appears to be the principal origin. Theories which propose that the carbon skeletons of furfuryl alcohol and maltol of heated milk derive from carbon atoms 2 to 6 and 1 to 6, respectively, in the glucose moiety of lactose remain attractive in light of these findings (*10*).

S. Patton
R. J. Flipse

Department of Dairy Science,
Pennsylvania State University,
University Park

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8 March 1957

Gamma Rays from Local Radioactive Sources

There is considerable interest at the present time concerning the possible effects of man-made radiations on man himself. Because one source of these radiations is of world-wide extent, the interest has also become world-wide. Although considerable literature now exists on the subject of man-made radioactive contamination, on the one hand, and on the biological effects of radiation, on the other, the actual importance of the first as far as the second is concerned has often been obscure. It is thought desirable at this time to present some independent experimental data that will allow individuals to reach their own conclusions.

As early as 1928, R. A. Millikan became interested in the gamma rays emitted by local radioactive materials in the soil and rock at various localities in order to determine the effect of these radiations on the cosmic-ray measurements in which he was primarily interested. These measurements extended from California into the Rocky Mountain area and on up to Churchill, Manitoba (*1*). They probably represent a unique series of measurements, since they were made before man-made contamination became widespread.

An ionization chamber measures directly the quantity of interest as far as the biological effects of gamma rays are concerned, and this is the instrument here employed. One of the instruments Millikan made and calibrated is still in good condition after 26 years and is very convenient to use. A recent redetermination of the absolute value of the calibration (*2*) agrees with Millikan's value to 0.3 percent. In this survey, Millikan's instrument has been used for some of the measurements, and a more modern ionization chamber (*3*) for others. The two give essentially the same answer. Both were used unshielded in the measurements reported here.

