern Utah and the collection and analysis of Utah and Nevada records of thyroid surgery are both useful steps. Whether "extensive epidemiologic studies" should be designed on the basis of Dr. Mays' dosimetry is questioned by Dr. Wolff because the present field study is difficult and costly, with "no characteristic clinical picture that can be reliably screened out of a 'well' populatior recourse to intensive study."

The prouiem .s certainly a unique, complex and difficult one, but it is of such importance that neither difficulty nor cost should be allowed to stand in the way of expanded and, if necessary, intensive studies.

Dr. Wolff does not comment on the possibility of improving the dosimetry. If this could be done and small areas of high dosage identified, the intensive studies might first be concentrated in those areas.

In looking for thyroid damage within the "well" population, new and unorthodox methods may have to be tried; new screening procedures sought. If the questions now being asked are not yielding the answers, other questions may have to be asked; other studies designed. This is a challenge, not only to the Public Health Service, but to all members of the scientific community who have an interest in the problem and a competence in one of the related disciplines.

Robert A. Conard

Robert A. Conard is head of the Marshall Island Surveys at the Brookhaven National Laboratory.

The studies of the Utah children proposed by Dr. Mays are worthy of consideration. However, the task of reconstructing the thyroid doses in this population due to fallout from detonation of different nuclear devices over the past years would appear to be extremely difficult, if not impossible. Also the logistics of instituting retrospective and prospective studies in this population of children are formidable. The diagnosis of radiation-induced thyroid lesions would be extremely difficult to separate from thyroiditis and other prevalent thyroid conditions in this population without careful pathologic and other studies. The Salt Lake City population of children is quite large for the thorough studies that would be necessary. Perhaps concentration of efforts on the more heavily exposed Washington County children would result in more meaningful information.

In our studies in the Marshall Island people exposed to fallout in 1954, twelve years ago, we have noted over the past few years the development of thyroid abnormalities in fifteen of nineteen children exposed at less than ten years of age (thirteen with benign thyroid nodules and two with hypothyroidism).[1] One adult developed cancer of the thyroid. It should be pointed out that the incidence of thyroid disease is quite low in the Marshall Islands. Although dose estimates are not precise, it was calculated that the thyroid glands of the young Marshallese children received in the range of 700-1400 rads from radioiodines internally absorbed and in addition 175 rads from gamma radiation (similar to x-rays). These doses are considerably higher than those received by the Utah children. More pertinent is the absence thus far of any thyroid abnormalities in 40 other Marshallese children, on a different island, exposed in the same age range, who received an estimated 55-125 rads to their thyroid glands, and also lack of thyroid abnormalities in six children, on still another island, that received an estimated 300-600 rads to their glands. These doses are probably also higher than those received by the Utah children. Therefore, based on the Marshallese experience, it does not seem likely that an easily detectable increase in thyroid abnormalities will be found in the Utah children. However, it should be pointed out that the number of exposed Marshallese children is too small to establish a low or threshold dose of induction of thyroid abnormalities. If thyroid dosimetry proves satisfactory and thyroid studies could be effectively pursued in the Utah children, the data collected, even if of a negative nature, would be valuable.

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Robert C. Pendleton

Robert C. Pendleton is head of the Radiological Health Department of the University of Utah.

Dr. Mays has covered the problems relative to reassessing the hazard to children in the Utah area admirably, and my comments will be concerned with the ecological factors that have to date not been taken into consideration in assessing this hazard and possible methods for increasing ▬ ·curacy of the assessment.

So far, most attention ⁿ— been centered around St. George, Utah. This is natural, since the maximum single radiation incident as a result of fallout occurred there. However, the St. George area, located in the lower Sonoran life zone, is arid with very low humidity during the major portion of the growing season and it contains almost no swamp or wet land pastures. Furthermore, it has relatively few milk producers who feed "green chop" (fresh cut alfalfa). Standing water in fields, sparse vegetation in pastures, and feeding of green chop, all lead to accentuated accumulation of radioactive materials. The virtual absence of these factors near St. George would tend to reduce the yield to milk supplies in that area, whereas other parts of Utah in which these conditions are common could accumulate as much, or more, iodine 131 as entered the St. George milk supply from less total fallout.

