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PROGRAM STATUS REPORT

to the JOINT COMMITTEE on ATOMIC ENERGY (U)

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December 31, 1958

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Part VI

Biology and Medicine

BROOKHAVEN MEDICAL RESEARCH CENTER (UNCLASSIFIED)

The Brookhaven Medical Research Center was dedicated on December 16. Dr. Shields Warren, who was the first Director of the AEC's Division of Biology and Medicine and is presently Pathologist at New England Deaconess Hospital and Professor of Pathology at Harvard University, delivered the dedicatory address. Commissioners John F. Floberg and Willard F. Libby, representing the AEC, both gave brief talks.

The $6,500,000 center has been under construction for 2 years. Included in the center are a tank-type reactor, which will be used for research on neutron capture therapy and other medical research, a 48-bed hospital, and laboratories for studies in biochemistry, medical physics, microbiology, pathology, and physiology. Startup of the reactor is planned for early 1959, with patient treatment to begin later in the year.

MEDICAL REEXAMINATION OF THE RONGELAP PEOPLE

The people of Rongelap Atoll in the Marshall Islands have received periodic medical examinations* since their accidental exposure to radioactive fallout in March 1954. The latest survey, conducted in February and March 1958, found them generally in good health.

Except for residual changes in skin from beta burns, manifested by mild atrophy, some scarring, and pigment aberrations, there has been no outward evidence of radiation effects. No symptoms or diseases have occurred which are related to radiation effects. Disease incidence among the irradiated people is about the same as in the unirradiated population used as a control. The death rate appears to be about the same for both groups. The three deaths that occurred in the irradiated group were not associated with radiation effects.

Although blood studies continued to show a slight lag in the recovery of the lymphocytes to normal levels, there was no indication of ill effects attributable to this condition.

Long-term effects are being watched for carefully, but none have been seen. No malignancies, leukemias, increase in degenerative diseases, premature aging, lifeshortening, radiation-induced cataracts, or genetic effects have been noted.

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*Earlier examinations were made 6 months, 1 year, 2 years, and 3 years after the exposure, and the reports have been published.

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Data obtained through the use of the whole body counter transported to the Atoll indicate that body burdens of certain radioisotopes are higher than normal, but well below accepted tolerance levels.

In the followup study scheduled for February 1959, a whole body counter will be used again to determine if any additional internal contamination resulted from the HARDTACK series of tests in 1958.

RONGELAP ECOLOGICAL STUDIES

Reconnaissance surveys of Rongelap, Eniwetok, and Kabelle Islands were made during September as part of the first phase of the long-term ecological study of Rongelap Atoll described in the April-June 1958 Quarterly Progress Report. Detailed examination of soil profiles was followed by systematic collection of soil samples, together with samples of birds, rats, fish, corals, plankton, and some invertebrates. Food samples were also collected in order to monitor radioisotopes ingested by the natives and to provide information required for food chain studies.

Two surveys are to be conducted during 1959 as part of this long-term study.

AERIAL RADIATION SURVEYS

During the year, U. S. Geological Survey teams made aerial surveys of several major AEC installations and a number of reactor locations to obtain information on radiation levels. The first survey, completed in June, was of the area around the AEC's Savannah River plant at Aiken, South Carolina. Surveys were also made of the Nevada Test Site; the Brookhaven National Laboratory; the Lawrence Radiation Laboratory at Berkeley and Livermore, California; and the areas around Oak Ridge, Tennessee; Schenectady, New York; Groton, Connecticut; and Windsor, Connecticut.

Data obtained from these flights should lead to better understanding of the long-term effects of radiation on the environment and be helpful in appraising changes in environmental levels of radiation resulting from atomic energy activities or radiation accidents.

Plans were made and schedules set up for continuing the surveys at a number of other installations and proposed reactor sites.

WHOLE BODY COUNTERS

Whole body counters, developed in AEC installations for experimental purposes, hold promise of becoming valuable adjuncts in dealing with people accidentally exposed to neutron irradiation, or who have inhaled or ingested dangerous radioisotopes. Most major AEC installations either have or are planning to have whole body counters for operational or experimental purposes.

These counters primarily measure gamma-emitting radioisotopes, but will also pick up secondary X rays caused by beta emitters.

