The National Academies of
SCIENCES • ENGINEERING • MEDICINE

Developing a Long-Term Strategy for Low-Dose Radiation Research in the United States

MEETING #2 (Virtual)
August 26, 2021, All times are EDT

PUBLIC AGENDA

SESSION 1 – OPEN TO THE PUBLIC

ZOOM CONNECTION

https://nasem.zoom.us/j/96270123233?pwd=ekVnb1lTSnpCRWthQ0JhWmVNK3kvZz09
Password: 491085

11:00 AM – 11:05 AM **Welcome and Open Public Session**
Joe Gray, Committee Chair

11:05 PM – 11:25 PM **Comments from Congress on the Request for the Study**
Alyse Huffman and Adam Rosenberg, Committee on Science, Space, and Technology, Energy Subcommittee, U.S. House of Representatives

- *Motivation for the study request and regulations in need of better understanding of low-dose risks.*
- *Clarification on charge 7 of the statement of task—what is Congress's intention?*
- *Views on high priority research.*
- *Views on DOE's low-dose research activities for FY2021 and expectations for FY2022.*
- *Metrics of success for the low-dose program.*
- *Views on sustainability of funding for the low-dose program; what happens past FY2024?*

11:25 PM – 11:45 PM **Q+A with the Committee and Staff**
Moderated by Joe Gray, Committee Chair

11:45 PM – 12:05 PM **Perspectives from the Interagency Steering Committee on Radiation Standards (ISCORS)**
Mike Boyd, Environmental Protection Agency; Vince Holahan, U.S. Nuclear Regulatory Commission

- *Introduce ISCORS, role, and membership.*
- *Regulations that could be better informed by improved understanding of low-dose risks.*

- *Process for changing regulations in light of new scientific evidence and coordination across agencies.*
- *Views on high priority research.*
- *Mechanisms, if any, for ISCORS or individual agencies within ISCORS to provide input to DOE's Office of Science.*

12:05 PM – 12:25 PM **Q+A with the Committee and Staff**
Moderated by Joe Gray, Committee Chair

12:25 PM – 12:45 PM **DOE Office of Domestic and International Health Studies Radiation Health Studies Programs**
Anthony Pierpoint, Director, Office of Domestic and International Health Studies

- *Overview of programs and activities on radiation health; emphasis on low-dose radiation studies.*
- *Risk-communication efforts related to these programs.*
- *Coordination and cooperation of these programs/activities with the previous DOE low-dose program.*
- *Views and opportunities for coordination and cooperation with the new DOE low-dose program.*

12:45 PM – 1:00 PM **Q+A with the Committee and Staff**
Moderated by Joe Gray, Committee Chair

1:00 PM **Adjourn Public Session 1**

SESSION 2 – OPEN TO THE PUBLIC

ZOOM CONNECTION – Same as for Session 1

3:00 PM – 3:15 PM **Perspectives from the Previous DOE Low-Dose Program**
Tony Brooks, Washington State University Tri-Cities (emeritus)

- *Please build on your presentation at the 2019 Beebe Symposium and avoid repeat. The committee has access to that presentation and will review in advance.*
- *Overview of the program including number of projects and laboratories funded per year and $ amounts.*
- *Major scientific achievements and implications in regulations/guidance.*
- *Views on how to improve the new low-dose program.*

3:15 PM – 3:25 PM **Q+A with the Committee and Staff**
Moderated by Joe Gray, Committee Chair

3:25 PM – 3:40 PM **Cooperation and Coordination of the Previous DOE Low-Dose Program and Research at NASA**

Francis Cucinotta, University of Nevada, Las Vegas

- *Overview of cooperation and coordination of NASA with DOE's low dose program including number of projects and laboratories funded per year and $ amounts.*
- *Major scientific achievements and implications in regulations/guidance from this cooperation/coordination.*
- *Views on how to improve cooperation and coordination with the new low-dose program.*
- *Other agencies/programs NASA coordinated its radiation research.*

3:40 PM – 3:55 PM **Q+A with the Committee and Staff**
Moderated by Joe Gray, Committee Chair

3:55 PM – 5:30 PM **Panel Discussion**
Edouard Azzam, Canadian Nuclear Laboratories
Mary Helen Barcellos-Hoff, University of California San Francisco
David Brenner, Columbia University
Amy Kronenberg, Lawrence Berkeley National Laboratory
Al Fornace, Georgetown University
Zhi-Min Yuan, Harvard T.H. Chan School Of Public Health

Proposed format: 6-7 minute statements (or up to 5 power point slides) from each panelist to cover the topics below. Q+A with the committee after all panelists have provided their comments.

