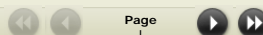


**Health Risks from Exposure to Low Levels of Ionizing Radiation: BEIR VII Phase 2 (2006)**
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RESEARCH TOOLS

HEALTH RISKS FROM EXPOSURE TO LOW LEVELS OF IONIZING RADIATION

BEIR VII PHASE 2

*Committee to Assess Health Risks from Exposure
to Low Levels of Ionizing Radiation*

Board on Radiation Effects Research

Division on Earth and Life Studies

*NATIONAL RESEARCH COUNCIL OF THE
NATIONAL ACADEMIES*

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Figure 8 Exposure to Low Levels of Ionizing Radiation: Box VII Phase 2 The NATIONAL ACADEMIES' Adversity to the Nation's Science, Engineering, and Medicine The National Academy of Sciences is a private, nonprofit, self-perpetuating society of distinguished scholars engaged in scientific and engineering research, dedicated to the furtherance of science and technology and to their use for the general welfare. Upon the authority of the charter granted to it by the Congress in 1963, the Academy has a mandate that requires it to advise the federal government on scientific and technical matters. Dr. Ralph J. Cicerone is president of the National Academy of Sciences. The National Academy of Engineering was established in 1964, under the charter of the National Academy of Sciences, as a parallel organization of outstanding engineers. It is autonomous in its administration and in the selection of its members, sharing with the National Academy of Sciences the responsibility for advising the federal government. The National Academy of Medicine was organized in 1970 under the charter of the National Academy of Sciences to identify and study the highest achievement in medicine and public health care, to establish and support programs free of local conflicts of interest and to advise the federal government on medical care, research, and education. Dr. Harvey V. Fineberg is president of the Institute of Medicine. The National Research Council was organized by the National Academy of Sciences in 1916 to associate the broad community of scientists and technologists with the Academy's purposes of furthering knowledge and advising the federal government. Functioning in accordance with general policies determined by the Academy, the Council has become the principal operating agency of both the National Academy of Sciences and the National Academy of Engineering in providing services to the government, the public, and the scientific and engineering communities. The Council is administered jointly by both Academies and the Institute of Medicine. Dr. Ralph J. Cicerone and Dr. Wm. A. Wulf are chair and vice chair, respectively, of the National Research Council.

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Health Risk from Exposure to Low Levels of Ionizing Radiation: BEIR VII Phase 2 Preliminary BACKGROUND. This is the first in a series of reports from the National Research Council (NRC) prepared to advise the U.S. government on the relationship between exposure to ionizing radiation and human health. In 1996 the National Academy of Sciences (NAS) was requested by the U.S. Environmental Protection Agency to initiate a scoping study regarding a new review of the health risks from exposure to low levels of ionizing radiation. The main purpose of the new review would be to update the Biological Effects of Ionizing Radiation (BEIR) VI report published in 1990, using new information from epidemiologic and experimental research that has accumulated during the 14 years since 1990. Analysis of those data would help to determine how regulatory bodies should best characterize risks at the doses and dose rates relevant to most workers and members of the general public. BEIR VII-Phase I was the preliminary scoping study; to evaluate whether it was appropriate and feasible to conduct a BEIR VII-Phase 2 study. The Phase 1 study determined that it was appropriate and feasible to proceed to Phase 2. The Phase 1 study, Health Effects of Low Levels of Ionizing Radiation: Report for Biotechnology¹, published in 1998, also provided the basis for the Phase 2 Statement of Task that follows. BEIR VII-Phase 2 STATEMENT OF TASK. The primary objective of the study is to develop the best possible risk estimate for exposure to low-dose rate ionizing radiation. The committee will address the following issues: (1) Consider a comprehensive range of potential endpoints, including cancer and noncancer effects, as well as genetic and cellular damage, reproductive outcomes, and other adverse biological effects. (2) Develop estimates of relative biologic effectiveness, genomic instability, and adaptive responses and appropriate methods. (3) Consider the current literature and available data on the topics of carcinogenesis and noncarcinogenesis, including critical assessment of all data that might affect the shape of the response at low doses, in particular, evidence for or against thresholds in the response relationships and evidence for or against adaptive responses and radiation hormesis; (4) consider, when appropriate, potential target cells and problems that might exist in determining dose to the target cell; and (5) consider any recent evidence regarding genetic effects not related to cancer. In performing the above tasks, the committee should consider all relevant data, even if obtained from high radiation exposures or at high dose rates, provided that they are relevant to the question being addressed. With respect to modeling, the committee will (1) develop appropriate risk models for all cancer sites and noncancer endpoints, including genetic effects, and (2) identify key areas where additional data are needed. The committee will consider individual susceptibility and variability, age, sex, environment (such as altitude and ultraviolet radiation), and life-style (such as smoking history and alcohol consumption) factors; and (3) identify critical gaps in knowledge that should be filled by future research. WHAT HAS CHANGED SINCE THE LAST BEIR REPORT ON THE HEALTH EFFECTS OF LOW LEVELS OF LOW LET IONIZING RADIATION IN THE 15 YEARS since the publication of the previous BEIR report on low-LET radiation (BEIR VI), much new informa-