In an incident involving inhalation or ingestion of unknown amounts of dangerous radioisotopes, effective medical treatment may depend on an accurate estimate of the amount of radioactivity and kind of radioisotope retained in the lung, skeleton, or other critical organ.

Excretion tests currently in use are not very precise and to be useful must be carried out repeatedly; in some instances the time required to perform the tests may exceed the period during which decontamination procedures should be undertaken.

A whole body counter was recently used in an attempt to estimate dosage of radiation received by the men involved in the criticality incident in the Y-12 plant at Oak Ridge.* Results obtained suggest that the whole body counter under certain conditions may well prove useful in estimating dosage. Where there is contamination of body surfaces, however, the counters will give high readings and the true dosage cannot be obtained until sometime later when the body surfaces have been thoroughly decontaminated.

GENETICS

A broad program in basic and applied genetics continues to be a major segment of the AEC's research activity in the life sciences. The mutation-inducing property of ionizing radiation makes genetics a requisite area for intense study; the ultimate hope is the critical assessment of the long-term hazards of nuclear radiation to man's genetic potential.

Human Genetics

Direct studies of human populations are always difficult, but several noteworthy advances were made during the year in studies involving the survey of the offspring of marriages between related individuals (first cousins) and the calculation of the normal load of detrimental genes in man. Study of a group of such marriages in the Chicago area indicates that about four detrimental genes are carried on the average. A preliminary report on cousin marriages in Japan also indicates that an increased probability of early death coincides with this mild form of inbreeding. More detailed investigations of the Japanese are to be continued jointly with the Japanese under the Atomic Bomb Casualty Commission, and a new contract was signed for a study by a genetics group at the University of Pavia in Italy of the effects of consanguinity in that country. The latter study will also include a direct attempt to measure the mutation rate of several common blood antigen genes.

Efforts to study radiation-induced genetic damage in man must take advantage of any available opportunities. Alteration of the sex ratio (ratio of the numbers of males and females born) is one accessible measure. An analysis of the Hiroshima-Nagasaki data indicates a real possibility that detectable sex-linked lethals were induced and that the rate of mutation per roentgen in man is probably similar to the mutation rate found in experimental determinations in mice. Study of a small group of offspring of American women receiving ovarian radiation exposure for therapeutic purposes also suggests that sex-linked lethal gene mutation is a significant hazard in man.

Experimental Genetics

The most significant recent finding in the field of experimental genetics is an optimistic one. Data on mice strongly suggest that, per roentgen absorbed, protracted or low intensity exposure is only one-third to one-fourth as effective in inducing mutation as acute or burst-type exposure. This is contradictory to all past experience, which was based almost entirely

*"Accidental Radiation Excursion at Y-12 Plant, June 16, 1958," Y-1234. Copies have been furnished to the Joint Committee.

on nonmammalian organisms. Present interpretation is that the protracted exposure does not cause serious damage to the normal metabolic activities of the germinal tissue and that consequently some forms of mutational damage are repaired, or washed out. This assumes, of course, that the mutational event is not an immediate all-or-none affair but can involve a series of changes.

Evidence of a time delay in the formation of a mutation has been found within the past year in basic genetic studies on micro-organisms and plants. Some repair can occur in the presence of active protein metabolism. This information may support the findings in mice, noted above. Although it is still too early to make refined judgments, it now seems credible to assume that the mutational process may not be the absolute and inalterable event previously considered. However, there is no evidence, direct or inferred, that complete recovery can occur; the new evidence suggests only that the probability of damage is not uniform under all conditions of exposure.

In an effort to extend knowledge of mammalian genetics, a long-term study on swine has been instituted at Iowa State College. Swine are well-known with regard to such quantitative traits as growth, early viability, and productivity, and this background of knowledge is to be applied to the problem of radiation-induced genetic variability. The progeny of irradiated boars are to be studied through the greater part of their lifetimes in order to evaluate the effect of genetic damage that can alter the more subtle traits of a population. It will be several years before preliminary data can be analyzed.

Beneficial Uses of Radiation in Genetics

A small program of crop improvement by radiation has been active for some years. The goal here is to select from the radiation-induced genetic changes those variants that have potential agronomic value because of increased yield, modified maturation time, or altered disease resistance. Studies undertaken 10 years ago culminated recently in the release by the North Carolina Agricultural Experiment Station of a strain of peanuts resistant to disease and possessing other characteristics which make them superior to other commercial strains. This new variety, the first of its kind to be released in the United States, resulted from subjecting peanuts to a radiation dose of 18,500 roentgens, studying the resultant 11,000 mutations over a 10-year period, and selecting from among these the superior mutant.

