regulators to maintain standards in the workplace at the same level as those maintained for the past 25 years. It can be estimated what a given reduction in the worker exposure limit would cost; and, thus, what value these studies have had for the consumer/taxpayer. For example, a reduction of the annual worker exposure limit from the current 5 rem*/year to 0.5 rem/year would cost the Government and industry nearly $2 billion/year. In both commercial and DOE facilities, moreover, the increase in number of work crews required to reduce exposure times would, in turn, increase cumulative exposure because each worker receives some fraction of his or her exposure during the nonproductive time spent in removing contaminated protective gear. The greater the frequency of such changes, the greater cumulative exposure to perform the same amount of work. For a 0.5-rem/year limit, the Atomic Industrial Forum estimates an increase of 5400 man-rems/year for the power-reactor industry and an increase of 2300 man-rems/year for DOE's various programs. While there is substantial uncertainty in the financial evaluation of increased radiation exposure, the 7700 man-rems/year increase is certainly significant.

Because research supported by DOE and its predecessor agencies has put industrial radiation protection practices on a firmer scientific basis, these practices can readily be defended in legal actions taken against the United States Government and its contractors. OHER's research does not serve as part of Government advocacy but, rather, provides a scientific basis upon which claimants' injuries can be assessed and equitable decisions can be reached. One example involved a claim against the DOW Chemical Company, Rockwell International, and the United States Government for $200 million in damages alleged to have been caused by plutonium spilled at the Rocky Flats nuclear weapons facility between 1959 and 1965. Small amounts of plutonium were blown by the wind into neighboring lands. The claim, filed in 1975 in District Court in Denver, Colorado, was dismissed in May 1982 because the Government, and its contractors were able to demonstrate acceptably to all parties that the level of plutonium outside of the Rocky Flats facility did not represent a significant hazard.

*The amount of ionizing radiation required to produce the same biological effect as one Roentgen of high-penetration X-rays.

Our understanding of the role of dose rate in risk estimation was significantly enhanced by the animal studies. Studies on mice, for example, demonstrated for the first time that for the same cumulative dose of radiation, fewer mutations and cancers are produced in animals receiving low dose rate exposures than in those receiving the same exposure at a high rate. Furthermore, it was shown that the same total amount of radiation delivered in smaller increments to mice was less damaging than when delivered as a single exposure. These data showed that mammals other than man are capable of repairing damage to cells involved in transmitting the genetic information from one generation to the next. A careful evaluation of the same endpoints from the radiation exposures of mice, dogs, and man has provided a model for the scaling of radiation effects between the species. Animal studies are also providing information on differences in radiation sensitivity as a function of the age when irradiated. The positive contribution is to provide sound scientific data that are essential for those charged with developing guidelines for the protection of human health.

The radiation biology research program and the applied studies in radiation effects continue to hold great promise of a better understanding of biological processes and of treatments and therapies for a number of human diseases. Research to date has led to a host of theories on the possible causes of genetic diseases, birth defects, aging, and cancer, as well as to advances in immunology and treatment. Much of this research may eventually resolve the question of the existence of a threshold for radiation damage.

Simple discoveries, such as the use of tritium-labeled thymidine as a DNA precursor, were instrumental in helping characterize DNA replication and recombination in mammalian cells, as well as the properties of the different phases of the cell cycle. A knowledge of such phases is important not only in the estimation of mutagenic and carcinogenic risk, but also in radiation therapy as well.

Synthetic Fuels Human epidemiological studies provide the most direct information for developing relationships between levels of exposure and health risks. However, these studies are rarely available for industrial products not already on the market, as is the case for the products of such technologies as oil shale or synthetic oil from coal. Thus, laboratory studies are generally undertaken to provide the needed information. These usually begin with studies using bacteria and mammalian cells in cultures (see Fast Test for Cancer-causing Chemicals in "Detection and Measurement of Human Health Effects") and may progress to exposures of whole laboratory animals by skin painting, inhalation, or ingestion. Because costs of these studies increase markedly with the level of complexity, most elaborate life-span studies using laboratory animals are undertaken only when the less costly cell culture assays indicate a potentially important human health concern.

Mathematical methods are also being developed to combine the results of short-term bioassay tests, whole animal studies, and human epidemiology to predict the health risks associated with new chemical substances. With these methods the toxic potential of new substances is determined through comparison with other substances that act in similar ways and for which human health risks have been measured. Human health risks can thus be estimated per unit of exposure, providing the