

**Columbia University
Center for Radiological Research**

Centennial Symposium

*Radiation and Cancer:
Understanding the Two-Edged Sword*



April 28 – 29, 2016



RADIATION AND CANCER: UNDERSTANDING THE TWO-EDGED SWORD

Radiation is indeed a two-edged sword: Radiation therapy is used to cure cancer but, in other contexts, low doses of radiation can actually produce cancer.

Over the past 100 years the Center for Radiological Research has been at the forefront of research in both these contexts:

- At high radiation doses, our goal has always been to produce better radiation therapy techniques in order to eliminate the cancer while minimizing any side effects.
- At low radiation doses, there are multiple areas where radiation can really benefit society: But we need to understand the associated radiation risks if we are to make informed decisions of when and where radiation should be used, and where it should not be used.

Our symposium covers both these areas, and in particular their application to where we are today. Can we improve our treatment of cancer? Can we optimize the use of radiation in medicine? Can we be better prepared for a large scale radiological exposure event?

On behalf of our Center, we welcome you to our centenary symposium, which takes a look back to where we have come from, but more importantly looks to where we are going in our next century!



David Brenner
Fourth Director,
Center for Radiological Research

APRIL 28: DAY 1**9:00–9:20 Welcome and Introduction****DAVID BRENNER***The CRR and the Two-Edged Sword***Morning Sessions: Radiation Therapy to Cure Cancer****9:20–10:35 Precision Radiotherapy: Tailoring the Radiation Treatment to the Individual Patient****BARRY ROSENSTEIN***Radiogenomics: Radiation Biology Enters the Era of Big Data and Team Science***HOWARD LIEBERMAN***Rad9: A Predictor of Radiotherapeutic Response?***EILEEN CONNOLLY***Toward Individualized Optimization of Breast Cancer Radiotherapy***10:35–11:00 Coffee break****11:00–12:15 New Approaches to Improve Contemporary Radiotherapy****DAVID CARLSON***Why Is Stereotactic Radiotherapy so Successful?***MARCO DURANTE***New Approaches to Charged Particle Radiotherapy***MARCO ZAIDER***Radiotherapy: Do We Have any Idea What We Are Doing?*

12:15–1:45**Lunch break****1:45–2:15****ERIC J. HALL***Our History: 100 Years at the Center for Radiological Research***Afternoon Sessions: Understanding the Risks of Low Doses of Radiation****2:15–3:30****How Do We Estimate Cancer Risks Associated with Very Low Radiation Doses?****JOHN BOICE***The Million Worker Study***JEROME PUSKIN***Epidemiological Studies of Domestic Exposure to Radon***ROBERT ULLRICH***Risks Associated with Space Radiation***3:30–4:00****Tea break****4:00–5:15****Low Radiation Doses in the Real World: How Best to Use CT Scans****DAVID BRENNER***Estimated Risks from CT Scans***HEDVIG HRICAK***Radiomics in Oncology: The Next Frontier in Clinical Decision-Making***KIMBERLY APPEGATE***Safety Culture and the Image Gently Campaign in Radiology: A Paradigm Shift*

APRIL 29: DAY 2**9:00–9:30****STEVEN MARINO***50 Years of RARAF, Our Radiological Research Accelerator Facility***9:30–10:45****New Mechanisms that Might Modify Radiation Risks****SILVIA FORMENTI***Convergence of Radiation and Immunogenic Signaling Pathways***JONINE BERNSTEIN***Does Family History or Genetic Status Affect Sensitivity to Radiation-Induced Cancer?***TOM HEI***Radiation-induced Bystander Effects***10:45–11:15****Coffee break****11:15–12:30****Radiation in Today's World: Countermeasures to Radiological Terrorism****GUY GARTY***The RABit and Cytogenetic Biodosimetry: Where We've Been and Where We're Going***ALBERT FORNACE***Radiation Metabolomics – Implications for Radiation Effects and Biodosimetry***NELSON CHAO***Radiation Injury Treatment Network (RITN): Progress on Preparing for Radiological and Nuclear Incidents***12:30****Concluding Remarks**



DR. DAVID J. BRENNER is the Columbia University Higgins Professor of Radiation Biophysics and, since 2008, the Director of the Center for Radiological Research and the Radiological Research Accelerator Facility. Dr. Brenner is also Professor of Environmental Health Sciences in the Mailman School of Public Health.

Dr. Brenner received his education and training in the United Kingdom and earned his BA and MA in Physics and Philosophy from Oxford University. He received a MSc. in Radiation Physics from the University of London and in 1980 was awarded a PhD in Physics from the University of Surrey.

Dr. Brenner's research focuses on developing mechanistic models for the effects of ionizing radiation on living systems, both at the chromosomal level and in the whole animal (or human). He divides his research time equally between the effects of high doses of ionizing radiation (relating to radiation therapy) and the effects of low doses of radiation (relating

to medical, environmental and occupational exposures).

At the chromosomal level, he has focused on the mechanisms of radiation-induced chromosome aberrations and its potential use as biomarkers for past exposure to different types of radiations.

In medical imaging, he has focused on the risk/benefit balance of higher-dose imaging techniques, particularly computed tomography (CT).

In radiotherapy, he has focused on optimizing radiation exposure fractionation schemes for different tumor types to maximize tumor destruction and minimize serious side effects. This includes modeling the mechanisms of radiotherapy-induced second cancers, with the goal of reducing secondary cancer risks.

Environmentally, he has focused on the biological effects of radon, both at the chromosomal and human levels.