The St. George region was hit by high levels of fallout relatively few times, whereas the central and northern parts of Utah have been laced by fallout tracks repeatedly. Conditions of relatively high humidity, standing water, feeding of green chop and relatively poor pastures are commonly found in the northern part of Utah. As a consequence, it is entirely possible, indeed very probable, that the radiation effects to children inhabiting the north and central parts of Utah may exceed those for the St. George children.

In the 1962 incident, the highest observed levels of iodine 131 in Utah milk occurred near Altonah, over 400 miles from the Nevada test site, whereas much lower levels were observed from farms in southwest Utah that were closer to the source. Even with the long lived emitters, such as cesium 137 and strontium 90, enormous differences in concentrations in milk result from the location of the fallout tracks and the effects of ecological factors. For example, the cesium 137 concentration in milk in May, 1962 was 173 times higher in our "highest" station than in our "lowest" station. (Note that this was *before* the tests of July, 1962.) In July, 1962 the variation was 248. It is probable that sizable numbers of infants received doses much greater than the population average. Efforts should be made to identify all high yield farms and study groups of children from them.

The study of irradiated children should not only be expanded to northern Utah, but should also include areas in the surrounding states wherever the indicated doses appear significant. Because of uncertainties in conventional methods of dose estimation, new methods such as iodine 129 evaluation in thyroid tissue from pathologists' files should be explored.

The expense of proper studies is justified by the urgent need to learn more about the long term effects of radiation exposures to children. It is unlikely that definitive answers can be obtained by restricting the present to the small number of children in the St. George region.

Arthur H. Wolff

Arthur H. Wolff is chief of the Research Branch, Di· sion of Radiological Health, for the U.S. Public Heal Service with headquarters in Rockville, Maryland.

We have reviewed Dr. Mays' article and your e(torial introduction scheduled for the next edition *Scientist and Citizen.* The close deadline does not p(mit an exhaustive commentary and I am responding some major points raised by the article and editori introduction particularly the recommendation concer ing future studies of Utah children. I might add th these comments have been discussed with Dr. Jose] E. Rall, Director of Intramural Research, National I stitute of Arthritis and Metabolic Diseases, and th meet with his concurrence.

As an overall comment, I think that Dr. Ma' hypotheses on dosimetry and dose-effects are reasonat but I believe that several of the assumptions made Dr. Mays' paper are oversimplified. Whereas they m serve as a semi-quantitative basis for risk estimates aı may be useful to bracket the risks of environment contamination, there is a reason to believe that th may not be valid for designing extensive epidemiolog studies. Some of my reservations in this regard we submitted to Dr. Mays when I reviewed an earlier dra of his paper. However, I was out of the country durii that time and my earlier comments may have been su mitted to him too late for his consideration.

As you know, we now have had considerable exp rience with epidemiologic field studies of the childre in Washington County, Utah. We are convinced, base on this experience, that the screening studies of childre are not only extremely difficult and costly but do n(appear to be a practical means of diagnosing presume radiation-induced pathology in large population group Indeed, this latter point is the crux of the problem i that there is no characteristic clinical picture that ca be objectively or reliably screened out of a "well" popı lation without recourse to intensive study. Our effor to date have uncovered a spectrum of thyroid abno malities in a "well" juvenile population which so f: do not appear to be radiation-related. Definitive dia; noses of very carefully screened cases could only t made after extensive clinical, laboratory, and surgic. study—the latter being not without some risk to tł patient. We do intend to continue, prospectively, t study in depth the populations initially selected f(study in Arizona, Utah, and Nevada but the fiel

6

methodology that we have developed is not directly applicable to larger populatic · currently have under investigation over 2000 children in Washington County, Utah, (St. George area) and about 1400 from an area in Arizona essentially free from Nevada test site fallout. This fall we are expanding the potentially exposed group to include about 400 Nevada children and planning to add about another 1000 to the Arizona comparison group.

