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ADVISORY COMMITTEE FOR BIOLOGY AND MEDICINE
TO THE
UNITED STATES ATOMIC ENERGY COMMISSION
WASHINGTON 25, D.C.

Dear Mr. McCone:

Several months ago questions were raised by the Joint Committee on Atomic Energy concerning the radiation dose to the population of the United States from the isotopes of short half-lives produced by the nuclear detonations which had occurred prior to the time of the present moratorium. Since a complete answer to these questions would require a most extensive study, the ACBM recommended in its letter report of January 14, 1960 to the Chairman that the study be undertaken by the Division of Biology and Medicine. Attention was called to the fact that a substantial amount of analytical data could be found outside of the AEC and urged that full use be made of all sources of information and that the capabilities of the Health and Safety Laboratory be utilized.

The recommended study would necessarily require considerable time. In the meantime, Dr. Dunham directed the Fallout Studies Branch of the Division of Biology and Medicine to review the readily available data in order to arrive at the best possible approximations. The report which is forwarded herewith is the result of this undertaking and, in our opinion, is the most lucid and scientifically firm analysis of the problem which has as yet been produced. We concur unanimously in our comments which follow.

From the study, it is evident that recent analytical data make it possible to estimate the general radiation dose to the population much more accurately than heretofore. For the general population of the United States living during the decade 1950-1960, it appears that the average 30-year external whole-body gamma dose from all nuclear testing conducted to date is probably between 40 and 60 millirads; and that about one-half of this dose is due to cesium-137; and that about one-half of the 30-year dose has already been delivered from a mixture of many shorter lived activities. The corresponding 70-year dose is estimated to lie between 45 and 65 millirads. Persons born after 1960 will necessarily receive substantially less exposure.

From the internally deposited cesium-137 it appears that the whole body and gonadal dose will lie between 20 and 30 millirads. It also appears that the average dose to infant thyroids from iodine-131 during the past few years has been of the order of a few tenths of a rad, with a small percentage probably receiving doses of 2 to 3 rads. The iodine isotopes of shorter half-lives contributed an additional 10% to 40% of the dose from iodine-131.

From strontium-90, persons born during these years will experience a 70-year dose to the bone of about 1 rad to which would be added about 0.055 rad from strontium-89.

It will be recalled that in 1957, the ACBM prepared a statement for the Commission on the chief problems presented by radioactive fallout. This was subsequently published by the American Scientist, and a reprint for your information is forwarded with this memorandum. It is interesting to find that the assessments of eventual doses to the whole body and to bone which were made at that time are still reasonable. The actual figures at the present time which are based on the total fission yield of all tests up to the cessation of tests in 1958 come reasonably close to our original estimates of the situation based on the assumption that all tests were to have stopped in the fall of 1957. This comes about because it is now apparent that the stratospheric burden is substantially less than had been previously estimated, and that in fact most of the material is already down.

With radioisotopes of long half-life, such as Sr^{90}, there is a slow diffusion downward in the soil into an ever larger pool of their stable counterparts. With the passage of years the radioelements of chief concern not only become increasingly diluted but more firmly bound in relatively insoluble forms. Both mechanisms decrease their availability to the root systems of plants and account, in part, for the tendency of root uptake to be less than that usually predicted.

In soil contaminated by fission products, cesium-137 and strontium-90 are the most important isotopes in plant absorption. This is because these isotopes act chemically very much like potassium and calcium, respectively. The cesium-137 therefore is in competition with potassium and the strontium-90 with calcium. Accordingly, plants take up more cesium-137 from soils poor in potassium and more strontium-90 from soils poor in calcium. Or, stated in reverse, uptake of cesium-137 in poor soil can be inhibited by applying potassium and uptake of strontium-90 by applying calcium.

Cesium-137 and strontium-90 are often adsorbed tightly onto the clay particles in soils. If they are bound tightly, they are less prone to be absorbed by plants, but also less likely to be leached downward into the lower soil and out of reach of roots. Conversely, if weakly bound, the isotopes enter plants more readily and leach away more rapidly. Some soils, therefore, give up isotopes to the plants fairly rapidly but during fewer years. Other soils give them up more slowly but over more years.

We need vastly more research information on rates of uptake and rates of leaching of different isotopes for different soils, for different crops, and for different seasons.

The accumulated observations from many sources show that the rate of clearance of material from the stratosphere is much more complex than originally thought. Recent data (including stratospheric sampling) indicate that the simple exponential expression for the rate at which debris is deposited from the stratosphere does not adequately describe the situation.

Since January 1958 the fallout rates of the longer lived products could be better described by quasi-symmetrical peaks characterized by maxima appearing from 1.5 to about 11 months post-detonation and by widths at half maximum varying from 3 to 8 months. Although these time intervals seem to be inversely correlated witn the latitude at which detonations have occurred, the influence of the height reached by the cloud and of the season of year at which tests occur remains to be assessed. In any event, all indications suggest that most of the fission debris injected into the atmosphere during 1958 has already been deposited on the ground except for that fraction pertaining to weapons detonated at high altitude in August 1958. This debris has not yet reached its maximum deposition rate as of March 1, 1960 and seems to account for a sizable fraction of the present radioactivity in the air.*

It seems likely, therefore, that some modification of past appraisals and future extrapolations in the matter of radiation dose will be necessary. Most obvious from present information is the expectation that the increase in the skeletal deposition rate of Sr^{90} will be considerably less than that postulated in the past, since the present rate of deposition in soil is already comparable to the rate of radioactive decay of the Sr^{90} therein.

