RADIATION RISK ASSESSMENT

Workshop Proceedings

November 5 - 7, 2001
Las Vegas, Nevada

Co-Sponsored by:

U.S. Environmental Protection Agency

EPA

Japan Atomic Energy Research Institute

JAERI

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Agenda

EPA/JAERI Workshop Agenda

November 5

8:15	Registration/Coffee and Pastries Available in Skyview I Room
9:00	Welcoming Remarks – Richard Hopper, Deputy Director, EPA's Radiation and Indoor Environments Laboratory, Las Vegas and Shohei Kato, Deputy Director, Department of Health Physics, JAERI
9:20	Radiobiology Session (Part 1)
	Keynote Address: Recent Findings from DOE-funded Research into the Biological Effects of Exposure to Low Level Radiation – Antone Brooks, University of Washington
	JAERI Funded Research on Molecular and Cellular Mechanisms of Radiation Induced Cancer – Shin Saigusa, Radiation Risk Analysis Laboratory, JAERI
10:30 - 10:50	Break
10:50	The Application of Site-Specific Microbeam Irradiation in Defining a Bystander Effect – Charles Geard, Center for Radiological Research, Columbia University
	BEIR VII Committee Update – Rick Jostes, Board on Radiation Effects Research, National Academy of Sciences
	Open Discussion
12:00 - 1:30	Lunch (on your own)
1:30	Radiobiology Session (Part 2)
	Molecular Dynamics Simulation of Damaged DNA's and Repair Enzymes – Miroslav Pinak, Radiation Risk Analysis Laboratory, JAERI
	How Tissues Respond to Damage at the Cellular Level: Radiation Effects on Cell-Cell Communication – Mary Helen Barcellos-Hoff, Lawrence Berkeley National Laboratory
	Monte Carlo Simulation of Initial Process of Radiation-Induced DNA Damage – Presented by Miroslav Pinak, JAERI, on behalf of Ritsuko Wanatabe and Kimiaki Saito
3:00 - 3:30	Break (refreshments provided)
3:30	A Regulator's Perspective on Mechanistic Approaches to the Study of Radiation Oncogenesis and Risk Assessment – Lowell Ralston, Radiation Protection Division, US EPA
4:00 - 4:30	Session Wrap-Up: Open Discussion with All Presenters

November 6

8:00	Coffee and Pastries, Skyview I
8:30	Current Issues in Dosimetry Session
	Review of the NAS Report, A Status of the Dosimetry for the Radiation Effects Research Foundation (DS86) (2001) – Evan Douple, Director, Board on Radiation Effects Research, National Academy of Sciences
	Conversion from Tooth Enamel Dose to Organ Doses for ESR Dosimetry – Fumiaki Takahashi, External Dosimetry Laboratory, JAERI
	Dose Conversion Coefficients for High-Energy Radiations – Yukio Sakamoto, External Dosimetry Laboratory, JAERI
	Review of Work Related to ORNL's Collaboration with JAERI – Keith Eckerman, Oak Ridge National Laboratory
10:00 - 10:30	Break
10:30	Shielding Calculation Parameters for Effective Dose Evaluation – Yukio Sakamoto, JAERI
	Development of CT Voxel Phantoms for Japanese – Hiroshi Noguchi, Head, Internal Dosimetry Laboratory, JAERI
	Current ICRP Committee 2 Issues (Weighting Factors, New GI model, etc.) – Keith Eckerman, ORNL
	Evaluation of Specific Absorbed Fractions in Voxel Phantoms Using Monte Carlo Simulation – Hiroshi Noguchi (JAERI)
12:00 - 1:30	Lunch (on your own)
1:30	Developments in Radiation Risk Assessment Session
	An Uncertainty Analysis of EPA's Current Cancer Risk Coefficients – David Pawel, Radiation Protection Division, US EPA
	Effects of Baseline on Uncertainty of Radiation Risk Models – Shohei Kato, JAERI
	Detailed Dose Assessment for the Two Heavily Exposed Workers in the Tokai-mura Criticality Accident – Fumiaki Takahashi, JAERI
	Open Discussion
3:00 - 3:30	Break (refreshments provided)
3:30	An Overview of the Methodology Used to Develop Cancer Risk Coefficients in Federal Guidance Report No. 13 – Michael Boyd (EPA) and Keith Eckerman (ORNL)
4:30 - 5:00	Wrap-up of Day 2