We have elected another approach to define the problem of statewide risks in Utah and Nevada. For the past several years we have been collecting records of every surgical procedure involving the thyroid glands of persons under 30 years of age in these states. Records covering the year 1948-1962 already have been assembled and are in the process of review and analysis for any significant changes in the pattern of thyroid pathology with respect to age, sex, diagnoses, geographic and temporal distribution. Concomitantly, we are collecting reports and data from other parts of the country presumably not exposed to significant amounts of iodine for comparative purposes. So far we have found no striking anomalies with respect to statewide occurrence of thyroid diseases or clustering of this condition in one region or another.

You may be interested to know that the Division of Radiological Health has other studies under way which may help clarify the dose-tumorigenic response to iodine 131. One is a followup study of 37,000 patients who were treated for thyrotoxicosis. In this study we are comparing the frequency of neoplasia in patients treated with iodine 131 to those treated surgically. Another study just initiated concerns the followup of juvenile patients who received doses of 5-100 mc of iodine 131 for diagnostic purposes.

I appreciate the opportunity to review this paper and hope you find our comments helpful.

Joshua Z. Holland

Josuha Z. Holland is chief of the Fallout Studies Branch, Biology and Medicine Division of the Atomic Energy Commission.

Dr. Mays' suggestions for obtaining the maximum possible information on thyroid iodine 131 burdens, radiation doses, and possible effects in the areas immediately downwind of the Nevada Test Site are laudable. They should be analyzed carefully by the experimental scientists who might have the capability of carrying them out.

While Dr. Mays' paper was being prepared, a report entitled "Estimation of Dosage to Thyroids of Children in the U.S. from Nuclear Tests Conducted in Nevada During 1952 Through 1955" (UCRL-14707) by A. R. Tamplin and H. L. Fisher was issued by the University of California ıce Radiation Laboratory, Livermore. This study, a part of the fallout research program supported by this Division, represents an attempt to do part of what Dr. Mays is recommending, namely to reconstruct the dosimetry. The results are not inconsistent with those of Dr. Mays.

I shall not comment on the medical aspects of the paper since others are much better qualified to do so.

John Garner

John Garner is director of the Radiological Health Animal Research Laboratory, Fort Collins, Colorado, and has done pioneer research in iodine fallout in the food chain.

I am obliged to you for your invitation to comment on the final version of Dr. Mays' paper. I feel that *Scientist and Citizen* has expressed my own views so admirably in the editorial comments which accompanied the draft that all I can add is an expression of my profound respect for Dr. Mays' objectivity in his treatment of this highly emotional subject.

Arthur R. Tamplin

Arthur R. Tamplin is a member of the Biomedical Research Division of the Lawrence Radiation Laboratory, Livermore, California. He has recently published (with H. Leonard Fisher) a report on iodine 131 dose estimates from the 1952-1955 nuclear tests.

My colleague, H. Leonard Fisher, and I have recently made a detailed study of the thyroid dosimetry following the Nevada tests conducted from 1952 through 1955.[1] Our best estimate of the thyroid dosage to children in the Salt Lake City area, who were drinking one liter of milk per day from cows on pastures, is approximately 50 rad for the period 1952 through 1955. Thus, our analysis would support Dr. Mays' contention that the Utah children received sufficient dosage to justify consideration of an expanded study in the Utah area in an effort to shed some light on the question of the effects of low dosage radiation. If adequate samples are available Dr. Mays' suggestion of using iodine 129 to improve the dosimetry would represent another line of evidence that has the potential of reducing the overall error of the dosage estimates.

