rate of exposure. It was also found that the germ cell in the female mouse is so resistant to mutation induction by radiation that no significant increase over naturally occurring, spontaneous mutation rates has been detected in the irradiated animal.

These last two findings together suggested that genetic risk in man is only about one-sixth of what it was estimated to be when radiation exposure limits were based on high dose-rate results and on the assumption that females and males were equally sensitive. Although the findings did not lead to the raising of permissible levels of radiation exposure, they did provide a cogent argument for no further lowering of permissible levels.

5. *Supporting Animal Studies.* To interpret experimental results, it was necessary to understand the natural changes occurring in animals being studied, that is to study the role of aging and to gain a better understanding of the biological process of aging itself. Strong support was given to recording and analyzing specific biological parameters such as brain mass, metabolic rate, body temperature, and body mass—important parameters that correlate with and serve as actuarial predictors of longevity in animal species. The white-footed field mouse and the common laboratory mouse were particularly useful in this regard. Although these two species are similar in coloration, form, and size, the field mouse has a lifespan of nearly 8 years while the laboratory mouse seldom lives longer than 3 years. Additional aspects of aging and longevity are being explored and include immunologic factors and possible relationships between the aging process and cellular DNA repair.

Evaluation of Exposure Potential to Workers and the Public Detailed information on appropriate industrial hygiene practices was developed to ensure safe operation of industries that use radiation sources and radioactive isotopes and to ensure public safety. This information was developed through major OHER-supported research and educational programs in the areas of radiation monitoring; dosimetry and toxicology; air, water, and soil analysis; bioassay; and health risk and analysis. These are now broadly included in the field of health physics.

To evaluate radiation exposures of workers in nuclear industries, health physicists needed devices to measure radiation from external sources and bioassay methods to determine the amounts of radioactivity that may have been taken into the body. Personal dosimeters were developed, first from radiation sensitive film and then from thermoluminescent crystals. Biological assay or bioassay techniques were developed that used radiation counters that measure radiation absorbed by the body, excretion assays, and biomathematical models of the metabolism of internally deposited radionuclides. These techniques have provided working lifetime records of external radiation exposures and the amounts of radioactivity that may have been taken into the body. Exposure records are available today for most workers in industries using radioactive processes or equipment and can be used to evaluate the potential for an individual developing a radiation-related injury.

Extensive research programs were initiated and expanded to develop models needed to project the dispersion of radioactivity in the environment and its uptake and retention by people. Models are currently available to predict transport of radioactivity through air, groundwater, and soil. Other biological research programs have produced models to project the transfer of radioactive isotopes through food pathways to man and their uptake from food, water, and air.

Large research and educational programs were established during the 1940's and 1950's to study radiation concerns of the future. Graduate level training programs were begun at the University of Rochester, Harvard University, Vanderbilt University, and the University of California, among others. They were also coupled to research programs at several National Laboratories supported by the AEC. The majority of trained health physicists working in nuclear industries today are graduates of these programs.

The radiation monitoring instruments, measurement techniques, and models described above are the major tools used by health physicists in industry and Government safety programs to evaluate human radiation exposures at operating plants and facilities. They were mainly developed in DOE-supported research programs and have been used for many years to provide exposure records and risk evaluations for radiation workers and members of the general public. The nuclear industry is unique among industries that handle potentially toxic substances because of the state of development of its detailed methods to characterize or document human exposures.

Currently, about 200,000 people in the United States have occupations that involve handling radiation sources and radioactive isotopes. Their safety depends on proper application of radiation exposure standards and the abilities of health physicists to measure and record exposures. Thus, the most important uses of technology developed in radiation research programs supported by DOE and its predecessor agencies are in industrial hygiene and radiation safety.

Benefits of Nuclear Technology Research The bulk of worldwide regulatory and environmental assessment action regarding nuclear power is based largely on the body of knowledge acquired in the OHER Program.

A concrete example of a benefit of this information is to United States electric power consumers in a recent decision by Federal