RADIATION TOXICITY

Neutron Toxicity

Evidence is beginning to accumulate that fast neutrons are significantly more hazardous when the exposure is at a lower rate protracted over the lifetime than when the same total exposure is at a higher rate of short duration early in life. In other words, the relative biological effectiveness (RBE) of neutrons to X and gamma rays tends to increase as the duration of exposure increases and the rate of exposure decreases. This observed change in RBE has broad implications in the appraisal of reactor hazards. It has also been tentatively concluded that recovery from neutron irradiation seems less dependent upon dose rate than recovery from X and gamma irradiation.

This problem as well as others in the field of neutron toxicity will be subject to more detailed investigation in the near future at Argonne National Laboratory. A small research reactor is being built for the Biology Division at Argonne. This reactor will have two primary

thermal columns, one for high dose rates and one for low dose rates. The attached exposure rooms will permit large-scale studies of neutron toxicity to be carried out in conjunction with the existing studies on gamma-ray toxicity.

An additional extension of the toxicity studies at Argonne also has practical importance for reactor hazards evaluation. This extension entails a large-scale program on the toxicity of mixed fission products in dogs, in which attention will be paid to mixtures that are typical of the effluent from accidental reactor excursions.

WORLDWIDE FALLOUT STUDIES

During the year substantial progress was made in the studies of worldwide radioactive fallout from weapons tests. United States scientists attended information meetings on special topics such as techniques of atmospheric sampling, intensified sampling and analysis associated with Operation HARDTACK, and periodic reviews of worldwide atmospheric transport and deposition data and theories. Joint meetings were also held with the British at Harwell and with the Canadians at Ottawa.

Responsibility for both administrative and technical supervision of all AEC contracts for radiochemical analysis of environmental samples was assigned to the Health and Safety Laboratory of the New York Operations Office. Exchange of samples for comparison of analytical results among AEC contractors, AEC laboratories, and cooperating Federal agencies was intensified.

In addition to the comprehensive tabulation of existing data on fallout that was issued in October,* a number of research papers on worldwide fallout by AEC and contractor scientists appeared in scientific journals.

The U. S. Weather Bureau expanded its activities relating to correlation and evaluation of worldwide fallout data and advised the AEC on sampling requirements. (End of UNCLASSIFIED section.)

HARDTACK Tracer Program [redacted]

Atmospheric sampling capabilities of the AEC, Air Force Cambridge Research Center, Air Weather Service, Armed Forces Special Weapons Project, and Naval Research Laboratory have been organized into a screen extending from the equator to polar latitudes of both hemispheres and from ground level to as high as 90,000 feet at several latitudes. During and immediately following the HARDTACK test series, samples were analyzed not only for fission products, but also for tungsten 185, which is present in debris from this test series in quantities sufficient for use as a worldwide tracer. Studies using this isotope are expected to provide new information on the movement and deposition of debris from equatorial tests. They already have shown that there was a rapid spread of material across the equator to the Southern Hemisphere under the particular meteorological conditions existing during this series.

Selected samples were also being analyzed for DELETED which was released as a tracer in one of the rocket shots over Johnston Island. It is a ques-

*"Environmental Contamination from Weapons Tests," HASL-42, prepared by the New York Operations Office. Copies have been furnished to the Joint Committee.

tion of great interest whether, and how rapidly, the finely divided debris from such a high altitude burst returns to the lower atmosphere. [redacted]

Ground-Level Fallout Monitoring (UNCLASSIFIED)

The worldwide network of high-walled steel pots, which are used for collecting monthly samples of rain and fallout, was expanded from 25 to 29 stations during the year. Replacement of the pots by a new collector employing a funnel and ion exchange column was under way at the end of the year.

The "washtub" program, in which larger collectors (approximately 5 square feet in area) are sampled after each significant rain, was expanded from one station at Pittsburgh, Pennsylvania, to five stations in the United States (Pittsburgh; Westwood, New Jersey; Richmond, California; Houston, Texas; and Louisville, Kentucky), and arrangements were made with the Department of Scientific and Industrial Research, New Zealand, to operate a similar sampling station at Gracefield, New Zealand. At these stations, shorter lived isotopes are measured as well as strontium 90 in order to learn more about the origin of the fallout.