- *Highlights of projects funded, findings to advance understanding of low-dose radiation risks, and publications (to be sent to the committee in advance to be added in the final public agenda).*
- *Implications of termination of previous low-dose program in continuing research and training in the speakers' organizations; alternative sources of funding for their research.*
- *Projects/research directions the panelists would like to dedicate funding, when it becomes available.*
- *Current infrastructure (facilities and intellectual) in the panelist's organization.*
- *Views on the 7 charges of the statement of task (see next page) and suggestions for specific sources of information and additional experts to brief the committee. Panelists can select the charges of the statement of task they feel the most strongly about to provide their views.*

5:30 PM – 5:45 PM **Public Comment Period**

5:45 PM **Adjourn Public Session 2**

Statement of Task

The National Academies of Sciences, Engineering, and Medicine will perform a study and provide a report with findings and recommendations on the current status and development of a long-term strategy for low-dose radiation research in the United States. Specifically, the objectives of the study will be to:

1. Define the health and safety issues that need to be guided by an improved understanding of low dose and low dose rate radiation health effects.
2. Identify current scientific challenges for understanding low dose and low dose rate radiation health effects.
3. Assess the status of current low dose radiation research in the United States and internationally.
4. Recommend a long-term strategic and prioritized research agenda to
    - address scientific research goals for overcoming the identified scientific challenges in coordination with other research efforts
    - support education and outreach activities to disseminate information and promote public understanding of low-dose radiation.
5. Define the essential components of the research program that would address this research agenda within the universities and National Laboratories.
6. Address coordination between federal agencies (including the National Institutes of Health, the National Science Foundation, National Aeronautics and Space Administration, and different DOE offices) and with international efforts to achieve objectives.
7. Identify and, to the extent possible, quantify, potential monetary and health-related impacts to Federal agencies, the general public, industry, research communities, and other users of information produced by such research program.

The National Academies will prepare a report with findings and recommendations that addresses the objectives above.

Speaker Biographies

Edouard I. Azzam is a Researcher in the Low Dose Radiobiology section of the Health Sciences team at the Canadian Nuclear Laboratories. Dr. Azzam works with a dedicated team in unravelling the mechanisms underlying the biochemical changes induced in cells and tissues exposed to low doses/low fluences of different radiation types. The goal is to contribute knowledge focussed at alleviating the uncertainty in predicting the health outcomes of occupational exposures, whether in the nuclear industry and health sector or during deep space exploration. Ongoing projects also examine how low dose radiation effects can be harnessed to enhance the effectiveness of cancer therapeutics and in regenerative medicine. He is particularly interested in studying the roles of oxidative metabolism and intercellular

communication in radiation-induced adaptive and bystander responses. Previously Dr. Azzam was a professor in the Department of Radiology at Rutgers University – New Jersey Medical School where he performed research supported by the DOE Low Dose Radiation Research program, NASA and the NIH. He received his doctoral degree in the field of radiation biology from the University of Ottawa (Canada) in 1995. From 1995 to 2000, he pursued post-doctoral studies at the Harvard School of Public Health under the mentorship of Professor John B. Little.

Mary Helen Barcellos-Hoff, Ph.D, is Professor and Vice Chair of Research at the University of California, San Francisco's (UCSF) Radiation Oncology School of Medicine. As principal investigator at the Helen Diller Family Comprehensive Cancer Center, she studies radiation carcinogenesis and biologically augmented radiotherapy. After conducting postdoctoral research on extracellular matrix and mammary epithelial functional differentiation with Mina Bissell at the Lawrence Berkeley National Laboratory (LBNL), Dr. Barcellos-Hoff joined LBNL as a staff scientist eventually becoming Senior Scientist and Associate Director of the Life Sciences Division. Her research focused on low dose and heavy ion radiation carcinogenesis using a novel mammary chimera model and defining the biology of TGFβ in the irradiated tissue. In 2008, she joined New York University School of Medicine as Director of Radiation Biology in the Department of Radiation Oncology beginning a program of translational radiation biology to understand the contribution of TGFβ to the response to therapy. In 2015, she moved to UCSF using the two arms of the lab to further explore radiation as a carcinogen that mediates immune response and breast cancer diversity and molecular and immune mechanisms by which TGFβ impacts tumor response to therapy. Dr. Barcellos-Hoff received an undergraduate degree from the University of Chicago and earned a doctoral degree in experimental pathology from the University of California, San Francisco.

