Rocky Flats Revisited: Carl Johnson Responds

The exact relationship between exposures to < 10 rads of ionizing radiation and the biological injury induced is a subject of controversy. Some believe the same degree of injury is induced per rad at low doses as at high doses (linear relationship), others report a greater effect per rad at low doses, and a third group say there is less effect. However, members of this third group will usually accept a linear relationship as a conservative estimate of risk (1). Controversy has characterized the field of radiation protection since the 1920's, when some scientists alleged that radium caused disease and other scientists alleged it did not (2).

The National Academy of Science Committee on the Biological Effects of Ionizing Radiation (the BEIR Committee) concedes that exposure to natural background radiation is the cause of a significant number of cancers and birth defects. The US Federal Radiation Council (cited by the BEIR Committee) estimated that 170 millirems (mrem) per year for 30 years would cause an increase in cancer of 2 percent per year, an increase of 0.3 percent per year in genetic effects, and an increase of 5 percent per year in non-specific effects on health. Because of such considerations a US Environmental Protection Agency regulation permits no more than 4 mrem/year to any organ or to the total body for man-made beta or photon emitters in drinking water, and their guidelines permit exposures no more than 25 mrem/year to persons living in the vicinity of nuclear plants. Their present guidance on uranium in drinking water advises a limit of 10 picocuries per liter (pCi/l), compared to the old limit of 6000 pCi/l (3–5).

IONIZING RADIATION: DAMAGE AT ANY LEVEL

Ionizing radiation does not have positive effects on living organisms. While visible light (not without exception) and heat within a narrow temperature range are necessary to life, where are the studies that show anything but harmful effects from ionizing radiation? One atom of plutonium, americium, uranium, radium or other alpha radiation emitter can emit an alpha particle which, striking through the nucleus of a cell, may kill the cell or injure it seriously. Other types of ionizing radiation at the cellular level can induce similar if less severe injury. A photon of gamma radiation may penetrate 30 000 or more cells as it transects the body. A beta particle may transect about 1000 cells before it comes to rest. The violence of these effects at the cellular level has been photographed with autoradiography. There is no living organism which would not survive in healthy condition in the total absence of any form of ionizing radiation.

Natural background radiation varies from place to place. People living in the village of Guarapari on the coast of Brazil are exposed to 640 millirads/year (640 mr/yr) of background radiation (6). A study of chromosomes in lymphocytes of villagers compared to controls found a 94 percent excess of chromosome breaks. In coastal Kerala in India where background radiation is 1500 to 3000 mr/yr, chromosome abnormalities were nine times more frequent than in a control population (100 mr/yr), and the prevalence of mental retardation of the genetic type (mostly Down's syndrome) was four times higher (7). Plutonium workers at the Rocky Flats Plant (RFP) who had 1–10 percent (400–4000 pCi) of the body burden permitted by US guidelines for workers had a 33 percent increase in the number of chromosomal aberrations, compared to fellow workers with less than 400 pCi (8). These effects are life-long, since the excretion rate of plutonium is about one-half in 200 years.

Concern about health effects prompted the RFP to make annual reports of cancer among workers and retirees (7). No information was available about thousands who left the plant for reasons other than retirement. A preliminary analysis of this cancer incidence data, comparing the numbers of cancer in each class to all cancer (excluding skin cancer not melanoma) indicated, that workers had 8 times more brain tumors than expected, 3 times more malignant melanoma and an excess of respiratory cancer (25 percent) (10).

Cancer death rates attributed to radiation exposure among survivors of Hiroshima and Nagasaki increased by 2.4 times between 27 and 32 years after the nuclear bombs (11). The number of workers at RFP required to wear radia-

tion monitors (badges) for the first five years of the plant's operation (1953–1957) averaged only 400 (12). These 400 men are now about 25 years past their initial exposures (1953–57) and may show an increase in cancer deaths by a factor of 2.4 in the next five years. The number of workers required to wear badges for the next 5 years (1958–62) averaged 1800, and (excepting 400 members of the first group) may not experience this surge in cancer deaths for another 5 to 10 years or so. Reliance should not be placed on studies of death rates because the time between onset and death varies greatly with different classes of cancer. An investigation of cancer by date of diagnosis is preferred. However, the US Department of Energy (DOE) has funded a study of cancer deaths at the DOE facility at RFP, prompted by several successful legal actions by widows of workers dying of cancer.

EARLIER STUDIES

The first report by the DOE group studied deaths among 7112 employees who worked at RFP between 1952 and 1979 (operations actually began in 1953) (13). An error in comparing mortality of Rocky Flats workers to a national average confounds their data with the "healthy worker" effect and large regional differences in cancer mortality. Workers at RFP must also pass a security clearance, an additional selection factor of importance; and most have advanced education. Another selective factor is the discretion exercised in forcing or encouraging certain employees to seek other employment. A study of radiation effects on workers must compare exposed workers to unexposed fellow workers, and control for such confounding factors as age, education, period of exposure (considering the latency period of cancer), security clearance, doseage of radiation, *etc.*

The DOE report on cancer deaths among RFP workers was presented at the University of Colorado School of Medicine in Denver on October 19, 1981, and the author was asked to explain why the study reported only 8 deaths from brain tumors in 7112 current and former RFP workers, when the RFP medical director had earlier reported 16 brain tumor deaths among only 3937 current and retired RFP employees (the balance had left RFP to seek other employment and had been lost to follow-up) (14). The author did not have a satisfactory explanation for this discrepancy, but indicated that the DOE study of cancer incidence would be completed in 15 to 20 years.

In contrast to the RFP workers, who wear protective clothing, breathe carefully filtered air, are monitored frequently for radiation exposure and have medical supervision, families downwind from the plant have no such protection and at times are within the stack exhaust plumes from the plant. One study reports a concentration of 50 pCi per gram of air-borne soil in the Rocky Flats area (15). In this arid, windy climate, a cubic meter of air may contain 1 or more grams of suspended dust. The major exposure was the result of a fire and explosion in 1957 which blew out over 600 industrial filters and a 4 year accumulation of plutonium nitrate and oxide, and uranium. The filters had not been replaced since the plant began operation in 1953.

RFP reports indicate a large amount of radionuclides other than plutonium have been released, and these are listed in the *Ambio* report (16). The area nearest the RFP and with the most exposure to radionuclides from the plant is predominantly suburban and has no other heavy industry. Denver itself (Areas 2 and 3) has little heavy industry, and has been selected as a site for the headquarters of a number of organizations because of its usually pleasant climate and living conditions.

As described in *Ambio*, there have been several surveys of plutonium in soil and surface dust in the Denver metropolitan area (16). The amounts of plutonium found in the soil were used as a surrogate measure to indicate a large number of other radionuclides known to be released by the plant. The excess incidence of cancer in the exposed areas, after correction for age, race, sex and ethnicity, was significantly higher. A direct comparison between Area 1 near RFP and the control population of cancer cases in anglo males and females, stratified by age, confirmed the higher incidence of cancer near the plant. The classes of cancer in excess were chiefly those found to be in excess in the survivors of Hiroshima and Nagasaki.

Preliminary studies may be done of cancer death rates around nuclear plants, but the more difficult cancer incidence studies are of greater value in the assessment of health effects produced by such plants. It is important that a national cancer registry be established to facilitate such studies. We have reason to hope that cancer, in large part, may be controlled by surveillance and intervention, as has been done with most of the communicable diseases.

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