In 1996, Dr. Brenner received an honorary Doctor of Science degree from Oxford University. He was the Radiation Research Society's Failla Award recipient in 2011. Most recently, Dr. Brenner was awarded the 2015 Weldon Memorial Prize,

which is given annually by the University of Oxford to the person who has published the most noteworthy contribution to the development of mathematical or statistical methods applied to biology in the 10 years prior to the date of award.



DR. BARRY ROSENSTEIN has performed research in radiation biology for more than 40 years, with a particular emphasis on the application of genetic and genomic approaches. The focus of his research program is on radiogenomics, which is the identification of genetic/genomic markers associated with response to radiotherapy. Dr. Rosenstein's group was among the first to hypothesize and provide evidence that possession of single-nucleotide polymorphisms in certain genes could make cancer patients more susceptible to toxic effects of radiotherapy. Dr. Rosenstein has published numerous papers and has made

substantial progress towards the development of an assay to predict response of cancer patients to radiotherapy. Dr. Rosenstein has also become a leader in the effort to use "Big Data" to enhance basic and clinical research in radiation oncology. In 2009, Dr. Rosenstein established and co-led the Radiogenomics Consortium (RGC), including 188 members at 110 institutions from 26 countries. The RGC is supported by the National Cancer Institute/NIH through the Epidemiology and Genomics Research Program (epi.grants.cancer.gov/Consortia/single/rgc.html). The overall goal of the RGC is to provide a collaborative infrastructure to permit large-scale genome-wide association studies to discover and validate genetic factors linked with outcomes resulting from radiotherapy and to develop assays to predict radiation response.

**DR. HOWARD B. LIEBERMAN**

is a Professor of Radiation Oncology at Columbia University Medical Center and Professor of Environmental Health Sciences in the Mailman School of Public Health. He is Director of the Radiation Research Shared Resource of the Herbert Irving Comprehensive Cancer Center. Dr. Lieberman received his Ph.D. working with Dr. Evelyn M. Witkin at Rutgers University, and then completed post-doctoral work with Dr. Frank H. Ruddle at Yale University.

Dr. Lieberman's research focuses on defining the molecular basis of the cellular response to DNA damage and its relationship to carcinogenesis. In particular, his research is focused on elucidating the activities of the RAD9 gene in the context of maintaining genomic integrity and its role in prostate cancer, with a view towards developing novel precision medicine-based diagnostic and therapeutic tools.

Dr. Lieberman served as a member and Chair of the NIH Radiation Study Section, and a member of the basic and preclinical Subcommittee C of the NCI Initial Review Group, as well as the Radiation Therapeutics and Biology Study Section. He serves on numerous editorial boards and advisory committees, and is an Associate Editor of the *Journal of Cellular Physiology* and *Radiation Research*. Dr. Lieberman is an Elected Fellow of the American Association for the Advancement of Science.



DR. EILEEN CONNOLLY is an Assistant Professor of Radiation Oncology at NewYork-Presbyterian/Columbia University Medical Center. She is a board-certified radiation oncologist who specializes in the treatment of breast and pediatric malignancies with radiation therapy. She participates in a number of Children's Oncology Group (COG) protocols for the treatment of pediatric malignancies and works closely with the Pediatric Oncology group at Morgan Stanley Children's Hospital of NewYork-Presbyterian/Columbia University Medical Center.

Dr. Connolly received her M.D. and Ph.D. degrees and internal medicine and radiation oncology training from New York University School of Medicine, where she was Chief Resident of Radiation Oncology. During her residency

training she received both the 2010 Varian Medical Systems/RSNA Research Resident Grant and the 2010 ASTRO Residents/Fellows in Radiation Oncology Award. Dr. Connolly was also trained in Gamma Knife Radiosurgery at the University of Pittsburgh Medical Center - Center for Image-Guided Neurosurgery, pioneers in the field of stereotactic radiosurgery for brain cancers and malformations.

In addition to her clinical responsibilities, Dr. Connolly is the director of a translational research laboratory where she seeks to understand cancer's radiation resistance mechanisms. Specifically, her work focuses on the PI3K/Akt pathway with a goal of developing targeted agents that may be used as radiation sensitizers to reduce the risk of local recurrence. She has received a 2012 Radiological Society of North America (RSNA) Research Seed grant for her research, and a 2012 Irving Institute/Clinical Trials Office Pilot Award.



DR. DAVID CARLSON is an Associate Professor at Yale University School of Medicine and a Medical Physicist at Yale-New Haven Hospital. He received his Ph.D. from Purdue University in 2006 and completed a residency in Radiation Oncology Physics at Stanford University in 2008. He currently serves on the Board of Directors of the American Association of Physicists in Medicine.

The overall goal of his research is to develop more accurate biological dose-response models that will advance biologically-guided cancer therapy. He strives to make scientific contributions to advance our basic understanding of the underlying physical, chemical, and biological mechanisms that govern treatment response, to improve radiotherapy treatments for cancer patients, and develop in vivo biodosimetry techniques that can benefit the general public.



DR. MARCO DURANTE was appointed Director of the Trento Institute for Fundamental Physics and Applications in Trento, Italy in April, 2015. He has served as Director of the Biophysics Department at GSI Helmholtz Center for Heavy Ion Research in Germany since 2007. He is also Professor of Physics at the University of Naples Federico II in Italy, Adjunct Professor at Temple University in Philadelphia and at the Gunma College of Medicine in Japan.