Health risks from exposure to low levels of ionizing radiation. Since the VII Phase 2a has become available on the health effects of ionizing radiation. Since the 1990 BEIR V report, substantial new information on radiation-induced cancer has become available from the Hiroshima and Nagasaki survivors, slightly less than half of whom were alive in 2000. Of special importance are cancer incidence data from the Hiroshima and Nagasaki tumor registries. The committee evaluated nearly 13,000 incidences of cancer and 10,000 cancer deaths in contrast to fewer than 6000 cancer deaths available in the BEIR V committee. Also, since the 1990 report, new information has emerged from studies of the Hiroshima and Nagasaki atomic bomb survivors that about half of the health effects, such as cardiovascular disease and stroke, can result from radiation exposure. A major reevaluation of the dosimetry at Hiroshima and Nagasaki has recently been completed that lends more certainty to dose estimates, provides increased confidence in the relationship between radiation exposure and the health effects observed in Japanese A-bomb survivors. Additional new information is also available from radiation worker studies, medical radiation exposures, and populations with environmental exposures. Although the cancer risk estimates have not changed greatly since the 1990 report, confidence in the estimates has risen because of the increase in epidemiologic and biological data available to the committee. Progress has also been made since the 1990 report in areas of science that relate to the estimation of genetic (hereditary) effects of radiation. In particular, (1) advances in human molecular biology have been incorporated into the conceptual framework of genetic risk estimation, and (2) it has become possible to project risks for all classes of genetic diseases (i.e., those with more complex as well as simple patterns of inheritance). Advances in cell and molecular biology have also contributed new information on the mechanisms through which radiation causes cancer. The committee has also reviewed the epidemiologic and genetic data on the health effects of radiation in children. The committee was conducted with the assistance of the Board of Radiation Effects Research of the Division of Earth and Life Sciences. The committee held 11 meetings over a period of 4.5 years. The long duration of the committee was due largely to a period of reduced activity following completion of the update of the dosimetry and exposure estimates to atomic bomb survivors of the Hiroshima and Nagasaki, Japan (the so-called DS02: Dosimetry System 2002). Six of the meetings included participation of the public for a portion of the meeting, and five of the meetings were conducted exclusively in executive session. Each meeting included extensive deliberations involving the committee as a whole. In addition, two major subcommittees were formed that were termed "biology" and "epidemiology." Dr. Manson convened the epidemiology sessions and Dr. Cleaver convened the biology sessions. Also, a number of loosely organized and nonpermanent working groups were formed to discuss the many issues before the committee. This enabled biology and nontoxigenicity to work together and evaluate each other's work. ORGANIZATION OF THE REPORT As noted under its STATEMENT OF TASK, the committee's focus was to develop the best possible risk estimate for exposure to low-dose, low-LET radiation in human subjects. Accordingly, Chapters 1-4 discuss basic aspects of radiation physics and radiation biology, including the known interaction between radiation exposure and genetic material, cellular structures, and whole organisms. Chapters 5-9 provide an extended summary of the epidemiologic and genetic data on the health effects of radiation. Chapter 10 provides an extended summary of the epidemiologic and genetic data on the health effects of radiation. Chapter 11 provides an extended summary of the epidemiologic and genetic data on the health effects of radiation. Chapter 12 provides an extended summary of the epidemiologic and genetic data on the health effects of radiation. Chapter 13 is an overall scientific summary and lays out the research needs identified by the committee. The Executive Summary is an abbreviated and reorganized version of Chapter 13 that provides an overview of the report. The Public Summary addresses the findings of the committee and the relevance of the report to public concerns about exposure to ionizing radiation.

of page 99. Exposure to Low Levels of Ionizing Radiation: Box VII Phase 2 Reviewers This report has been reviewed in draft for editorial purposes chosen for their diverse perspectives and technical expertise in accordance with procedures approved by the National Research Council's Report Review Committee. The purposes of this review are to provide candid and critical comments that will assist the Institution in making the published report as sound as possible and to ensure that the report meets institutional standards for objectivity, evidence, and responsiveness to the study charge. The review comments and draft manuscript remain confidential to protect the integrity of the deliberative process. We wish to thank the following for their participation in the review of this report: Seymour Abrahamson, University of Wisconsin, Madison, WI; John A. Ahearn, Sigma Xi, The Scientific Research Society, Research Triangle Park, NC; Allan Balmink, University of California, San Francisco, CA; Michael Corns, University of Texas, Galveston, TX; James F. Crow, University of Wisconsin, Madison, WI; John Easton, University of Chicago Hospitals, Chicago, IL; Eric J. Hall, Columbia University College of Physicians and Surgeons, New York, NY; Richard D. Hichew, University of Iowa, Iowa City, IA; Heidi Hivick, Memorial Sloan-Kettering Cancer Center, New York, NY; Glenn E. Knoll, University of Michigan, Ann Arbor, MI; Jack S. Mandel, Emory University Rollins School of Public Health, Atlanta, GA; John P. Mursane, University of California, San Francisco, CA; Hooshang N. Niaz, University of California, San Francisco, CA; Robert O. O'Connor, University of California, San Francisco, CA; George M. Homburger, Ernest H. Professor of Environmental Sciences and Associate Dean for the Sciences, University of Virginia, and John C. Ballar III, Professor Emeritus, University of Chicago. Pointed out by the National Research Council, they were responsible for making certain that an independent examination of this report was carried out in accordance with institutional procedures and that all review comments were carefully considered. Responsibility for the final content of this report rests entirely with the authoring committee and the National Research Council. GENERAL ACKNOWLEDGMENTS The committee thanks the directors and staff of the Radiation Effects Research Foundation (RERF), Hiroshima, Japan, for providing the most current life span Study data on the Japanese atomic bomb survivors. These data continue to be the primary source of epidemiologic information on the relationship between exposure to ionizing radiation and its effects on human health. In particular, Dr. Donald Pierce was especially helpful in communication between RERF and the committee. He also aided in the consideration of its charge not only by comments from the public but also by formal presentations by experts from a number of fields. These presentations were made as part of the public portion of the meetings (in order of appearance):

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