Stratospheric Monitoring

Two new types of stratospheric sampling devices were flown by the Balloon Division of General Mills, Inc., at Minneapolis. These are an improved filter device developed by General Mills and an air liquefaction apparatus developed by Chicago Midway Laboratories, Inc. Two new contractors began research and development on other promising concepts of stratospheric particulate sampling. One contractor, Del Electronics, Inc., is developing an electrostatic precipitator which, if successful, would collect very small particles with high efficiency. Because resistance to air flow is negligible in this type of collector, power and weight requirements may be reduced. The second contractor, Western Precipitation Corp., is studying the feasibility of adapting a newly developed centrifugal collector to stratospheric conditions. This system, if successful, would have the most accurately predictable collection efficiency.

It is planned that the present stratospheric monitoring program (Project Ash Can) will be reduced to two domestic stations during calendar year 1960. This decision is partly a result of the decision by the Air Force to curtail their own balloon flight program, which has borne the major operational costs of the AEC Ash Can program. Future plans for stratospheric monitoring will be based on results of current studies of the data collected so far, on progress in developing more efficient and economical methods of collection such as those mentioned in the preceding paragraph, and on future stratospheric contamination.

Food Sampling for Fallout Contamination

The U. S. Public Health Service has been developing and expanding its United States liquid milk monitoring program. The U. S. Food and Drug Administration monitors other commercially important United States and imported foods. The AEC has noted the development of these surveillance programs with interest and has cooperated in providing information and data to speed their development.

During the interim period until the Food and Drug Administration (FDA) can obtain for itself adequate chemical analysis facilities, the Lamont Geological Observatory, under contract to the AEC for fallout studies, has agreed to perform a limited number of chemical analyses for FDA. In return, FDA will act as a collecting agent to provide food samples of interest to Lamont's scientific programs.

[redacted]

Foreign food samples will also be provided to Lamont by the U. S. Interdepartmental Committee on Food and Nutrition for National Defense, to which the AEC contributes some support.

Biological Hazard of Carbon 14 from Nuclear Weapons

An unclassified AEC report on the biological hazard of carbon 14 was issued during the year* and was reprinted, with minor alterations, in the magazine *Science*.

In essence, the report states that the hazard from carbon 14 arises not only from the effect of the ionizing beta radiation emitted by carbon 14, but also from the so-called transmutation effect. The transmutation effect is the effect on genetic mutation rates of the disintegration of carbon 14 atoms originally a part of the organic molecules of deoxyribonucleic acid in the germinal cells. When these atoms disintegrate, they are no longer carbon 14 atoms and therefore the organic molecules are in some manner disturbed. This may lead to a mutation.

The report states further that, even including the transmutation effect, the genetic hazard of carbon 14 from weapons testing to date is only about one-tenth of 1 percent of the natural carbon 14 genetic hazard, and that the latter in turn is only about 1 percent of the genetic hazard from all natural background radiation over the same period.

General Levels of Worldwide Fallout in 1958

Fallout levels continued to rise during the year as testing continued and as material already stored in the atmosphere continued to fall out.

The rainfall collections in New York City indicated a rise of about 10 millicuries of strontium 90 per square mile for the year for New York City, with full data not yet available.

The results of analysis of 12 sets of soil samples collected from irrigated pastures and other types of land in California, Nevada, and Utah during 1957 after Operation PLUMBBOB indicated strontium 90 deposition levels of from 5 to 45 millicuries per square mile, values that are not very different from values recorded all over the world, away from any test site. Analyses were not yet completed on additional soil samples from types of land not represented in the first 12 sets of samples.

During the part of 1958 for which data are available, strontium 90 levels for liquid milk in New York City ranged from 3 to 5 strontium units, which represented lower values than were recorded in 1957. The milk in Mandan, North Dakota, which had been up to about 30 strontium units in 1957, ran at about 15 strontium units in early 1958 and then rose again to about 22 strontium units toward summer. These findings strongly indicate that direct leaf pickup is more important for grasses than is root pickup in times of increased rate of tropospheric fallout from weapons testing.