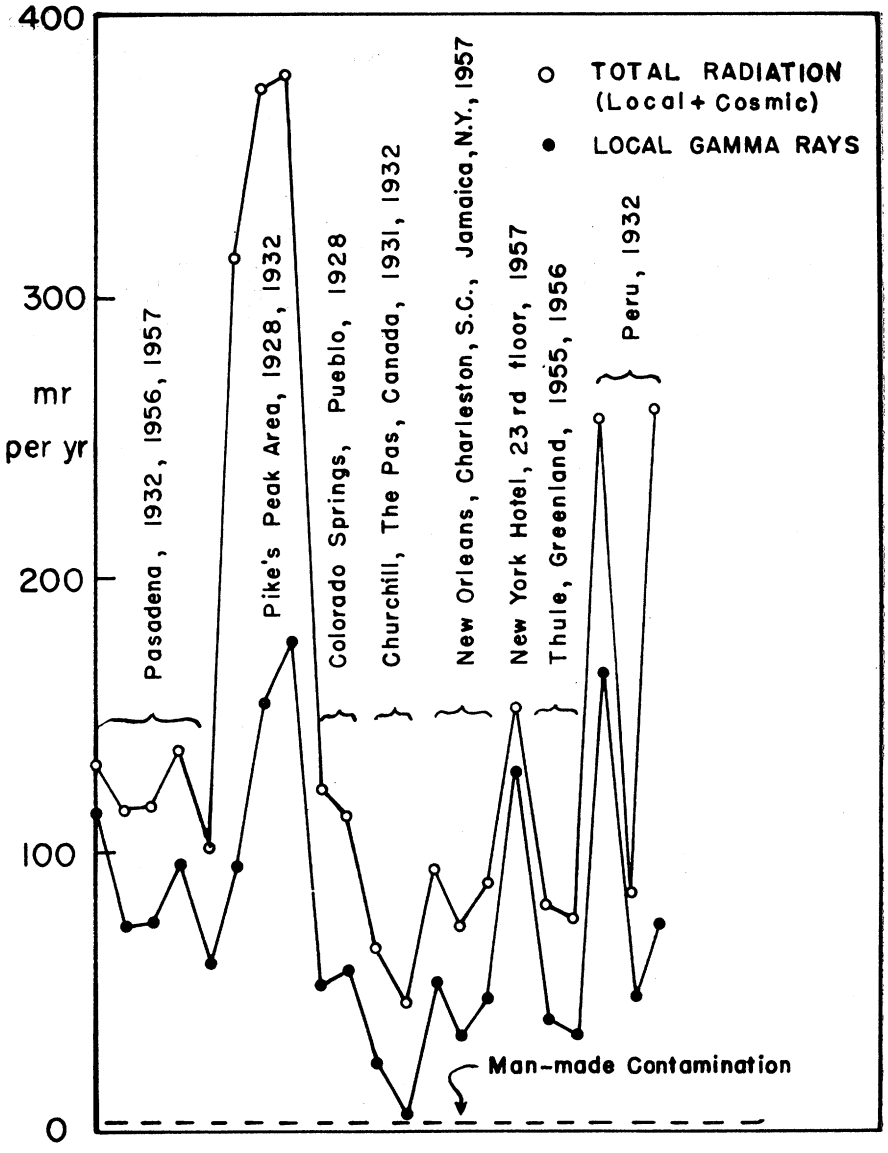

Fig. 1. "Noise level" of gamma rays and cosmic rays in the Western Hemisphere. Abscissas roughly increase with increase of distance from Pasadena. The amount of man-made contamination is taken from the National Academy of Sciences report, *Biological Effects of Atomic Radiation* (*7*). As is stated in that report, ". . . U.S. residents have, on the average, been receiving from fall-out over the past five years a dose which, if weapons testing were continued at the same rate, is estimated to produce a total 30-year dose of about 0.1 roentgen" (an average of 3 mr per year).

In Fig. 1, most of the values taken during the years have been entered. The ordinates are in milliroentgens (mr) per year. To convert into ion pairs per cubic centimeter, per second in 1 atmosphere of air, divide the ordinates by 15. The various stations are plotted as abscissas with the same increment from one to the other. Roughly, the stations get farther from Pasadena with increase in abscissa. The chief reason for plotting in this manner was to bring out the variability of radioactivity from one station and region to another.

Measurements were made of the total radiation at a given station; then the known contribution from cosmic rays (*4*) was subtracted to get the effect of the gamma rays from local radiation only.

In the Rocky Mountain region, the local radiation is high, presumably because of the granite, which is known to

contain something like 4 g of uranium and 15 g of thorium per ton (*5*). In Peru, the radioactivity of the coastal plain is much the same as that of the Mississippi region near New Orleans. The local radiation at an elevation of 15,000 feet in southern Peru is only slightly higher than that of the soils of the coastal plain. Most of the houses of Arequipa are built of a light rock called "tuva" which is of volcanic origin. This rock is 3 or 4 times as radioactive as the soil near Lima.

There is considerable variability of local radiation in some cases over small distances. According to Millikan (*6*), the gamma rays on the Laurentian Shield near Churchill, Manitoba, give 0.8 ion cm^{-3} sec^{-1} atm^{-1} of air, or 12 mr yr^{-1}, while nearby the intensity on the glacial sand is 35 mr yr^{-1}. It may be of interest that the radioactivity on the ice cap near Thule, Greenland, in August 1956 was less than 2 percent of cosmic rays.

A wooden building forms some shielding from local gamma rays. In my own house, the gamma rays on the first floor give 60 mr yr^{-1}, while in the back yard the intensity is 95 mr yr^{-1}. The rather high value of 130 mr yr^{-1} on the 23rd floor of a major hotel in New York is presumably owing to the material from which the building is constructed.

The root mean square "noise" level of the total radiation given in Fig. 1 is about 160 mr yr^{-1}. To find the effect on the population, the local radiation must be weighted according to the population. This has not been done. Perhaps it is fortunate that most of the population of the country lives where the radiations due to cosmic rays and local radiations are relatively low.

The dashed line near the bottom of Fig. 1 is taken from the Summary Reports on the Biological Effects of Atomic Radiation of the National Academy of Sciences (*7*). Even though there is some error in the determination of this value, as well as considerable variation of fallout over the country, it is quite evident that man-made contamination is still small compared with the changes in radiation from one part of the country to another.

The data presented here are for gamma rays only, since the walls of the ionization chamber are too thick for beta rays to penetrate, either from naturally occurring or artificially produced radioactive materials.

H. V. Neher

Norman Bridge Laboratory of Physics, California Institute of Technology, Pasadena

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15 March 1957

New Method for Detection of Human Poliomyelitis Antibodies

We have reported that if the lower edge of a strip of filter paper is placed in a suspension of a virus, the virus rises on the paper and becomes distributed in a regular, reproducible manner (*1*). The experiments described in this report show clearly that the upward spread of virus is decreased when serum containing specific antibody is placed in a band across the filter paper (*2*). Serum without antibody does not exhibit this effect. The "blocking" action of specific antibody has been observed with polioviruses and with six other viruses. The "blocking" of polioviruses by human serums which contain neutralizing antibody is type specific.