Michael A. Boyd is the Director of the Center for Science and Technology in the U.S. Environmental Protection Agency's Office of Radiation and Indoor Air/Radiation Protection Division. The Center is responsible for the development of radiation dose and risk assessment guidance and for providing technical support for radiation protection policy issues. Mr. Boyd is also the co-chair of the Federal Guidance Subcommittee of the Interagency Steering Committee on Radiation Standards. He is a member of the NCRP's PAC 5 and currently serves on the NCRP Board of Directors. He is a past member of the International Commission on Radiological Protection (ICRP) Committee 4 and chairs ICRP Task Group 98 on Application of the Commission's Recommendations to exposures resulting from contaminated sites from past industrial, military and nuclear activities. Mr. Boyd is a member of the Health Physics Society Board of Directors. He has a BS in Biology and MS in Public Health from the University of North Carolina at Chapel Hill.

David J. Brenner is the Director of the Columbia University Center for Radiological Research, which is the oldest and largest radiation biology center in the US. He is also P.I. of the Center for High-Throughput Minimally-Invasive Radiation Biodosimetry, a multi-institute consortium to develop high-throughput biodosimetry technology to rapidly test individual radiation exposure after a radiological incident. He is also Director of the Columbia Radiological Research Accelerator Facility (RARAF), which is a national facility dedicated to probing the mechanisms of radiation induced cancer. Brenner's research focuses on mechanistic models for the effects of ionizing radiation on living systems. He divides his research time between the effects of high doses of ionizing radiation (relating to radiation therapy) and the effects of low doses of radiation (relating to radiological, environmental, and occupational exposures). At low doses, he was the first to quantify the potential risks associated with the rapidly increasing usage of CT scans in the US. At high doses, his proposal to use large-fraction radiotherapy for prostate cancer (hypofractionation) is increasingly being used in the clinic. Dr. Brenner has published more than

350 peer-reviewed papers; in addition, he is the author of two books on radiation for the lay person: "*Making the Radiation Therapy Decision"* and "*Radon, Risk and Remedy"*. He is a recipient of the Failla gold medal, the annual award given by the Radiation Research Society for contributions to radiation research.

Antone L. Brooks retired in 2008 from the Washington State University Tri-cities as a Professor in the Environmental Science Department. His career included positions as Laboratory Senior Scientist and Section Manager at Battelle, Pacific Northwest National Laboratory; Manager of the Cellular and Molecular Toxicology Group at Lovelace Inhalation Toxicology Research Institute, Albuquerque; and Technical Representative in Washington D.C. for the U.S. Department of Energy, Office of Health and Environmental Research. He is a member of the Health Physics Society, the Mutation Research Society, and the Radiation Research Society. Dr. Brooks' research interests include cytogenetics, radiation-induced cancer, radiation risk, and public outreach on radiation effects. The focus of his research has been understanding the biological changes induced by low doses of ionizing radiation. Dr. Brooks served as the Principal Investigator for the project "Optimizing the Scientific Regulatory and Societal Impact of the DOE Low-Dose Research Program." This includes radiation from both external radiation sources and from internally-deposited radioactive materials. He was the Chief Scientist for the DOE Low Dose Radiation Research program and wrote a history of the program, "Low Dose Radiation, The history of the U.S. Department of Energy Research Program". The use of biomarkers for exposure, dose, susceptibility and disease have been a major research effort directed toward making it possible to better estimate radiation risk using short term biological endpoints. Dr. Brooks has authored or co-authored over 170 publications. In 1961, Dr. Brooks earned a BS in Experimental Biology and 2 y later received his MS in Radiation Ecology both at the University of Utah. Dr. Brooks completed his PhD in Physical Biology in 1966 at Cornell University. Dr. Brooks was first elected to NCRP in 1979 and served as a member for 30 y becoming a Distinguished Emeritus Member in 2009. Dr. Brooks served on the Board of Directors and was Scientific Vice President for PAC 1, *Basic Criteria, Epidemiology, Radiobiology and Risk* from 2005 to 2008. He chaired Scientific Committees (SC) 1-3, 57-10, 57-11; co-chaired both SC 1-13 and 57-10; and was a member of SC 45 and SC 83. Dr. Brooks chaired the 2008 and served as a member in 2002 of the Annual Meeting Program Committee.

