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March 23, 1945

A. H. Compton

K. S. Cole.

RESULTS OF BIOLOGICAL RESEARCH

Dr. Stone has asked me to submit more specific data to amplify his general report to you on research problems connected with health.

The first objective of the biological research in the Biology Section is to determine the results of exposures of animals to Project radiations and radioactive materials and to estimate the results of exposures of man to these hazards. The more important data and conclusions bearing on this objective are now summarized.

About fifteen percent of the radioactive materials inhaled has been deposited in the lungs. The time required to remove one half of the deposited materials varied from a few seconds to two weeks, for the fission products investigated (I, Sr, Y, Ru, Zr, Ce) and from twelve hours to two weeks for plutonium, while the times for ninety percent removal were about two months for Ce and Pu. These times depend so much upon the element and its chemical and physical form that no generalizations are possible. Fifty microcuries of Ce deposited in rat lungs caused severe lung injuries and killed half of the animals within three months.

It has been found that half of the rats swallowing fifteen microcuries of Y, Sr or mixed fission products per gram of body weight did not live over a month. When about three microcuries of Sr, Ba-La, Zr-Cb, or Y per gram were introduced directly into the bodies of mice, rats, rabbits or dogs half of the animals died in a month. About one-half microgram of Pu or Ra per gram of body weight produced the same result in mice, rats and dogs. For the present it is reasonable to assume that a man will be killed promptly by fifteen microcuries of fission products per gram or a half microgram of plutonium per gram introduced into the body.

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For smaller amounts of material in the body mice live longer, six months for two and a half microcuries of Sr per gram to ten months for half microcurie per gram but they develop an average of fifteen percent bone tumors and twenty-five percent lymphoma and leukemia before death. Similar figures may be available in six months for plutonium.

About 500 r of x-rays has killed half of several strains of mice, rats, rabbits and dogs in a month and we can expect the same effect on man. With fast neutrons the value is about 100 n for mice and rabbits. It has been found that about half of the x-ray injury to rats was gone in a week after an exposure. But 70 r per day also killed rats and mice in a month and 10r per day shortened their lifetime considerably.

Dogs and rabbits which ultimately died in two weeks after x-ray exposure had an immediate prostration followed by gradual loss of red blood cells. After a week the animals lost weight rapidly and developed other symptoms suggesting that death was caused by circulatory failure. Two dogs receiving fatal and near-fatal amounts of plutonium showed the same effects but without the initial prostration.

Blood counts on animals exposed to various radiations and radioactive materials have shown that the lymphocytes were the most sensitive cells in the blood, 100 r of x-rays or 24 n of fast neutrons removed half of these cells while 25 r and 10 n respectively produced minimum detectable effect. About two microcuries of Sr or Ba-La reduced the lymphocytes to half in mice, rats and rabbits while about a half microcurie per gram was detectable. Pu and Ra reduced these cells to half in mice, rats and rabbits at about one-fifth micrograms per gram.

The microscopic examination of tissues from exposed animals showed that fission products and x-ray produced the most damage in the marrow of the bones. The lymphatic tissues, the lining of the gut and the reproductive organs were also damaged. Plutonium caused severe damage to the bone itself while for equivalent exposure, Sr and Ba-La had less effect and x-rays did not produce any detectable damage. The injured tissues recovered more completely from x-ray damage than from that caused by fission products.

In conclusion I wish to summarize the present situation. The major portion of our fact-finding program on the immediate effects of fission products and external radiations is completed. Practically all of our personnel and facilities are now occupied by work on Plutonium and on delayed injuries.

K. S. Cole

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