Research on the Internal Effects of Strontium 90

Studies with rats at the University of Rochester showed that feeding strontium 90 for 10-day periods at different dose levels produced observable effects depending on the body

* "The Biological Hazard to Man of Carbon 14 from Nuclear Weapons," WASH-1008. Copies have been furnished to the Joint Committee.

burden of strontium 90. A retained body burden of about 1 microcurie of strontium 90 produced no visible damaging effects nor life shortening over a period of 20 months, while one of 2 microcuries likewise gave no visible effects in 16 months, although tissue effects were noted. When the burden was 15 microcuries of strontium 90, the life span was decreased, and a 20 percent incidence of bone sarcoma was found.

An experiment was completed at Argonne National Laboratory which involved injecting mice with strontium 90 at varying dose levels. On the basis of injection of 960 mice, it was concluded that the data do not warrant an interpretation of linearity in dose response at low levels which are still hundreds of times greater than the levels to which man is exposed. Other experiments with rats, cats, and dogs are continuing.

A large-scale project was under way at Davis Campus, University of California, to test the acute and chronic effects of strontium 90, given orally, on the growth and development of the beagle skeleton. Toxicity levels were being established and skeletal norms worked out, but insufficient time had elapsed for possible tumors to appear.

Clinical studies using strontium 85, whose short half-life of 65 days makes possible its use in tracer doses in human patients, are proceeding at five hospitals, two in New York City and one each in Chicago, Omaha, and Los Angeles. Strontium 85 has the further advantage of being a gamma emitter, and its distribution in the living body can be followed by an external scanner. These studies are directed toward determining the comparative metabolic turnover of calcium and strontium, as well as possible means of removing strontium from the skeleton where it deposits.

The largest program on toxic effects of strontium 90 is at the University of Utah. Purebred beagles are given a single injection of either strontium 90 or radium at an early age and are followed throughout their life span. These experiments are based on the fact that considerable data already exist on the effects of a known body burden of radium in man. The best known group of documented radium cases is the so-called radium dial painters. Some of the dogs are given radium injections at doses which cover the range of internal radiation found in the human radium cases. Other dogs are given strontium 90 in doses which duplicate the radium burdens. It is believed that any observed parallelism between radium and strontium in dogs can be profitably extrapolated back to man.

Major areas of research under way at the Laboratory of Radiation Biology, Cornell University, include (1) preparation of an annotated bibliography containing abstracts of all available papers and reports on strontium, iodine, and cesium as related to the fallout problem, (2) factors affecting secretion of radioactive materials in milk, (3) deposition and removal of radioisotopes from the body, (4) fission product metabolism and response in laboratory and domestic animals, (5) clinical estimation of thyroid function in the dog, and (6) estimation of tissue dosage from internally administered radioisotopes.

Research in Soils and Plants

The uptake by barley plants of strontium 90 applied at various depths of a California soil (Columbia, a very fine sandy loam) in lysimeters, was measured under both irrigated and non-irrigated moisture treatments. Results indicate that for some plants, soils, and moisture conditions, deep plowing of surface soil contaminated with strontium 90 to a depth of 2 feet or more should reduce appreciably the introduction of this isotope into food chains.

In another lysimeter experiment with the same soil and crop, determination was made of the uptake of strontium 90 from artificially contaminated saline ground water maintained at

depth of 18 or 42 inches. Although there was upward movement of salt from the water table under all the various irrigation and cultivation treatments, the uptake of strontium 90 was relatively small. This suggests that for similar soils the danger of contamination of crops such as barley with strontium 90 from contaminated groundwaters is slight. A possible explanation is that the strontium ions become tightly adsorbed on soil colloid surfaces at depths considerably below the water table as soon as the contaminated water comes in contact with the soil.

Under some conditions, or as a last resort, the decontamination of agricultural land heavily contaminated with fallout from nuclear weapons or nuclear reactors might have to be accomplished by the physical removal of a layer of surface soil, standing crops, or crop residues. Field plot experiments to compare the effectiveness of various power implements and removal methods for this purpose were begun in 1958. The first experiment indicated that the removal of contaminated grass sod by a sod cutter and of thick straw mulches by a side delivery rake were relatively effective. Mowing of Sudan grass and soybean plants, followed by flail chopping of the stubble, was less beneficial. In a second experiment, the removal of a 2- to 4-inch layer of bare soil by a road maintainer, with the blade mounted between the two pairs of wheels, was highly effective when the ground surface was relatively level. Plowing the surfaces did not provide acceptable contamination reduction. The disposition of the removed contaminated soil or safe land management in its presence requires further consideration.