Dr. Durante earned his Ph.D. in physics in 1992 and has dedicated his research efforts to the biophysics of high-energy charged particles, with applications in cancer therapy and space radiation protection. He is recognized as a world leader in the fields of particle radiobiology and medical physics and is co-author of over 290 papers in peer-reviewed scientific journals. He is currently chair of the ESA Life Sciences Advisory group and vice-chair of the

Particle Therapy Co-Operative Group. He has been awarded several prizes for his outstanding contributions to charged particle biophysics, including the 60th Timofeeff-Ressovsky Medal by the Russian Academy of Sciences, the 8th Warren K. Sinclair Award of the U.S. National Academy of Sciences, the 2013 IBA-Europhysics Award for Applied Nuclear Science and Nuclear Methods in Medicine (European Physics Society) and the 2013 Bacq & Alexander Award of the European Radiation Research Society.



DR. MARCO ZAIDER is Professor of Physics in Radiology at Weill Cornell Medical College and attending physicist and Head of Brachytherapy Physics at Memorial Sloan Kettering Cancer Center. He is also on the faculty of Columbia University, where he teaches in the graduate program in Medical Physics.

His interests include the planning and delivery of brachytherapy (the placement of radioactive “seeds” inside a tumor), radiation oncology, microdosimetry, the biological effects of ionizing radiation, and biostatistics.

Dr. Zaider received the Edelman Award for Achievement in Operations Research — presented by the Institute for Operations Research and the Management Sciences — for his paper entitled “Operations Research Answers to Cancer Therapeutics.”, with Dr. Eva Lee at the Georgia Institute of Technology in Atlanta.

Dr. Zaider devises sophisticated optimization modeling and computational techniques to implement an intra-operative three-dimensional treatment planning system for brachytherapy. This work has been shown to improve the survival rate of patients with prostate cancer, reduce treatment side effects, and lower healthcare costs.



DR. ERIC J. HALL is The Higgins Professor Emeritus of Radiation Biophysics at Columbia University, and Special Lecturer in Radiation Oncology. Until December 2007, he was Director of the Center for Radiological Research, a position he held for 24 years.

Dr. Hall has been a New York resident for over 47 years, after receiving his doctorate in radiobiology from Oxford University in the United Kingdom. He has received more than 30 honors and awards, including gold medals from ASTRO, RSNA, ACR, and ARRS, the Janeway Medal from The American Radium Society, the Failla Award from the Radiation Research Society, and the Kaplan Award of the IARR. Dr. Hall is an honorary fellow of both the American College of Radiology and The Royal College of Radiology, an honor conferred on select few laboratory scientists. He is also a Fellow of ASTRO and the Society of Radiological Protection.

Dr. Hall is the author of over 390 publications in peer-reviewed journals and has authored or co-authored four books, one of which, *Radiobiology for the Radiologist*, is the definitive text for students of radiation biology worldwide now in its 7th edition. The book was recently translated into traditional and simplified Chinese, as well as Japanese and Korean.

His research interests include cancer induction by low doses of radiation, the radiobiological basis of radiotherapy and radiation cataract, work currently funded by NASA. Dr. Hall is a past president of the Radiation Research Society, the American Radium Society and the International Association of Radiation Research.



DR. JOHN BOICE is professor of Medicine at Vanderbilt University and President of the National Council on Radiation Protection and Measurements. He is an international authority on radiation effects and serves on the Main Commission of the International Commission on Radiological Protection, the United Nations Scientific Committee on the Effects of Atomic Radiation, and the Veterans' Advisory Board on Dose Reconstruction.

Dr. Boice was the first chief of the Radiation Epidemiology Branch at the National Cancer Institute. His seminal discoveries and over 450 publications have provided guidance for public health measures designed to prevent or reduce radiation-associated diseases.

He visited Fukushima after the earthquake, tsunami, and reactor accident and subsequently testified before the U.S. House Committee on Science, Space and Technology.

Dr. Boice received the Harvard School of Public Health Alumni Award of Merit; the E.O. Lawrence Award from the Department of Energy; the Gorgas Medal from the Association of Military Surgeons of the United States; the outstanding alumnus award from the University of Texas at El Paso; and the Distinguished Service Medal from the U.S. Public Health Service.

Dr. Boice has a bachelor's degree in Physics from the University of Texas at El Paso; a master's in Nuclear Engineering from Rensselaer Polytechnic Institute; a master's in Medical Physics and a doctoral degree in Epidemiology from Harvard University.

Dr. Boice studies atomic veterans who participated in nuclear weapons tests and over a million other radiation workers to examine the lifetime risk of cancer. He studies the children of cancer survivors to assess possible genetic risks from curative radiation treatments.



Until his recent retirement, **DR. JEROME PUSKIN** served for 30 years in the Radiation Protection Division at EPA, developing and applying methodologies for assessing radiation doses and health risks. Among his areas of special interest are the estimation of cancer risk at low doses and dose rates and the risks from radon in homes.

He is a Distinguished Emeritus Member of NCRP and has served on its committees to assess radiation exposure to the U.S. population and the RBE for low-LET radiations. He has also served on the Executive Committee for JCCRER, which helps to oversee epidemiological research on radiation-exposed populations in Russia, and on the Nuclear Energy Agency Expert Group on Radiation Protection Science. Prior to joining EPA, he worked at the Nuclear Regulatory Commission on radiation risk assessment. Before entering government, he was on the faculty of the Radiation Biology and Biophysics Department at the University of Rochester.