Since it might be of general interest, I went through our analytical procedure with iodine 129. These calculations suggest that following a single deposition the concentration of iodine 129 in human thyroids (assuming the consumption of one liter of milk per day) would rise to a maximum of 1.6 F, where F=atoms (I-129)/m^2, on the first day of contamination. The material available to me indicates that the limiting sensitivity of neutron activation analysis is 10^{-13} gram of iodine 129.[2,3]. This is equivalent to approximately 5×10^8 atoms. Using the relationship between iodine 131 and iodine 129 given by Dr. Mays, and the above factors, the following conversions can be derived (assuming one liter of milk consumed per day):

Infant Thyroids

$$\frac{5 \times 10^8 \text{ atoms (I-129)}}{\text{gram of thyroid}} = 0.8 \text{ rad to children's thyroids from iodine 131;}$$

Adult Thyroids

$$\frac{5 \times 10^8 \text{ atoms (I-129)}}{\text{gram of thyroid}} = 8.0 \text{ rad to children's thyroids from iodine 131.}$$

Data presented by Eisenbud[4] suggest that, on the average, adults consume only one third as much milk per day as children. This would suggest that 5×10^8 atoms (I-129)/gram of adult thyroid = 24 rad to children's thyroids from iodine 131. Following Shot Nancy of the Upshot-Knothole Series we estimated that children received 30 rad. This would suggest that neutron activation analysis is sufficiently sensitive, at least for this test, even with small tissue specimens. Actually, by pooling the tissue samples, it would be adequate for many other tests. For example, 5×10^8 atoms (I-129)/100 gram of adult thyroid = 0.24 rad to children's thyroids from iodine 131 (assuming only one third liter of milk consumed per day for adults).

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REVIEW

NEW RADIOIODI

ESTIMATION OF DOSAGE TO THYROIDS OF CHIL DREN IN THE U.S. FROM NUCLEAR TESTS CON DUCTED IN NEVADA DURING 1952 THROUGH 1955 By Arthur R. Tamplin and H. Leonard Fisher. Lawrenc Radiation Laboratory, University of California, Livermore Bio-Medical Research Divison, May 10, 1966. UCRL-14707

TWO SCIENTISTS in the Bio-Medical Research Divi sion of the University of California's Lawrenc Radiation Laboratory at Livermore have published a important piece of work estimating radiation dosag to the thyroids of children exposed to iodine 131 fall out in the early years of testing.

The report by Arthur R. Tamplin and H. Leonar Fisher represents a significant refinement of previou estimates, and substantiates the earlier conclusion b CNI, Charles Mays and Harold Knapp that man children received doses ranging from a few rads up t more than a hundred rads (S/C, August and Novembe 1963 and the *Joint Committee on Atomic Energy Hea ings* of the same year). While previous studies focuse

ESTIMATED DOSES OF IODINE 131 to the thyroids c children from nuclear testing at the Nevada Test Site, 195 1955. The numbers give estimated doses at various locatio throughout the United States, and the shaded portions ind cate areas where the dosage is estimated at 10 rads* or mor

SAMPLING STATIONS

Boise, Idaho	Goodland, Kansas
Pocatello, Idaho	Amarillo, Texas
Cheyenne, Wyoming	Dallas, Texas
Rock Springs, Wyoming	Fort Smith, Arkansas
St. George, Utah	Des Moines, Iowa
Salt Lake City, Utah	Memphis, Tennessee
Flagstaff, Arizona	Milwaukee, Wisconsin
Albuquerque, New Mexico	Grand Rapids, Michigan
Roswell, New Mexico	Cleveland, Ohio
Denver, Colorado	Buffalo, New York
Grand Junction, Colorado	New York, New York
Scottsbluff, Nebraska	Boston, Massachusetts
Concordia, Kansas	New Haven, Connecticut

*A rad is the basic unit for measuring the absorbed dose of ionizi radiation per gram of matter. It is the amount of energy imparted matter per unit mass of material.

5