Research on Uptake of Cesium 137

An experiment was conducted at Hanford in an artificial pond 30 feet in diameter to test the hypothesis that the availability of cesium 137 in food chains originating in aquatic environments is greatly different from its availability in terrestrial food chains. The results of uptake of cesium 137 in the experimental aquatic food chains were reported in terms of concentration factors, that is, the ratio of the concentration of cesium 137 in the organism to that in the water. The organisms analyzed included algae, submerged, floating, and emergent seed plants, snails, tadpoles, bullfrogs, carp, sunfish, and dragonfly nymphs. All organisms accumulated concentrations of cesium 137 much higher than the concentration in the water. The vertebrate predators showed the highest cesium 137 concentrations of all the organisms analyzed. Of the plants, the algae and the submerged seed plants showed the highest concentration factors. Aquatic plants accumulated at least 500 times as much cesium as plants grown in soil. Animals feeding on these plants have an enriched source of cesium 137 and will become more contaminated than those obtaining their food through terrestrial food chains. It is reasonable to conclude that under certain circumstances hazardous quantities of cesium 137 could be ingested by man in foods derived from aquatic environments.

OPERATION HARDTACK RADIATION MEASUREMENTS

Pretest and posttest radiation surveys were made in the Pacific area in connection with Phase I of Operation HARDTACK. Data from these surveys are summarized in the AEC's Twenty-fifth Semiannual Report to the Congress. Preliminary data on levels of radiation in the vicinity of the Nevada Test Site resulting from the Nevada phase of HARDTACK are summarized in the same report.

A special report on radioactive contamination from the Nevada phase of Operation HARDTACK in the area around Los Angeles, California, during the latter part of October and the

first part of November was transmitted to the Chairman of the Joint Committee on Atomic Energy on December 22, 1958.

CIVIL EFFECTS ACTIVITIES

Participation in Operation HARDTACK*

Important results were obtained in projects conducted by the AEC Civil Effects Test Group (CETG) during Phase II of Operation HARDTACK at the Nevada Test Site which added to the understanding of radiation attenuation and the effects of blast on structures. Data obtained from a program to measure the angular distribution of prompt gamma and neutron radiation and to test shielding characteristics of light frame houses are expected to advance the combined Oak Ridge National Laboratory–Atomic Bomb Casualty Commission program for determining dosage to populations exposed to atomic bombs.

In another CETG program, airborne monitoring techniques were used to measure environmental radiation contamination around the Nevada Test Site. These measurements provide a base for future environmental studies.

The Office of Civil and Defense Mobilization also carried out several projects during Phase II of Operation HARDTACK.

Community Shelter

As a result of experiments conducted during the 1957 test series at the Nevada Test Site, the AEC has developed improved criteria and specifications for an underground shelter large enough to accommodate 100 persons for prolonged periods. An AEC contractor is preparing scaled drawings, outline specifications, and a bill of material for such a shelter in sufficient detail to permit its construction in any part of the country.

Although this shelter is being developed primarily to provide a relatively economical structure that could be used for the protection of personnel at AEC facilities, such a shelter would be immediately adaptable to any group requiring a protective facility.

There is little knowledge on the response of people to prolonged occupation of a shelter, and an experiment is being planned to obtain information on human behavior patterns as they appear over the course of a week or longer in a closed shelter.

Evaluation of Shielding

In May 1958 the AEC conducted an experiment at the Nevada Test Site to determine the shielding afforded by typical residential structures. Listed below are some of the conclusions drawn from this experiment, in which a large number of cobalt 60 sources were employed in such a manner as to simulate the radiation field of fallout.†

1. The most effective shielding material is that which is in the direct line of radiation.

* More detail on civil effects test activities is included in the Twenty-fifth Semiannual Report to the Congress.

† Results of this experiment have been published in "Evaluation of the Shielding Against Radiation Provided by Typical Residences," CEX 58-1, available from the Office of Technical Services, Department of Commerce.

2. Reduction of streaming of radiation through openings into basements and openings in concrete, brick, or block houses increases the effectiveness of the home as a shelter. For basements of brick and wood frame houses radiation is reduced by about a factor of 30.