DR. ROBERT ULLRICH is Vice Chairman and Chief of Research at the Radiation Effects Research Foundation in Hiroshima, Japan. After obtaining his Ph.D. at the University of Rochester, he joined Oak Ridge National Laboratory in 1974 and served as Director of the Radiation Carcinogenesis Unit until 1989 when he became Vice Chair and Director of the Biology Division in the Department of Radiation Oncology at the University of Texas Medical Branch. In 2001, he joined Colorado State University as Professor and Director of the Radiological Health Science and Cancer Research Program.

In 2008 he moved back to the University of Texas Medical Branch where he served as the John Sealy Distinguished Chair in Cancer Biology, Professor and Director of the Sealy Center for Cancer Biology and Director of the Cancer Center. His research has focused on risks and mechanisms of radiation-induced cancer. Initially this work was on the dose-response relationships at low doses and

dose rates for radiation-induced cancer in mice. Subsequently, his laboratory developed cell and molecular approaches to study mechanisms in the development of mammary cancer after radiation exposure. He currently directs a National Aeronautics and Space Administration (NASA) Specialized Center of Research in Radiation Carcinogenesis with a focus on studying cancer risks and mechanisms of cancer development following exposure to the unique forms of radiation encountered during space travel.

Dr. Ullrich has served on several scientific advisory groups both in the United States and internationally, including the National Cancer Institute, the U.S. Department of Energy, NASA, NCRP, the National Academies/ National Research Council, the International Commission on Radiological Protection, the European Commission, and the International Agency for Cancer Research. In 2012, the Radiation Research Society awarded him their highest honor, the Failla Medal, for significant contributions in the radiological sciences.



DR. HEDVIG HRICAK is the Chair of the Department of Radiology at Memorial Sloan Kettering Cancer Center. She is a member of the Institute of Medicine and has served on the Scientific Advisory Board of the National Cancer Institute (NCI) and the Advisory Council of the National Institute of Biomedical Imaging and Bioengineering. She received her MD from University of Zagreb School of Medicine (Yugoslavia) and her PhD from the Karolinska Institute in Sweden.

Dr. Hricak was also a member of the Nuclear Radiation Studies Board of the National Academy of Sciences (NAS) and chaired the NAS Committee on the State of the Science of Nuclear Medicine, which produced the highly-cited report “Advancing Nuclear Medicine Through Innovation.” Dr. Hricak’s distinguished posts have included: President of the California Academy of Medicine, Society for the Advancement of Women’s Imaging, President, International Society for Strategic Studies in Radiology, and President of the Radiological Society of North America.

Dr. Hricak strongly believes that medicine knows no borders and throughout her career, she has done her best to promote international collaboration in medicine, particularly with respect to education and research. In recognition of these efforts, Dr. Hricak was awarded an honorary doctorate in medicine from the Ludwig Maximilian University of Munich, Germany, elected a member of the Croatian Academy of Arts and Sciences and the Russian Academy of Medicine, and was made an honorary member or fellow of 16 radiological societies around the world.

Dr. Hricak received the Marie Curie Award from the Society of Women in Radiology, the gold medals of the International Society for Magnetic Resonance in Medicine, the Association of University Radiologists, the Asian Oceanian Society of Radiology, and the European Society of Radiology, the Beclere Medal of the International Society of Radiology, the Schinz Medal of the Swiss Society of Radiology, the Morocco Medal of Merit, the Jean A. Vezina French Canadian Award of Innovation, and the Order of the Croatian Morning Star of Katarina Zrinska, a Presidential Award from Croatia.



DR. KIMBERLY APPLGATE is a leader in radiology – she is the American College of Radiology Speaker of the Council, President of the Association for University Radiologists (AUR) Research and Education Foundation, and past President of the AUR, the American Association for Women in Radiology, and the Radiology Alliance for Health Services Research. She is a member of the National Council on Radiation Protection, the International Commission for Radiological Protection and the Steering Committee for the Image Gently Campaign to reduce radiation exposure in children.

Dr. Applegate's research interests focus on health services and policy, evidence-based summaries of imaging appropriateness, and radiation safety. Her research projects include appropriate use of imaging in abdominal pain in children, technology assessment, quality improvement, and CT safety, especially radiation dose reduction techniques. She received her MD degree from George Washington University and holds a MS degree in epidemiology and biostatistics from Case Western Reserve University.



MR. STEPHEN MARINO has been a member of the Radiological Research Accelerator Facility (RARAF) for more than 46 years – three with Brookhaven National Laboratory and 43 with the Columbia University Center for Radiological Research and its predecessor, the Radiological Research Laboratory. During that time Mr. Marino was Deputy Manager for 11 years and Facility Manager for over 25 years. He received his MS in Physics from Polytechnic Institute of New York.

In addition to management duties, Mr. Marino was the primary dosimetrist at RARAF for over 35 years. He performed dosimetry for a variety of types of radiation at RARAF and for research projects at several other facilities including monoenergetic and poly-energetic neutrons, charged particles over a wide range of ion types and energies, γ rays and X-rays. He has worked with dozens of scientists from the Center for Radiological Research and research groups from around the world who perform experiments at RARAF, both in physics and biology.