Francis A. Cucinotta is a professor of Health Physics at the University of Nevada, Las Vegas (UNLV). He received his doctorate in nuclear physics from Old Dominion University during 1988. He worked at NASA from 1990-2013 in several positions including research scientist, radiological health officer for spaceflight, and manager and chief scientist for the Space Radiation Research Project. Dr. Cucinotta was NASA's manager for the construction and operation of the NASA Space Radiation Lab at Brookhaven National Laboratory. He developed the astronaut exposure data base of organ doses, and cancer risk estimates for all human missions from Mercury to the International Space Station. He has developed models of cancer, circulatory disease and non-cancer risks to the blood forming organs, and central nervous system for understanding the risks to cancer patients and radiation workers. He led NASA's biodosimetry program for the International Space Station and discovered the association of increased incidence of cataracts in past space missions.

Albert J. Fornace Jr., MD, is a Professor in the departments of Oncology; Biochemistry and Molecular and Cellular Biology; and Radiation Medicine at Georgetown University. He was the first recipient of the Molecular Cancer Research Chair at Lombardi Comprehensive Cancer Center, joining Georgetown in 2006 from the Harvard School of Public Health, where he was the director of the John B. Little Center for the Radiation Sciences and Environmental Health. Earlier, he was Chief of the Gene Response Section at the National Cancer Institute. He is the

2015 recipient of the Radiation Research Society Failla Gold Medal. Research from the Fornace laboratory has included discovery of some of the first radiation-inducible genes including the gadd gene group of growth-arrest and DNA-damage inducible genes. His studies in this area led to the landmark paper where they and their collaborators at Johns Hopkins demonstrated the radiation-responsive ATM-p53-Gadd45a pathway, and showed for the first time that p53 could bind and induce a cellular gene. This was followed by a large series of important reports by their laboratories and others that elucidated the major contribution of the tumor suppressor p53 as a transcription factor in its role as a 'guardian of the genome.' Fornace's research has shown that stress-related signals inside the cell alter the expression of multiple genes involved in cell-cycle control, programmed cell death, DNA damage processing, metabolism, pro-inflammatory signaling, among others. Radiation signaling events were shown by his laboratory to occur at surprisingly low doses of radiation. His laboratory has contributed to our understanding of the key roles for important stress-signaling pathways in cancer prevention as well as their perturbations that contribute to tumor development after exposure to radiation. His radiobiology studies also include high-energy ion radiation where he leads a NASA Specialized Center of Research (NSCOR) in gastrointestinal carcinogenesis by low-dose space radiation.

E. Vincent Holahan is a Senior Level Technical Advisor for Health Physics within the Office of Nuclear Material Safety and Safeguards at the U.S. Nuclear Regulatory Commission (NRC). Dr. Holahan received a Bachelor of Arts degree in chemistry and a Bachelor of Sciences degree in biology from Gonzaga University. He received a doctoral degree in Radiology and Radiation Biology and an interdisciplinary degree in Cellular and Molecular Biology from Colorado State University, USA. He also completed a one-year postdoctoral fellowship in the Department of Radiation Oncology, University of California, San Francisco. At the NRC, Dr. Holahan is responsible for developing technical standards for issuing federal regulations and guidance to limit occupational and public exposure to ionizing radiation. Before joining the NRC in 1996, he was a senior program officer with the U.S. National Academies of Science. Dr. Holahan completed 35 years of active and reserve service in the U.S. Army as nuclear medical sciences officer. Dr. Holahan was a member of the U.S. National Economic Council panel that reviewed the occupational hazards associated with nuclear weapon production by the Department of Energy; a former U.S. representative to the International Atomic Energy Agency (IAEA) steering group on occupational radiation protection, the former NRC representative to the Nuclear Energy Agency (NEA) Committee on Radiation Protection and Public Health, a former Vice Chairperson of the NEA/IAEA Information Systems on Occupational Exposure, and is a Council member on the National Council on Radiation Protection and Measurements. Dr. Holahan joined the United States delegation to UNSCEAR in 2000, served as alternate representative for the sixty-second session in 2015, and as representative since the sixty-fourth session in 2017.

Alyse Huffman is a Professional Staff Member working on the Energy Subcommittee of the U.S. House of Representatives Science, Space, and Technology Committee. At Duke Energy Corporation (2014-2018), she worked as a nuclear engineer on core design and spent fuel pool criticality safety. Previously, she was a graduate student researcher for nearly 2 years in Paris at the OECD Nuclear Energy Agency's Expert Group on Burnup Credit within the Working Party on Nuclear Criticality Safety developing a handbook which contained the latest tools and techniques for burnup and criticality analysis of spent fuel for pressurized water reactors. Ms. Huffman was a former AAAS Glenn T. Seaborg Congressional Science and Engineering Fellow. She has a BS and MS degrees in nuclear engineering from the University of Florida.