3. Kitchen and bathroom fixtures cast shadows which give additional radiation protection, and the location of shelter areas to include shielding from such fixtures can increase the shielding potential of a home.

4. Dose rates are appreciably decreased behind chimneys and inside fireplaces.

5. An improved shelter consisting of a heavy table placed in the corner of a basement and covered with 7½ inches of concrete block reduces the radiation by a factor of 200 to 1,000.

6. The contribution of fallout on roofs of 2-story houses to the dose rate on the first floor is about one-tenth that from fallout on the ground outside.

The data obtained from this experiment are of immediate value to Federal agencies, builders, architects, engineers, and other technical personnel concerned with the construction of fallout protection in the home or with modifications and improvisations to improve shelter against fallout in existing homes.

Radiological Survey Vehicle

Data were collected in an experiment at the Nevada Test Site in May 1958 on which to base specifications for a vehicle equipped with radiation sources and instruments for evaluating the shelter characteristics of homes. A test vehicle is being developed by an AEC contractor, and trial runs are to be made, using the typical residences at the Nevada Test Site, in order to prove out the technique, to refine the procedures for deploying the radiation sources and measuring instruments, and to establish safe operating procedures.

When this survey vehicle has been perfected, it will be possible to evaluate the protection against fallout radiation afforded by individual homes, to point out to the homeowner the safest place in the house, and to suggest means for further improving the available protection. By this means the nucleus of a home protection plan can be established.

Combination Radio-Radiation Detector

In 1957 two experimental models of an instrument which combines a portable transistor radio and a radiation dose rate meter were fabricated, and in 1958 Radio Corporation of America manufactured 25 prototype instruments which have been purchased for evaluation and testing purposes. It is hoped that this unit will ultimately be commercially produced and marketed as a "citizen's instrument" which will serve the dual purpose of providing an individual with the means for measuring directly the radiation hazard in his environment and at the same time keeping him informed regarding official civil defense announcements.

Collaboration with the Office of Civil and Defense Mobilization

Close cooperation in civil defense matters continues between the AEC and the OCDM. In addition to participating in more formal meetings, members of the AEC staff are in daily contact with OCDM staff on matters of mutual interest ranging from technical information to emergency operations of government.

Work progressed on the completion of final reports of technical and scientific projects in the weapons test series including those of HARDTACK Phase II. These projects produce information useful to civil defense planning on such subjects as shelters and radiological defense

and involve not only OCDM-sponsored projects but also those designed and executed by AEC and its contractors.

OCDM and OCDM contractor personnel participated in the technical projects designed to obtain data on the shielding characteristics of typical residences, and in the planning of a project to obtain similar data for the multi-storied AEC headquarters building at Germantown. The information developed will be useful to shelter analyses conducted by civil defense authorities.

Greater public awareness of the problems of civil defense is sought by the AEC. Noteworthy in this educational effort have been the public statements of Commissioner Libby with respect to the hazard from wartime fallout, the critical need for shelters to protect the population against radiation from such fallout, and the need for radiation detection instruments which will allow the individual to appraise the hazard in his environment.

TREATMENT OF RADIATION INJURY

Oak Ridge Accident Cases

The criticality accident at Oak Ridge in June 1958 involving eight men focused attention on an aspect of the treatment of radiation sickness which had not been properly developed, namely, to provide the patients with superior nursing care and not to employ any therapeutic measures unless definitely and precisely indicated. It was decided to treat these cases in this manner because (1) the exact composition and size of the radiation dosage received by the men were not immediately known, (2) the clinical appearance of the patients was reassuring, (3) it was recognized that most of the suggested procedures were of a supportive nature, and (4) these men were in a state of excellent health and nutrition at the time of the accident.

The patients' subsequent conditions were characteristic of what was to be expected according to previous data, and the five of the eight with the highest dosage gave clear physiological evidence of severe radiation effects. Nevertheless, they recovered from the acute effects with minimum clinical illness. It is impossible from so few cases to make a reliable decision as to why these patients recovered so well, since the dosage subsequently was agreed to be in the lethal range, but it is reasonable to suspect that the physicians' minimal interference with the normal reparative process of the body was a significant factor. This concept of noninterference is believed to be an important step in arriving at effective treatment of radiation sickness. This approach has been verified in animal experiments at Brookhaven National Laboratory and the University of Rochester Atomic Energy Project.