An attempt to corroborate this prediction from the latest values of Sr^{90} content of milk is beset with the difficulty of estimating the relative contribution of foliar contamination of pastures. Although this effect is believed to be important, evaluation of its ultimate disappearance must await return of the herds to spring pasture. Complicating factors such as leaching and drainage of surface waters in meadows will require

*The lively debated question of a seasonal rise in fallout rate in the spring remains undecided at the moment because of this coincidental contribution of the Johnston Island tests.

longer periods of observations. All that can be said at present is that the milk values by the end of 1959 were roughly one-half the maximum values observed in the middle of that year. From the yearly averages already known it can be predicted that maxima of approximately 10 μμc Sr^{90} per gram of Ca may be found in selected samples of bones of children in localities where milk content has been observed to reach values exceeding 20 strontium units.

It may be useful to consider, however, that the variations in Sr90 concentrations measured thus far in foods available to man and in his skeleton appear to be comparable to those observed for the case of naturally occurring Ra^{226}; the latter has been shown to vary by more than a factor of 1000 in foods and by a factor of about 15 in assays of human and bovine skeletons selected from various geographical areas.

Strict comparison of the contribution of Sr^{90} to the biological dose in bone accruing from natural radioactivity awaits a more exhaustive analysis of the latter; however, some idea of the magnitudes involved can be had from the following table:

Radioisotopes in the Human Skeleton

Radioisotope	Skeletal Content (Units of 10^{-10} curie)	Average Dose mrad/yr	Average Dose mrems/yr
K^{40}	50.0	7.0	7.0
C^{14}	40.0	0.5	0.5
Ra^{226}	0.4	1.2	4.8
Ra^{228}	0.2	1.6	6.4
Pb^{210}	1.0	1.4	5.6
$U^{238} + U^{235}$	0.05	0.1	0.4
5 S.U. Sr^{90}	50.0	15.0	15.0
External Radiation		73-197	73-197

These values refer to skeletal values in localities where the contribution of Ra^{226} and Ra^{228} is due mostly to foods. In special localities it is known that intake of potable water can increase the contributions of these radium isotopes by a factor of 10.

In attempting to evaluate the bearing of the report on the contribution of short-lived isotopes and "hot spots" resulting from fallout to the estimation of induced genetic effects, the following comments may be made:

If the total 30-year gamma exposure of the United States population from past testing is 9 million man rads, and the dose to the population around the Nevada test site amounts to 90 thousand man rads, the latter is 1 per cent of the total genetically effective dose from fallout. The total genetically effective dose from fallout is in turn estimated to be 1.66% of average background radiation for the same period. Thus the genetically effective dose to the population around the Nevada test site from past testing is 1/6000 part of the natural dose that would normally be received by the whole United States population. In the over-all increase in harmful mutations it is therefore an exceedingly small fraction.

It remains to be considered whether the dose received by any individual in the area of highest exposures warrants great concern. It is estimated that from 100 to 500 persons received whole body exposures of 5 to 6.0 rads during the seven years of testing in Nevada. This is about ten times the exposure from average natural background for the same period. The Committee on Genetic Effects of Atomic Radiation of the National Academy of Sciences has recommended that no individual should receive more than 50r up to age 30. A small number of persons have thus received about 10% of the permissible gonadal exposure for an individual. These same few persons have in six years received up to double the Federal Radiation Council's "basic guide" for whole body radiation.

Another way of regarding the probable genetic effect of the maximum doses received by the small group of individual is to consider them in relation to the present load of tangible genetic defects occurring normally without relation to any added radiation. The United Nations Scientific Committee on the Effects of Atomic Radiation estimated that about 4% of all children born have at least one defect on a genetic basis. It further appears that there will be an approximately equal number of children that will exhibit one or more defects of a non-hereditary nature. Thus, normally, 500 persons, one-half of whom are in their reproductive years, might be expected to produce eventually about 350 children among whom there might be 28 with some degree of congenital defect. From considerations of the doubling dose and the general genetic behavior of developmental mutants, it follows that an additional 5 rad exposure to these 500 individuals would have about 1 chance in 10 of producing 1 additional case of tangible defect in their children; i.e., 29 cases instead of 28.

The medical implications of these findings must necessarily be expressed in general terms. Our scientific information is as yet much too incomplete to permit reliable quantitative predictions. We feel that the important point to stress is that these exposures of persons to fallout radiation both internally and externally must be considered in the perspective of natural situations in which substantial numbers of people have lived for periods of time extending to many centuries at background radiation levels several orders of magnitude greater than those under consideration.

The general tissue doses from fallout are of the order of one to two per cent of that which is ordinarily received at sea level from the natural radioactivity. We do not know even approximately the biological effects, if any, of this natural background radiation which is delivered at the slow rate of approximately 100 millirads per year. We do know that all life has evolved in this radioactive environment and that there has not been a single living cell since the beginning of life on earth that has not been constantly subjected to radiation originating both from without and from within its substance. We are aware that in the United States there is a considerable fraction of our population that lives in regions of background external radiation 100% greater than that normally at sea level. There are some heavily populated regions of the world where inhabitants have been subjected to levels of radioactivity at least 10 times that considered usual. Final conclusions as to the possible biological effects of these exposures must await future studies, but it can be said that there are no obvious manifestations of radiation injury in these situations.

Our conclusions are that until we have knowledge of the biological effects of natural radioactivity it is impossible to make a precise estimate of the significance of a small increment in the exposure. We assume, in accordance with the present state of knowledge of radiobiology, that such changes as may occur are to some extent injurious rather than beneficial. In any case, the degree of enhanced risk is so minute that detection has not been possible by any method.

The report stresses the irregularities in intensity and the maximum values for the fallout activities with special emphasis on the radioisotopes of short half-lives.

Respectfully submitted,

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Enclosure

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