Amy Kronenberg is a staff biophysicist at the Lawrence Berkeley National Laboratory (LBNL). Her research focuses on fundamental processes that may result in genomic change following exposure to sparsely or densely ionizing radiation, examining effects of radiation quality and

dose-rate using highly sensitive model systems. Her group has also considered evidence for early arising radiation-signature events as well as the incidence of genomic instability in lymphoid and epithelial models. Her work has also discovered links between molecular mechanisms of DNA damage repair and programmed cell death. Dr. Kronenberg taught radiation biophysics to students at the National Aeronautics and Space Administration Space Radiation Summer School throughout its existence and led the school in its final year. Dr. Kronenberg received her ScD in Cancer Biology from the Harvard School of Public Health. She has served on review panels for several Federal agencies and has participated in international scientific review panels. She is a senior editor for Radiation Research and is an international associate editor of the Journal of Radiation Research (Japan). Dr. Kronenberg served on the Board of Directors of the NCRP, as a member or chair of the NCRP Nominating Committee, and as a member of several NCRP scientific committees.

Dr. Anthony Pierpoint currently serves as the Director for the Office of Domestic and International Health Studies, responsible for research programs and monitoring activities, both domestically and internationally, that support the protection and promotion of the health of DOE workers, their families, and the broader community. He has over 30 years of experience in health and safety, having served at various levels in the public and private sector. Dr. Pierpoint has a bachelor's degree in applied chemistry and master's and doctorate degrees in environmental engineering from the University of Maryland. He also is a Certified Industrial Hygienist.

Adam Rosenberg is the Staff Director for the Energy Subcommittee of the House Committee on Science, Space, and Technology, which he joined in April 2013, and previously served as a professional staff member on the Committee from mid-2007 through 2010. In these roles, he was lead staffer in the House for the comprehensive set of enacted energy innovation provisions in the Energy Act of 2020, lead Democratic staff for the Department of Energy Research and Innovation Act, enacted in 2018, and lead for several enacted energy research provisions in the Energy Independence and Security Act of 2007. Dr. Rosenberg holds a B.S. in applied and engineering physics from Cornell University and a Ph.D. in plasma physics from Princeton University, where he studied magnetohydrodynamic instabilities and interactions between radio frequency waves and energetic ions in a large magnetic fusion experiment at the Princeton Plasma Physics Laboratory. While an undergraduate, he also completed internships at Argonne National Laboratory and Lawrence Livermore National Laboratory. From mid-2003 through 2004, Dr. Rosenberg was an American Association for the Advancement of Science (AAAS) Congressional Fellow on the Democratic staff of the Senate Energy and Natural Resources Committee, where he worked on improving the direction for advanced scientific computing research, support for the physical sciences, overall U.S. competitiveness in high technology industries, and a variety of other issues. He then accepted a position as a Program Manager in the Department of Energy (DOE) Office of Science's Fusion Energy Sciences Program, where he directly oversaw a major research facility at the Massachusetts Institute of Technology as well as several other research activities across the nation. Prior to his current position, Dr. Rosenberg served as Deputy Director for Technology Strategy in the Office of the Assistant Secretary of Defense for Operational Energy Plans and Programs. There he managed the coordination of the Department of Defense's joint activities with DOE to accelerate the development and deployment of advanced energy technologies for military applications. In addition, he served as the Assistant Secretary's lead staffer on alternative fuels policy and technical analysis.

Zhi-Min Yuan, MD, PhD, is the Morningside Professor of Radiobiology, Department of Molecular Metabolism, and Director of the John B. Little (JBL) Center for Radiation Sciences, Harvard T.H.

Chan School of Public Health. An internationally recognized radiobiologist, Dr. Yuan received his PhD from the University of Maryland and post-doctoral training at the Dana-Farber Cancer Institute before joining the faculty of Harvard T.H. Chan School of Public Health. His research interests are in the area of radiobiology, stress, and cancer with a focus on the tumor suppressor. His research programs are supported by NIH, ACS and DOE, among other funding agencies. He has published more than 70 peer-reviewed articles and is a member of the editorial board for three journals, as well as a chartered member of NIH Cancer Etiology Study Section and other grant reviewing bodies. Under Dr. Yuan's direction the JBL Center has taken a leadership position in studying the effects of radiation on organisms and informing researchers on the basic biological mechanisms of radiobiological stress resistance, intra- and intercellular communication, and adaptation to future stressors.