DR. TOM K. HEI earned his undergraduate degree *summa cum laude* from the University of Wisconsin-Whitewater, and his PhD in experimental pathology from Case Western Reserve University. He has been on the faculty of Columbia University since 1983 and is currently Professor and Vice-chairman of Radiation Oncology and Associate Director of the Center for Radiological Research. He holds a joint appointment as Professor of Environmental Health Sciences in the Columbia University Mailman School of Public Health as well as an adjunct professorship at the Chinese Academy of Sciences in Hefei. Dr. Hei was appointed as an Overseas Expert by the Chinese Academy of Sciences in Beijing, China in 2012. Dr. Hei's research focuses on understanding the

basic mechanisms of radiation and environmental cancer. His laboratory has made seminal contributions towards our understanding of the mechanism of radiation-induced non-targeted effects and the role of the tumor suppressor gene TGF β 1 in radiation carcinogenesis. Dr. Hei served as a panel member of the Institute of Medicine of the U.S. National Academy of Sciences in reviewing the NIOSH Roadmap for Research on Mineral Fibers as well as numerous NIH review panels. He was elected Educator of the Year by the Association of Residents in Radiation Oncology in 2012. He is a former president of the Radiation Research Society and has many years of experience in mentoring doctoral, medical, resident physicians and postdoctoral research fellows.



DR. SILVIA FORMENTI is Chair of the Department of Radiation Oncology at Weill Cornell, Associate Director of the Meyer Cancer Center and Radiation Oncologist in Chief at NewYork-Presbyterian Hospital. A prolific researcher, she has published over 190 papers in high impact journals such as *Journal of the American Medical Association*, *Lancet Oncology*, and the *Journal of Clinical Oncology*.

During the past 12 years, Dr. Formenti has introduced a paradigm shift in radiation biology, by elucidating the role of ionizing radiation on the immune system, and demonstrating efficacy of combining radiotherapy with immunotherapy to treat solid tumors. She has translated preclinical work to clinical trials for metastatic breast cancer, lung cancer and melanoma. Dr. Formenti has introduced a breakthrough strategy of recovering an immunological equilibrium in the setting of metastatic disease,

by converting a metastasis into an in situ, individualized vaccine. In the presence of immune checkpoint blockade (anti-CTLA-4, anti-PDL-1), the irradiated tumor becomes an immunogenic hub, similar to a vaccine. Once successfully immunized against the irradiated site, the host can develop an anti-tumor immune response capable of rejecting the other metastases. In some patients with metastatic disease refractory to standard treatment, the combination of local radiation and immune checkpoint blockade has already resulted in complete remissions, sustained for years after treatment without any other additional interventions. Her work has opened a new field of application for radiotherapy, whereby localized radiation can be used as an adjuvant to immunotherapy of solid tumors and lymphomas. Dr. Formenti has been funded by grants from NIH, the Department of Defense, American Cancer Society and Breast Cancer Research Foundation. She is currently leading four investigator-initiated clinical trials of immunotherapy and radiotherapy.



DR. JONINE BERNSTEIN is the Principal Investigator of the WECARE Study (Women's Environmental, Cancer, and Radiation Epidemiology), which examines genetic susceptibility and the impact of radiation exposure in breast cancer. Current investigations include studies of the roles of mutations in the ATM, BRCA1, BRCA2, Chek2, TP53BPI, MDC1, Rad50, and MRN genes. Recently, Dr. Bernstein was awarded a grant from NIH to conduct a multi-stage genome-wide association study to examine existing WECARE study cases and controls, and recruitment of a validation data set, in order to discover single-nucleotide polymorphisms associated with second primary breast cancer arising after radiotherapy.

Dr. Bernstein serves as a member of the Board of the American College of Epidemiology, the National Council on Radiation Protection and Measurement, the NCI Board of Scientific Counselors, the AACR Molecular Epidemiology Steering Committee, and is a member of the American Epidemiological Society. In 2011, she was co-Chair of the Third North American Congress of Epidemiology, held every five years and comprised of over 25 epidemiology societies.



DR. GUY GARTY earned his Ph.D. in physics from the Weizmann Institute of Science in Israel in 2004. While there, he developed several systems for detection and characterization of radiation fields for medical imaging and radiotherapy. Currently he is an Associate Professor at the Center for Radiological Research at Columbia University Medical Center.

Dr. Garty has participated in the development of microbeam technology for precise irradiation of individual cells in culture or in tissue with the goal of elucidating the mechanisms of radiation response. As part of the biodosimetry program, he has spun off the rapid imaging technology, developed for the microbeam, and applied it to high throughput biodosimetry in the Rapid Automated Biodosimetry Tool (RABiT). Dr. Garty has overseen the development of the RABiT and continues to be involved in development and implementation of novel biodosimetry assays using the RABiT II approach.



DR. ALBERT J. FORNACE, JR. is Professor in the departments of Biochemistry and Molecular and Cellular Biology, Oncology, and Radiation Medicine at Georgetown University. He is the first recipient of the Molecular Cancer Research Chair at the Lombardi Comprehensive Cancer Center. Prior to joining Georgetown in 2006, he was director of the John B. Little Center for the Radiation Sciences and Environmental Health in the Harvard School of Public Health. Before that, he was Chief of the Gene Response Section at the National Cancer Institute.

Dr. Fornace's research 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 laboratory demonstrated that several of these genes showed attenuated ionizing radiation responses in ATM-deficient cells, and helped

to define the ATM pathway. In collaboration with Dr. Michael Kastan's group, this led to a landmark paper demonstrating 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 reports that elucidated the major role of the tumor suppressor gene p53 in its role as a guardian of the genome.