November 7

8:00	Coffee and Pastries, Skyview I
8:30 - 10:00	Special Session on Current Issues in Risk Management and Radiation Protection Policy
	Update on the ICRP's Proposed Changes to the System of Radiation Protection – Shohei Kato (JAERI) and Michael Boyd (EPA)
	Unfinished Business: Assessing Genetic and Fetal Risks – Neal Nelson, Radiation Protection Division, EPA
	Derivation of Clearance Levels for Solid Materials in Japan – Akihiro Sakai, Department of Decommissioning and Waste Management, JAERI
	Developing a Technical Basis for Release of Solid Materials – Robert Meck, U.S. NRC
10:00 - 10:30	Break
10:30	A Status Report on Recent Activities Related to the WIPP and Yucca Mountain Projects – Scott Monroe (EPA)
	Safety Analyses for Shallow-Land Disposal of Alpha-Bearing Wastes – Hideo Kimura, Department of Fuel Cycle Safety Research, JAERI
11:30 - 12:30	Wrap-up Discussion and Adjourn Formal Meeting
12:30 - 2:00	Lunch
2:00	Optional Tours of EPA's Radiation and Indoor Environments National Laboratory and DOE's Yucca Mountain Visitors Center (Las Vegas)

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Participants

List of Workshop Participants

The following people attended the Workshop. They are listed below along with contact information:

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Introduction

For many years, the U.S. Environmental Protection Agency (EPA) and the Japan Atomic Energy Research Institute (JAERI) have been exchanging radiation science information under the terms of a Memorandum of Understanding supported by both organizations. In 1989 and 1994, the agencies held jointly sponsored workshops on residual radioactivity and recycling. The first workshop was held in the United States and the second was in Japan. The title of this third joint workshop, which was held in Las Vegas, Nevada, in November 2001, is "Radiation Risk Assessment in the 21st Century." The workshop explored recent scientific advances that contribute to improved human health risk assessments for exposures to radionuclides at environmental levels.

The three-day workshop was designed to increase understanding of the state of the science in both radiobiology and internal radiation dosimetry. There was also a session devoted to exploring the challenging, and sometimes contentious, issues that policymakers are wrestling with in assessing and managing radiation risk and in developing criteria for protecting human health. Presenters included radiation experts from JAERI, EPA, the Nuclear Regulatory Commission (NRC), the U.S Department of Energy, the University of Washington, Columbia University, the National Academy of Sciences, and Oak Ridge and Lawrence Berkeley National Laboratories.

Risk assessment and the science behind it were the focus of the first two days of the workshop. There were presentations on current cellular-level research into low dose effects being funded by the U.S. Department of Energy, computer simulation of radiation-induced DNA damage being conducted by JAERI, and current developments in biokinetics and the internal dosimetry models of the ICRP. As highlighted through these presentations, key questions that will need to be addressed in the new century are:

- What is the dose-response relationship at low doses of radiation exposure?
- How do laboratory observations in vitro compare to what actually is happening in a complex organism in vivo?
- How can we improve internal dosimetry models and better account for radiation dose distribution as a function of age, gender, and body type?
- How do we account for radiosensitive subpopulations?

The last day of the workshop was devoted to current events in the areas of risk management and radiation protection, including the follow-up to the licensing and certification efforts at the Waste Isolation Pilot Plant (WIPP) and recent activities regarding the Yucca Mountain regulations. The workshop concluded with a tour of EPA's Radiation and Indoor Environments Laboratory in Las Vegas.

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Radiobiology Session

Background

The Radiobiology Session was the largest session of the workshop with eight presentations. Distinguished radiobiologists and other radiation researchers shared the latest research in low-level radiation does effects, molecular and cellular mechanisms of radiation induced cancers, and microbeam irradiation / bystander effects. The research included topics in molecular dynamics of damaged DNA and repair enzymes, tissue response to cellular damage, and Monte Carlo simulation of DNA damage. Additional presentations included a regulator's perspective to the mechanistic approach to risk assessment and an update on BEIR VII activities.

Papers from Radiobiology Session

To follow are the papers written by the following conference presenters:

- Antone Brooks
- Shin Saigusa
- Charles Geard
- Rick Jostes
- Miroslav Pinak
- Mary Helen Barcellos-Hoff
- Ritsuko Wanatabe and Kimiaki Saito (presented by Miroslav Pinak)
- Lowell Ralston

Recent Findings from DOE - funded Research on the Biological Effects of Exposure to Low Levels of Radiation

Antone L. Brooks
Washington State University Tri-Cities

Abstract

This paper provides a brief review of the U.S. Department of Energy's (DOE) Low Dose Radiation Research Program and highlights some of the scientific advances made in the program. It discusses the problems associated with estimating the cancer risk following exposure to low doses of ionizing radiation and indicates that the high background rate for both radiation dose and cancer incidence makes it impossible to estimate risk at levels of radiation that are of concern in radiation protection. The DOE research program is then discussed as a new approach to helping with risk estimates. This paper reviews new paradigm shifts that are the result of the research and may have an impact on standards. These included: "Adaptive Response" versus "Additive or Synergistic Effects", the "Hit theory" versus "Bystander Effects", the "Role of "Mutations" versus "Gene Induction" in Cancer and the "Single Cell" versus "Tissue" responses. The research on these areas is providing a strong scientific base for the setting of radiation standards that are adequate and appropriate.