Whatman filter paper No. 3 is cut into strips 12 by 1.75 cm. Each strip is marked off by light pencil lines into 1-cm spaces (numbered 1 to 12), suspended from a rubber stopper, and autoclaved. Poliovirus cultivated in monkey kidney tissue is diluted to a concentration of 100 TCD_{50} per milliliter in 0.85-percent NaCl containing 10 percent bouillon broth. Thirty milliliters of the diluted virus is placed in a sterile bottle surrounded by ice. The serum to be tested (previously inactivated at 56°C) is then distributed evenly over spaces 3 and 4 of the filter paper. The paper is placed in the bottle containing the virus with only the lower half of space 1 below the surface of the virus suspension (see diagram of apparatus, Fig. 1). After 1 hour the strips of paper are removed, and each paper space is cut off and placed in a monkey kidney tissue-culture tube. Tissue culture tubes are incubated and observed for virus cytopathogenic effects in the usual manner. Neutralizing antibody titers of the serums used in the paper tests are determined by standard tissue culture methods.

Fifty-two successive tests (104 paper strips) with 14 human serums have given virtually identical results. Virus was detected by tissue culture on every wet space of every paper strip on which serum containing no antibody had been placed. In contrast, no virus was found above space 6 on any of the paper strips that were treated with serum which contained type-specific poliovirus antibody. No virus was detected above space 4 in the vast majority of such strips. Figure 1 shows examples of typical results. In

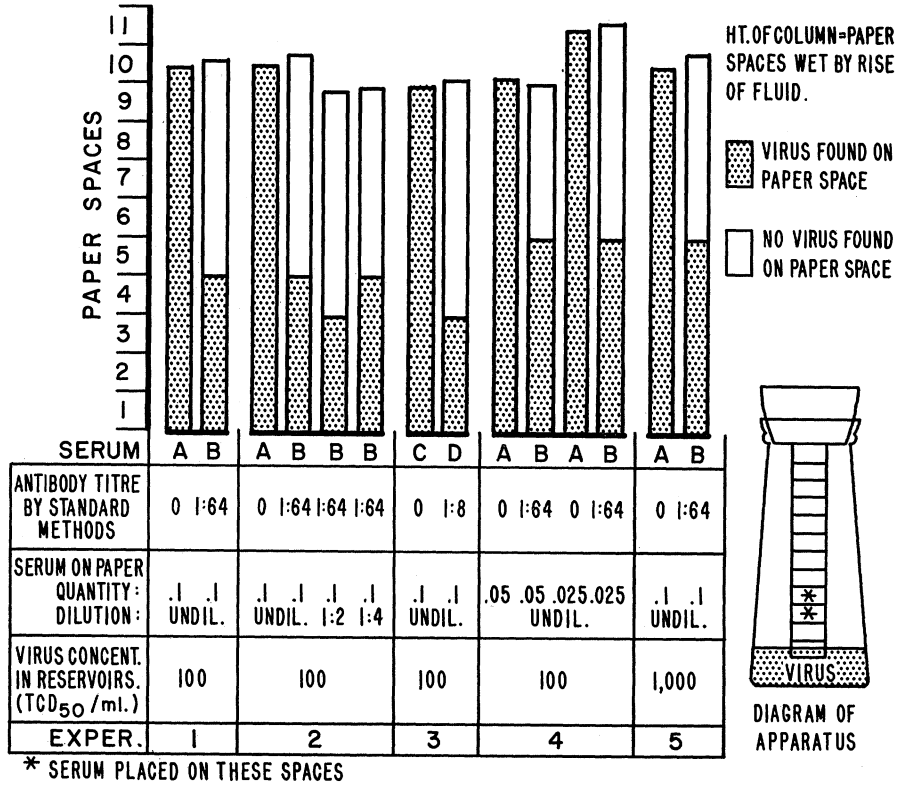

Fig. 1. Sample experiments showing that serum which contains type-specific antibody decreases the extent of the spread of type 2 poliomyelitis virus on filter paper.