Dr. 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, and DNA damage processing. His laboratory has contributed to our understanding of the key roles for important stress-signaling pathways in cancer prevention as well as the perturbations that contribute to tumor development after exposure to radiation or other genotoxicants. His carcinogenesis studies have been extended to high-energy ion radiation where he leads a NASA Specialized Center of Research in gastrointestinal carcinogenesis. His research has encompassed many areas of cell and tissue injury with particular relevance to radiobiology, as well

as to toxicology, carcinogenesis, genomic instability, and immune diseases.

In addition to his research on the molecular pathways of radiation-induced cancer, Dr. Fornace has also studied cellular stress responses at broader levels. His laboratory was the first, in collaboration with Jeff Trent's group at the NIH, to assess genome-wide responses to radiation using a transcriptomics approach. His "omics" studies have more recently been extended to the small molecule level (metabolomics), and his team, along with collaborators, have developed the field of radiation metabolomics. An important practical focus is the ongoing development of metabolomic biomarkers that can be used to assess radiation injury after a radiologic or nuclear event. Dr. Fornace currently directs the Waters Center of Innovation for Metabolomics at Georgetown University.



DR. NELSON J. CHAO is the Donald D. and Elizabeth G. Cooke Professor in Cancer Research, Professor of Medicine and Immunology and Chief of the Division of Hematological Malignancies and Division of Cellular Therapy/BMT at Duke University.

He received his undergraduate degree from Harvard University, his M.D. from Yale University, and completed his post-graduate training at Stanford University. Dr. Chao was the Associate Director of Stem Cell Transplantation at Stanford University prior to moving to Duke University in 1996 as the Director of the Bone Marrow Transplantation Program, renamed the Division of Cellular Therapy/BMT. He is also the Co-Director of the Clinical Stem Cell Transplantation Laboratory and directs his own research laboratory focused on understanding and preventing graft-versus-host

disease and improving immune reconstitution. Dr. Chao obtained his MBA from the Fuqua School of Business at Duke University in 2000. Currently, he also serves as the Director of Global Cancer for the Duke Cancer Institute and the Duke Global Health Institute. In 2012 he also became the Chief of the Division of Hematological Malignancies.

Dr. Chao is the author of approximately 250 peer-reviewed papers, 25 book chapters and one book. He is also a co-founder of two start-up biotechnology companies in Research Triangle Park, Aldagen and C2 Regenerate. Nationally, he is the co-chair of the Radiation Injury Treatment Network and the Principal Investigator for a Program Project Grant in stem cell transplantation and a Center for Medical Countermeasures against Radiation.

OUR FIRST CENTURY: FOCUSING ON THE TWO SIDES OF RADIATION

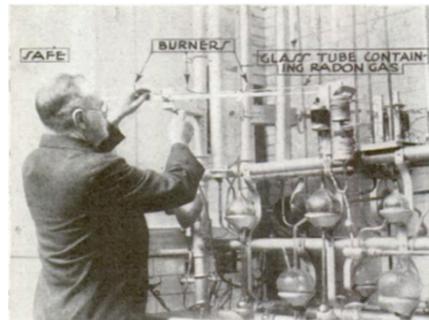
Radiation is a two-edged sword: Radiation therapy is used to cure cancer but, in other contexts, low doses of radiation can produce cancer.

For 100 years, the Center for Radiological Research has been at the forefront of research in both these contexts:

- At high radiation doses, our goal has always been to produce better radiation therapy techniques in order to eliminate the cancer while minimizing any side effects.
- At lower doses, there are multiple areas where radiation can significantly benefit society. For example, CT scans have revolutionized medical care and treatment over the last 30 years. In addition, if we could really understand the true health effects of low levels of radiation exposure, nuclear power could become a practical and safe option to reduce our reliance on fossil fuels.

Our Center was first established in 1916 by Gioacchino Failla, who was a student of Marie Curie. It

was known then as the Biophysical Laboratory, and was the first U.S. institution entirely devoted to developing and improving the medical applications of radiation.



The first radon plant, which was used to make radioactive needles that were directly inserted into a tumor

During Dr. Failla's 45-year tenure as Director, the laboratory was a world leader in turning radiation therapy from a promising idea to a technique which was the best approach for curing many common cancers. The Lab pioneered radiation therapy techniques and invented many of the measuring equipment that ushered in the new field of medical physics — allowing radiotherapists worldwide to improve the standard of medical care by delivering accurate and precise radiation doses to the tumor of every cancer patient.

By the time Dr. Failla retired in 1960, about half of all cancers were treated with radiation therapy – and that is still true today.

In 1942 the Biophysical Laboratory changed its name to the Radiological Research Laboratory and moved into our current location on the 11th floor of the Columbia University Vanderbilt Clinic building. This name change reflected a broadening scope of research, in particular an increasing interest in radiation biology. While remaining a leader in developing the still new field of radiation therapy, the Radiological Research Laboratory started to increasingly focus on the other side of the radiation “sword” — the effects of low levels of radiation exposure.



**Our first and second Directors,
Failla and Rossi**

When Dr. Failla retired in 1960, Harald Rossi took over as Director.

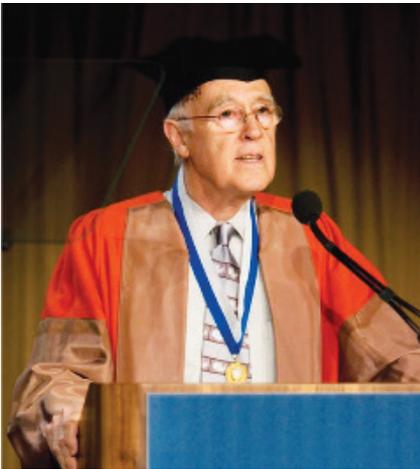
Much of Dr. Rossi’s work focused on creating ways to make precise measurements of the distribution of radiation energy depositions inside single cells. This came to be called “microdosimetry”, and the Center remains a leader in this field.