Introduction

The DOE Low Dose Radiation Research Program addresses the old problem of determining health effects following exposure to low doses of ionizing radiation. The research in the program is founded on extensive past scientific investigations triggered in part by the concern from fallout associated with nuclear weapons testing. As we know, the fallout was in and on everything, and resulted in low-level doses to both people and the environment. However, the question regarding fallout radiation exposure remains: Did the low doses from the fallout actually do anything that results in measurable health effects? If there were health effects from these low radiation doses, then it is very important for us to characterize them, since the methods of estimating the number of radiation-induced cancer at low doses can be rather large based on linear-no-threshold extrapolations. Current standards are set using this linear-no-threshold model rather than on real scientific data. Such extrapolations suggest that one particle or ionization results in one mutation, producing one cancer. Is the dose-response truly linear at these low doses, or are there biological processes that result in sub-linear or even super-linear responses to these very low doses? The DOE Low Dose Radiation Research Program addresses these questions.

Problems associated with Low Dose Radiation Risk Estimates

Two major problems make it hard to estimate cancer risks associated with low doses of ionizing radiation: the variable background exposure to ionizing radiation; and the high and variable background rate of cancer.

It is a well-known fact that we get about 370 mrem per year from different environmental radiation sources. Radon is calculated to be responsible for about half of this exposure. Our background dose can change according to where we live. The background level of radiation from cosmic-ray exposures can double from 24 mrem/year at sea level to 50

mrem/year in high elevation cities like Denver, Albuquerque and Salt Lake City (NCRP 1987). In other words, we can alter the dose or number of mrem we get by choosing where we live.

The level of radiation exposure that can be produced by any single exposure site is subject to regulation. For example, there is a discussion on whether to use 15 or 25 mrem as a clean-up standard for waste disposal sites. The difference between these two levels is trivial relative to increased health risk or the background radiation that we receive each year, but there is a very large cost associated with cleaning-up to the lower standard. It is important to realize that environmental exposures are usually a small fraction of the natural background and, as illustrated above, you can move from one location to another with a higher elevation and change your radiation dose. Many other factors can also influence background radiation such as the level of radon in our homes. Most of us aren't concerned about these low exposures relative to the location of our homes, but we are concerned about other changes that may impact background radiation. Multiple studies have tried to link cancer incidence to background radiation and have not demonstrated an association between them.

The other variable that makes it difficult to detect changes in risk following low doses of radiation is the high and variable background rate of cancer. Cancer frequency in any population is related to a large number of variables such as genetic background, environmental exposures, cigarette smoke, diet, and life style. All of these variables influence cancer risk. It is of interest to evaluate the cancer frequency as a function of the geographical distribution of the population in the United States. The National Institute of Health has evaluated cancer risk as a function of the county (Devesa et al. 1998). They have broken down in the cancer rate into percentiles. The cancer rate in the top 10 percentile of the population is as high as 800/100,000 per year. The rate in the bottom 10% is only 90/100,000. Such data illustrate that there is a huge variability in the cancer rates throughout the United States. For example, there is a strip of high cancer rates that runs up the lower Mississippi River. In addition, several big cities have high cancer rates, in comparison to other places. It's clear that this variability in cancer rate is not directly related to radiation because there are so many other factors that go into the equation. The NIH has published a map for every county site and for every cancer type. The cancer types are further broken down according to age, sex, and race. In fact, there is an entire book/series of these maps (Devesa et al. 1998). These maps are interesting and illustrate some of the problems of conducting epidemiology studies to relate cancer to radiation exposure. It is critical that both the background radiation and the background cancer rate be considered when trying to detect small changes in cancer rate associated with a small change in radiation exposure. Because of the limited sensitivity of epidemiology studies related to the discussion above, it is important to try to determine if changes in health effects are present, even if they are not detectable using standard toxicological or epidemiological approaches.

The Objectives of the DOE Low Dose Research Program

The Low Dose Research Program, started almost four years ago by the Department of Energy, was projected to last at least ten years with a funding level reaching $21 million per year. Currently, 54 projects are funded annually in hopes of better understanding the basic biological mechanisms that occur at low doses. That way, standards can be developed based on the best possible science.

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