To the Editor of the New York Times:

I have read with interest the letter from Drs. J. Laurence Kulp, Wallace S. Broecker, and Arthur R. Schulert, in your issue of 2 May 1958.

In this letter they say that my statement that carbon 14 represents "a far more serious long-term menace than all other radioactive by-products of an atomic explosion" is incorrect, and they deplore exaggerated statements by respected scientists. They say that carbon 14 will contribute only a minor fraction of the radiation produced by strontium 90 and cesium 137.

The statement made by these authors is not true. I think that when the cumulative dose to the entire population over the total lives of all isotopes is considered, the radiation from the carbon 14 produced by bomb tests is found to be considerably larger than the amount attributed by the ABC to other isotopes, and the number of defective children that can be predicted to be produced by the radiation from carbon 14 is far greater than the number predicted for the other isotopes.

In his 1956 paper on radioactive fallout Dr. W. F. Libby pointed out that neutrons released in the explosions of nuclear weapons in air react with nitrogen nuclei to make carbon 14; he said that "Fortunately
safe
this radioactivity is essentially/because of its long lifetime and the
enormous amount of diluting carbon dioxide in the atmosphere." Perhaps
because of a feeling of reassurance engendered by this statement and
others by Dr. Libby I did not make any calculations of the genetic and
somatic effects of the carbon 14 produced in the testing of nuclear
weapons until last month. In his 27 March 1958 address in Lausanne,
Dr. Libby gave additional information about carbon 14, including a
statement about the amount of carbon 14 generated per megaton,
with fusion and fission weighed as they had actually occurred; this
amount is 7.4 kilograms, about 7 times the amount that he had reported
in 1956 for a pure fission weapon. He stated that a considerable part
of the carbon 14 (which I estimate as two-thirds) falls back as calcium
carbonate, the rest of it entering the reservoirs of which the biosphere
is a part. At the present time the concentration of carbon 14 in the
atmosphere has been increased by the bomb tests by a value 10 percent
greater than its former value. As carbon dioxide dissolves in the ocean,
this percentage will decrease if the bomb tests are discontinued.

I shall calculate the effect of carbon 14 on the basis of the following
assumptions: A standard weight of bomb testing at 30 megatons per year;
one-third of the generated carbon $^{14}$ is released to the atmosphere; there is moderately rapid equilibrium with a large reservoir, including the ocean, with normal content 74,000 kilograms of carbon $^{14}$; the mean life of carbon $^{14}$ is 8070 years. The effect of a single gonad exposure of 0.1 roentgen of a world population equal to that at present is to cause ultimately a total of 380,000 seriously defective children (gross physical or mental defect, stillbirth, childhood death) plus 700,000 embryonic-neonatal deaths, as given estimated by Professor James F. Crow, a member of the National Academy of Sciences-National Research Council Committee on Genetic Effects of Atomic Radiation, in his testimony before the Congressional Subcommittee on Radiation on 4 June 1957; the population of the world, over which has increased by 1 billion during the last 100 years, will continue to increase and will have an average value during the next 10,000 or 20,000 years such that there will be five times as many children born as at present. The normal amount of carbon $^{14}$ in the human body produces a gonad exposure of 0.0015 roentgen per year, as stated in 1956 by Dr. Libby;

A straightforward calculation based on the above assumptions leads directly to the conclusion that 1 year of testing at the standard rate
of 30 megatons per year (two 15-megaton bombs, similar to the one detonated by the United States on 1 March 1954) will ultimately be responsible for the birth of 230,000 seriously defective children and also for 420,000 embryonic and neonatal deaths.

For comparison, we need to have a value of the amount of radiation produced by the other isotopes. The calculation of the effect of other isotopes is most readily made by the steady-state method. In the NAS-NRC report of 4 June 1956 it is said that if weapons testing were continued at the rate of the preceding five years it is estimated that a total 30-year gonad dose of about one-tenth of a roentgen would be produced, or, since the accuracy involved is probably not better than a factor of 5, a dose between 0.02 roentgen and 0.50 roentgen. The value in 30 years 0.1 roentgen has been reported as recently as this year, 1958, in the 23rd Semi-annual Report of the Atomic Energy Commission. It corresponds to 0.0033 roentgen per year, and accordingly to the production of 13,000 seriously defective children plus 23,000 embryonic and neonatal deaths. These numbers are far less than the numbers predicted as the
carbon $^{14}$ per year of testing, and accordingly the statement is justi-
genetic
gified that carbon $^{14}$ is a far more serious long-term menace than the other
products of atomic explosions.

Although the Atomic Energy Commission has not released any statement
about this matter, it seems to me not unlikely that the world-wide fallout
corresponds more closely to the upper limit given by the NAS-NRC committee,
0.5 roentgen in 30 years, than to the smaller value. If the upper limit is
in fact to be used, the number of defective children per year of testing
produced by radioactive material other than carbon $^{14}$ becomes 65,000, and the
number of embryonic and neonatal deaths becomes 115,000. These numbers
are still far less than those estimated for carbon $^{14}$. On the other hand, it must be pointed out that if the world population
remains constant, the effect of carbon $^{14}$ would be only about equal to
that of the other isotopes, assuming that the other isotopes irradiate the
gonads in amount 0.5 roentgen in 30 years, rather than the usually quoted
value 0.1 roentgen in 30 years.

The somatic effects of the bomb tests are more difficult to discuss,
because they involve more assumptions about the nature of the interaction
of high-energy radiation with the human body, and because 

scientists

are not in such overwhelming agreement as they are about the genetic effects. I shall content myself with the statement that it is likely

, in the long run, that the somatic effects of carbon 14 are/roughly equal to those of the

other isotopes, including strontium 90.

The bomb tests carried out so far (including 1958 (which is starting

off as a bad year) can be estimated to correspond roughly to a 30-megaton

years. Accordingly we may say that the predicted effect of the carbon

these

14 released in the bomb tests will be to produce about 1 million seriously

defective children and about 2 million embryonic and neonatal deaths,

and that the predicted effects of the other isotopes will be somewhat smaller.

As other people have pointed out, these numbers represent a minute

fraction of the total number of seriously defective children who will

during coming centuries.

The effects of the bomb tests carried out so far, some millions of

infective children individuals, are approximately the numbers corresponding

to one year at the present time; that is, approximately 1,500,000 seriously
I feel that each human being is important, and that it is well worth while to calculate the numbers of individual human beings who will be caused to suffer or to die because of the bomb tests, rather than to talk about "negligible effects," "undetectable increase," "extremely small fraction."

Linus Pauling

Pasadena, California

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