Under Dr. Rossi’s leadership, the Laboratory continued to focus on the links between radiation physics and radiation biology. This led to the founding of our Center’s Radiological Research Accelerator Facility (RARAF), located on the Hudson River in Irvington, NY in Westchester County and approaching its 50th anniversary in 2017. RARAF is used by our own researchers and by research scientists from all over the world, to investigate exactly how low levels of radiation produce health effects such as cancer.

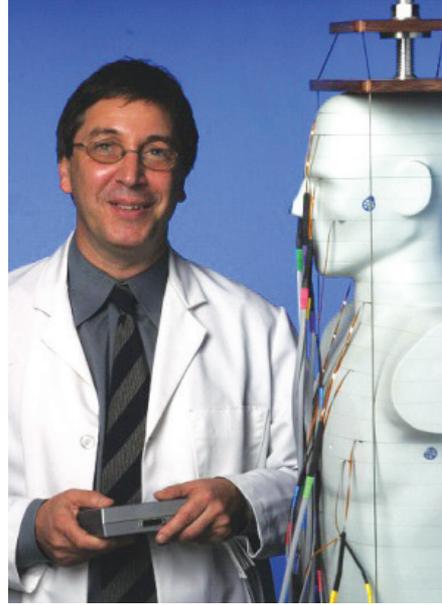
In 1984 Dr. Rossi stepped down as Director of the Radiological Research Laboratory and Dr. Eric Hall became our third Director. Dr. Hall is recognized internationally as an outstanding educator, authoring eight editions of the seminal textbook *Radiobiology for the Radiologist*, which every radiologist and radiation oncologist relies on during their training as essential reading. During Dr. Hall’s tenure the Laboratory grew in size

and diversity of faculty, particularly with the rapid development and increasing significance of molecular biology.

The Laboratory's work during this era set the stage for an increased emphasis on translational research—helping to bring research findings from the lab to the bedside. For example, the standard approach for treating prostate cancer with radiotherapy, called hypofractionation, was developed in our Center and based on our scientists' basic radiobiological studies.



CRR's third Director, Eric Hall



Our fourth and current Director, David Brenner

In 1988, in recognition of a significant multifaceted research program, the Laboratory was given Center status and is known today as the Center for Radiological Research or simply CRR.

Now under the guidance of our fourth Director, Dr. David Brenner, the Center for Radiological Research has continued to optimize the uses and assess the risks associated with ionizing radiation in medicine and in a wide range of other fields where potential radiation exposure may occur, including homeland security, nuclear power, occupational exposure and space travel.

RESEARCH PROGRAMS IN OUR CENTER TODAY INCLUDE:

Research to better improve radiation treatment for cancer, including:

- Improved treatments for pancreatic cancer
- More convenient treatments for prostate cancer
- Non-invasive alternatives to mastectomy for women with BRCA1/2 gene mutations
- Reducing the risks of a second breast cancer
- Using genomics to predict which patients are likely to respond well or less well to radiation therapy

Research to improve the nation's ability to respond to a large scale radiological event

- We are developing ultra-high throughput technologies to be able to assess, in the event of an accident or terrorist event, how much radiation each individual received. The Center is capable of assessing thousands of individuals per day.
- We are developing molecular-based techniques to determine which exposed individuals are more sensitive to radiation in order to prioritize treatments.
- We are developing techniques to simulate and understand health effects of neutron radiations associated with explosion of an improvised nuclear device.

Research to better understand the health risks to a population exposed to low dose radiation exposure. Applications include:

- Balancing the risks and benefits associated with CT scans and other medical imaging techniques
- Understanding the consequences of nuclear accidents such as Chernobyl and Fukushima
- Understanding the risks and benefits associated with whole-body screening at airports.

Understanding the molecular mechanisms by which low doses of radiation can cause cancer

- Of particular interest is the so called “bystander effect”, by which irradiated cells communicate information about their damage to nearby unexposed cells and may thereby affect their function.

Understanding the radiation health risks that astronauts face during space missions, either in earth orbit or on a prolonged Mars mission.

- We are studying the effects of space radiation on cancer induction, blood vessel formation and function, brain function, and cataract induction.

Development of new ultraviolet light techniques to kill microbes such as drug-resistant bacteria like MRSA, without producing any harm to humans.

- Our Differential Ultra-Violet Sterilizer (DUVS) uses 220 nm UV light to kill drug-resistant bacteria during surgery, while being safe for patients and staff. Our goal is to dramatically reduce the scourge of surgical site infections.
- We are investigating a variant of the DUVS approach to kill airborne viruses such as influenza and measles, in populated locations, such as hospitals and airports.

Our Radiological Research Accelerator Facility continues to be a world leader in the development of charged-particle microbeams – a key technology in research to help understand how information about DNA damage is transmitted from one location to another within human cells and human organs.

- Our microbeam facilities are used by visiting scientists from all over the world.