Had the decision been to treat vigorously, the patients would have received antibiotics and fluids, including fresh whole blood, as "standard" agents, and bone marrow transplants and various types of blood platelet preparations among the more clearly recognized experimental procedures. All of these therapeutic agents were ready for use on a standby basis, but were not used.

The success of the conservative treatment of the patients at Oak Ridge has led to several conferences, notably one with AEC plant industrial physicians and one with medical research scientists interested in this field.

Bone Marrow Transplantation

Transplantation of bone marrow for the purpose of providing the irradiated person with stem cells for regeneration of the blood cells is a rather well developed technique now in

some species of animals, and there is reason to believe that it might work in man under the proper conditions. In the absence of accidentally irradiated persons, a number of clinicians working under AEC contracts are endeavoring to develop and apply in persons having various related blood diseases the principles of transplantation which the basic scientists have worked out in animals. In some clinics persons with fatal leukemia are receiving whole body irradiation to destroy the leukemic cells, followed by marrow transplants. Occasionally, other persons with rare conditions are receiving irradiation to depress the antigenic process, primarily for the purpose of increasing the chances of securing the successful transplantation of an organ such as a kidney from a donor. It should be recognized that efforts to transplant bone marrow are a step toward general organ and tissue transplants; the bone marrow is a good tissue with which to develop the principles, since it does not involve the secondary question of ingrowth of a blood supply.

TRAINING AND EDUCATION

Fellowships

AEC special fellowships in the fields of radiological physics, industrial medicine, and industrial hygiene were continued during the year, with no expansion in the program. Since 1955, about 8 appointments have been made each year in industrial hygiene and 8 in industrial medicine; over 400 fellows have studied under the radiological physics program since its beginning in 1948.

Assistance to States

In 1958 the AEC instituted a program of special financial assistance for a year's training in radiation control for employees of state agencies having responsibility in the area of radiation control, and for other persons sponsored by these agencies as potential employees. Starting in the fall of 1958 and continuing through the current academic year, four persons sponsored by state agencies are attending a course in radiation control at the School of Public Health of the University of Michigan. In conjunction with this course, 8 to 10 weeks of in-plant training is given at an AEC installation, where the trainee may participate directly in the daily operations at the plant and gain practical knowledge of radiation control. This program will be expanded in the 1959-60 academic year to include more trainees and additional training centers.

Plans were also being developed, in cooperation with the U. S. Public Health Service, for a shorter training program for state employees which will condense a year's training into 1 semester of intensive course work and 1 month of field work. This program is planned to fulfill a demand for a shorter period of training, but it in no way substitutes for the longer and more comprehensive training program.

Assistance to Colleges and Universities

Laboratory equipment grants of $1.2 million were awarded to 87 schools in the year ending December 31, 1958, to assist and encourage educational institutions in offering courses in nuclear technology as related to the life sciences. Altogether, 120 grants amounting to $1.4 million have been made to 92 schools since the first awards were made in October 1957.

The summer of 1958 was the third summer in which the AEC sponsored institutes in radiation biology for high school science teachers. Two hundred and forty high school teachers from 41 states and the District of Columbia received training at 12 universities. Beginning

with 3 institutes in 1956, the program increased to 5 in 1957, 12 in 1958, and will be increased to 15 in 1959. Approximately 400 high school science teachers have received training through this program.

Harvard University, one of the participating universities, is to undertake, under AEC contract, the preparation of a manual of laboratory experiments and demonstrations in applications of radioisotopes in biology. The manual will be suitable for use in high school classes and laboratories and tailored to the demonstration-teaching kits provided to the teachers by the AEC. Arrangements are also being made for providing radioisotopes under general license to those teachers who have completed the summer course.

A new program of summer institutes in radiation biology for college biology teachers will be initiated in the summer of 1959. Two institutes will be held the first summer, one at the University of Washington, Seattle, and one at the University of Michigan, Ann Arbor. Twenty teachers from small colleges will attend each institute.

Under the program of visiting lecturers, 23 scientists visited 26 schools during the past year. During the week's time spent on each campus, prominent scientists engaged in research or teaching in the field of radiation biology, give lectures, are interviewed, and consult with students and faculty members. (End of UNCLASSIFIED section.)

EXTRANEOUS MATERIAL DELETED

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