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**Proudly Congratulates
The Center for Radiological Research
on its
100 Years of Outstanding
Investigations
into
Radiation and its Effects
on the Human Condition**



**COLUMBIA UNIVERSITY
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With Best Wishes
for
Another 100 Years of Excellence
The Faculty and Staff
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Congratulations to the
Columbia University
Center for Radiological Research
on its 100th anniversary from
the Department of Microbiology & Immunology.
Historically, one of
Microbiology & Immunology's
primary areas of research
has involved cancer,
and we hope that recent
advances in immunotherapy
will prove valuable to
all those involved in the
fight against cancer.



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In tribute to my esteemed colleagues

**On the occasion of the
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Marking 100 years of
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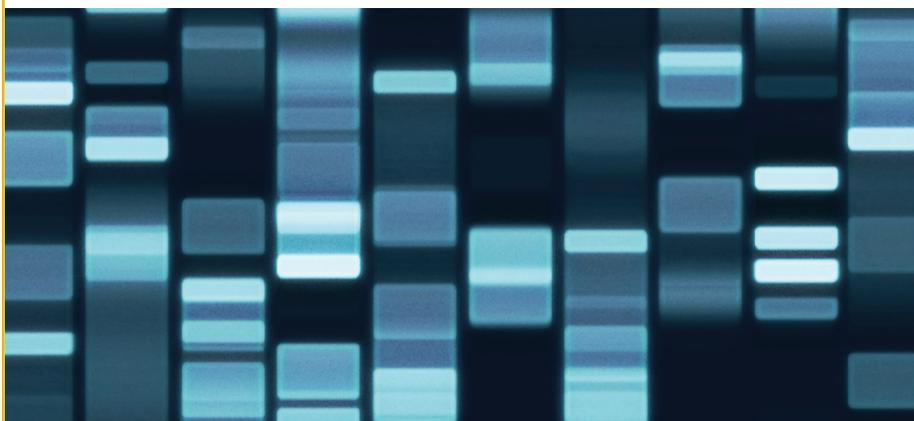
at

**The Center for Radiological Research
May the next 100 years be even more
successful!**

Israel Deutsch, M.D.

**The Mailman School of Public Health
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The Center for Radiological Research
On One Hundred Years of
Outstanding
Investigative Research and Service
to the Field of Public Health**

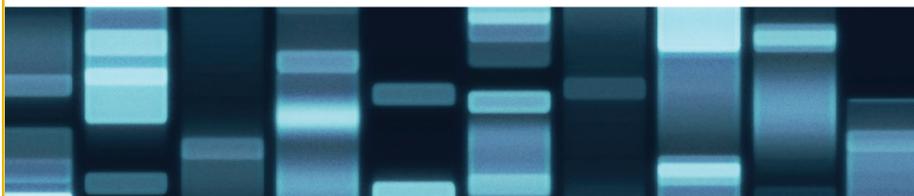




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Congratulations to Columbia University Center for Radiological Research from your colleagues at the Columbia Precision Medicine Initiative.

May the next 100 years be as pivotal as the first 100!





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is our business. Little surprise that
we recognize and support CRR!*

*In awe of your accomplishments...
Eric & Miriam Goldstone*

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Congratulations from the
Department of Medicine
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COLUMBIA UNIVERSITY
Department of Medicine

We join you in celebrating
the 100th Anniversary of the
Center for Radiological Research
and its tremendous
contributions to science
and human health.

We wish you continued
success, accomplishment,
and leadership over your
next century, and look
forward to continuing and
strengthening our connections.

ColumbiaMedicine.org





COLUMBIA UNIVERSITY

*Department of Pathology
and Cell Biology*



The faculty and staff of the

Department of Pathology and Cell Biology
at the Columbia University Medical Center

Congratulate the

Columbia University Center for Radiological Research
on its
Centennial Anniversary!

Kevin A. Roth, M.D., Ph.D.

Chairman and Donald W. King, M.D. and Mary Elizabeth King, M.D.
Professor of Pathology and Cell Biology
Pathologist-in-Chief, Columbia University Medical Center



The Greater New York Chapter of the Health Physics Society and The Radiological and Medical Physics Society of New York

Congratulate

The Columbia University Center for Radiological Research on its 100th Anniversary

The Center was founded by Dr. Gioacchino Failla, a student of the Nobel Laureate Dr. Marie Curie. The seminal contributions and pioneering work of Dr. Failla are celebrated yearly by both Chapters at the Failla Memorial Lecture. Lecturers from the fields of health physics and medical physics are selected from recognized scientific leaders, both nationally and internationally.

Happy 100th Anniversary
Center for
Radiological Research!
Congratulations and
Best Wishes for the Next
100 years!

*Division of Neuroradiology
at Columbia University Medical Center
Alexander G. Khandji MD*

**The Advisory Council of the Center
for Radiological Research**

**Proudly Congratulates the Center
on its
Centennial Anniversary**

**and is committed to making the
Center successful for the next
100 years**

Radiation is a fundamental part of our universe and our life on earth.

Understanding it is critical to our quality of life and perhaps will be even more important in the future.

Therefore, while I congratulate the Center for its first 100 years of work, I am predicting that the next 100 years of research will be even better!

-Gareth Roberts, Advisory Council Member

**Wishing you another 100 years of
leadership in**

- basic and translational radiation
research**
- education and training for the next
generation of radiation scientists and**
- providing accurate, scientific-based
information to health professionals,
elected officials and the
general public.**

**Laurin Blumenthal Kleiman
Norman Kleiman, PhD**

**The International Association for
Radiation Research (IARR)
Congratulates
The Center for Radiological Research
for
100 Years of Outstanding
Investigations into the Effects of
Radiation on the Human Condition**



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2015-2016**

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